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1. Introduction

1.1 Background and Motivation

The primary motivation for this work is rooted in the innovative insights provided by two seminal papers: "Behavioral Macroeconomics and Macroeconomic Behavior" by George A. Akerlof (2002) and "Lectures on Behavioral Macroeconomics" by Paul De Grauwe (2012). These works challenge the traditional assumptions of macroeconomic models and advocate for a paradigm shift towards a more behavioral approach.

In his seminal paper, "Behavioral Macroeconomics and Macroeconomic Behavior," George A. Akerlof (2002) explores the concept of behavioral macroeconomics, which he describes as a dream to develop macroeconomics in the original spirit of John Maynard Keynes' General Theory. Akerlof argues that macroeconomics should no longer suffer from the "ad hockery" of the neoclassical synthesis, which had overridden the role in the work of Keynes of psychological and sociological factors. He advocates for strengthening macroeconomic theory by incorporating assumptions that reflect the observation of these elements.

In “Lectures on Behavioral Macroeconomics” by De Grauwe (2012), on the other hand, the critique of mainstream macroeconomic models is related to the assumption that agents have superior cognitive abilities, making them capable of solving complex problems. De Grauwe argues that these models are implausible and have failed empirically. Instead, he proposes a behavioral model where agents have limited cognitive abilities, forcing them to use simple rules or heuristics. The author introduces rationality as the willingness of agents to learn by switching to alternative rules to improve their performance in forecasting the evolution of macroeconomic variables. This perspective acknowledges the cognitive limitations of individuals and the potential for systematic errors in decision-making, leading to a richer dynamics that aligns more closely with observed economic behaviors.

1.2 Research Objectives and Structure

The primary objective of this work is to provide an empirical validation of the behavioral macroeconomic model proposed by De Grauwe (2012). In particular, it aims to answer the following questions:

How well do the predictions of De Grauwe's model align with the empirical data from various economies?

This research question aims to provide empirical support to De Grauwe's model by investigating whether the observed distributions of key macroeconomic variables in different economies exhibit the non-normal characteristics predicted by the model. In addition, the correlations among "animal spirits" and output gap, inflation and interest rate are investigated across different countries.

How does the timing of a policy shock affect its transmission into the economy? The behavioral model suggests that the timing of the shock matters a great deal, but this could be empirically tested across different economic contexts and policy types.

This work will continue in Chapter 2 (Theoretical Framework), where the field of behavioral macroeconomics is presented after a critique of mainstream macroeconomics. It follows a review of relevant literature, giving an overview of the academic context of the discipline. Afterward, the chapter aims to illustrate the Behavioral Macroeconomic Model presented in the work of De Grauwe (2012), detailing its fundamental assumptions, mechanisms, and implications for monetary policy. In Chapter 3 (Empirical Analysis), there is a description of the data sources and methodology used in the study. The results are presented, comparing the distributions obtained from the behavioral model with those from real-world data. Estimations of the Taylor Rule for different countries are also provided to verify if the results obtained by the behavioral model are similar to real-world ones. In Chapter 4 (Discussion and Conclusion), there are a summary of the main findings, an acknowledgment of the limitations of the study, and suggestions for future research. A conclusion follows.

2. Theoretical Framework

2.1 The Problems of "Mainstream" Macroeconomics

Mainstream macroeconomics has been subject to numerous critiques, particularly in the aftermath of the 2008 financial crisis. These critiques often focus on the limitations of the rational expectations (RE) and efficient markets hypotheses, two critical pillars of mainstream macroeconomic thought.

Paul Romer's "The Trouble with Macroeconomics" (2016) strongly critiques modern macroeconomics. Romer argues that the field has gone back over the last three decades, with a significant part of the problem being the over-reliance on mathematical consistency at the expense of empirical relevance. He suggests that this has led to a disregard for the importance of real-world details and resulted in detached models.

Romer also criticizes the lack of accountability in the field, where economists often make assumptions without providing a solid basis for them. This fact allowed for the proliferation of models based on unproven or even disproven premises. Romer calls for a shift towards a more empirical approach in macroeconomics, where theories are constantly tested and refined based on real-world observations. He believes this would lead to more accurate models and policy recommendations.

In "Narrative Economics" (2017), Robert Shiller critiques traditional economics for its lack of attention to the role of narratives in shaping economic behavior. He argues that narratives, stories people tell to make sense of their experiences, are crucial in influencing economic decisions and outcomes. Narratives can spread and change over time, much like diseases or memes, and can significantly impact the economy.

Shiller suggests that economists should pay more attention to these narratives and incorporate them into their models and theories. He believes that doing so could lead to a better understanding of economic phenomena and improve the accuracy of economic predictions. The author also argues that advances in psychology, neuroscience, and artificial intelligence could be used to understand better the structure and impact of narratives in economics. In this way, he suggests, economists will be helped to move beyond traditional models and better understand the various kinds of drivers that move economic events.

In “What’s Wrong with Economic Models?” (2012) by Woodford, the author points out the lack of attention to financial intermediation and the role of banks in mainstream economic models. The latter, he argues, often abstract from many aspects of people's current circumstances, and instead, they involve heroic specificity about unknown aspects of the future. These models, therefore, are not representative of the actual world and can lead to inaccurate predictions and policy recommendations.

Woodford also criticizes the postulate of RE, which “*is often presented as if it were a simple consequence of an aspiration to internal consistency in one’s model and/or explanation of people’s choices in terms of individual rationality*” (Woodford, 2012). However, he argues that it is not a necessary implication of these methodological commitments. He points out that believing in the validity of one's own model and assuming that people make rational choices does not necessarily mean that these choices will align with what is deemed correct by someone who, like an economist, trusts the predictions of that model.

In "Where Modern Macroeconomics Went Wrong" (2018), Joseph Stiglitz provides a comprehensive critique of traditional economics, particularly the Dynamic Stochastic General Equilibrium (DSGE) models that have come to dominate the discipline. Stiglitz argues that these models fail to serve the functions which a well-designed macroeconomic model should perform. He points out that the standard model is intellectually incoherent and implicitly encourages society to move in a direction that would undermine both efficiency and well-being. The author also criticizes these kinds of models for their inability to explain how even a moderate shock has significant consequences on the economy.

Stiglitz highlights the weaknesses of these models, stating that they often incorporate features in an ad hoc manner, which results in the loss of elegance and weakens the claims that they are based on solid microfoundations. He also criticizes the complexity of these models, making it challenging to interpret what is really happening. Furthermore, the author points out that the models often impose several restrictions that directly contradict empirical evidence. He argues that “*if a model has been* *rejected along some dimensions, then a statistic that measures the goodness-of-fit along other dimensions is meaningless*" (Stiglitz, 2018).

Stiglitz also criticizes the reliance on DSGE models for policy recommendations. He argues that these models provide a poor basis for policy, and even minor modifications are unlikely to be helpful. He suggests that models should incorporate insights from information economics and behavioral economics. Also, they should better represent the financial sector and the role of distribution in fluctuations and crises. He concludes by stating that the challenge for economists is to develop increasingly sophisticated models that incorporate the various insights provided by a range of 'partial' models that help us understand the essential fluctuations in our economy.

2.2 Behavioral Macroeconomics

The critiques of traditional macroeconomics have led to a growing recognition of the need for a more descriptive approach to macroeconomics. This approach acknowledges the limitations of the RE and efficient markets hypotheses and seeks to incorporate more "behavioral" assumptions into macroeconomic models.

One of the key insights from behavioral economics is that individuals often deviate from the rational, optimizing behavior assumed in traditional economic models. For example, individuals may be subject to cognitive biases, have limited willpower, or base their decisions on rules of thumb rather than a detailed analysis of all available information. These traits can have significant macroeconomic implications, affecting everything from consumption and investment decisions to labor market outcomes.

Another important insight from behavioral economics is the concept of bounded rationality. This concept, introduced by Herbert Simon, suggests that individuals' rationality is limited by the availability of information, their cognitive limitations, and the finite amount of time they have to make decisions. This notion contrasts with the assumption of perfect rationality in mainstream economic models, where individuals are assumed to have unlimited computational abilities.

However, the development of behavioral macroeconomic models is still in its early stages, and much work remains to be done in this area.

George Akerlof is a renowned economist known for his significant contributions to the field of behavioral economics and information asymmetry. He was awarded the Nobel Prize in Economics in 2001, along with Michael Spence and Joseph Stiglitz, “for their analyses of markets with asymmetric information". On top of the already cited Nobel Prize Lecture ("Behavioral Macroeconomics and Macroeconomic Behavior", 2002), another relevant contribution to the field is given in “Animal Spirits: How Human Psychology Drives the Economy, and Why It Matters for Global Capitalism” in collaboration with Robert Shiller (2009). The book provides a comprehensive exploration of the role of human psychology in economic decision-making. They argue that to understand how economies truly function, we must consider the thought patterns that animate people's ideas and feelings, their “animal spirits”. They assert that economic events are primarily mental in nature and that variations in individual feelings, impressions, and passions matter in the aggregate.

The authors critique mainstream macroeconomics for often falling back on the most tortured and artificial interpretations of economic events. They argue that economic events are often assumed to be driven by inscrutable technical factors or erratic government action, ignoring that the origins of these events are found in our everyday thinking.

Akerlof and Shiller argue that the recent economic turmoil can be understood in terms of “animal spirits”. They suggest that the public, the government, and most economists had been reassured by an economic theory that guaranteed that nothing terrible could happen. However, in their opinion, that theory needed to be revised because it ignored the importance of ideas in the conduct of the economy and the role of animal spirits.

The authors propose that “animal spirits” such as confidence, fairness, corruption, money illusion, and stories are real motivations for real people and are ubiquitous in capitalist economies. They argue that these “animal spirits” are crucial in answering eight basic questions regarding capitalist economies: Why do depressions occur? Why do central banks have real powers? Why do we have involuntary unemployment? Why is there a long-run trade-off between inflation and unemployment? Why is saving so variable? Why do stock markets fluctuate so wildly? Why are the cycles in the housing market so large? And why is there continued minority poverty?

In summary, the work of Akerlof and Shiller provides a compelling argument for the importance of behavioral factors in understanding economic phenomena. They argue that a correct view of how the economy works is essential in making both personal decisions (such as how much we should save, where we should invest, what house we should buy, and whether we can trust our employer to pay our pension) and public decisions. Their work underscores the need for a shift in the narrative of who people are and who they should be in the context of economic decision-making.

2.3 Review of Relevant Literature

The literature on behavioral macroeconomic models provides a rich backdrop against which to understand the current state of macroeconomic modeling and policy-making.

Behavioral macroeconomic models have been proposed as a way to address the limitations of traditional models, particularly their inability to account for “extreme” movements of the key macroeconomic variables (booms and busts) and sudden changes in market sentiment (De Grauwe, 2012). These models incorporate agents with bounded rationality, which can lead to the formation of bubbles and market overreactions.

The role of monetary policy in stabilizing the economy has been discussed, with an emphasis on understanding the behavior of economic agents for effective policy-making (Yellen, 2007). Similarly, the role of financial intermediation in the economy has been highlighted, suggesting that understanding the behavior of financial intermediaries is crucial for macroeconomic modeling and policy-making (Levine, 2009; Fontanier, 2022).

The role of wage rigidity in macroeconomic models has been discussed, arguing that understanding the behavior of workers and firms in setting wages is crucial for macroeconomic modeling (Driscoll & Holden, 2014). The role of fiscal policy in stabilizing the economy has also been discussed, suggesting that understanding the behavior of government and its interaction with the economy is crucial for effective policy-making (Blanchard, 2017).

In the paper by Bao et al. (2013), a behavioral macroeconomic model that incorporates heterogeneous agents and market frictions is presented. The paper shows how these factors can lead to complex economic dynamics. Also, the authors suggest that high-efficiency levels in learning-to-optimize experiments should be treated with caution; even if efficiency metrics indicate that subjects are doing well on the optimization task, the implicit price forecasts may be far from rational.

Hommes (2018) further emphasizes the importance of a complex systems approach in behavioral and experimental macroeconomics, arguing that this approach can provide valuable insights into policy analysis. This work is further expanded in Hommes et al. (2019), where the authors delve deeper into the management of heterogeneous and unanchored expectations, particularly in the context of monetary policy.

On the other hand, De Grauwe (2012) and De Grauwe and Ji (2017) have focused on the role of "animal spirits" or psychological factors in macroeconomics. They argue that mainstream macroeconomic models, dominated by the paradigm of the "homo economicus," fail to account for the impact of these psychological factors on economic behavior. Their work proposes a behavioral macroeconomic model that incorporates these factors, leading to endogenous business cycle fluctuations. They also explore the trade-off between output and inflation and how the flexibility of the economy moderates it.

These works collectively underscore the importance of incorporating behavioral factors and acknowledging the heterogeneity of expectations in macroeconomic models. They also highlight the need for a more nuanced understanding of the trade-offs faced by monetary authorities in managing the economy.

2.4 The Behavioral Macroeconomic Model of De Grauwe

2.4.1 Overview

In this section, “Lectures on behavioral macroeconomics” (2012) by De Grauwe will be further explored. The author argues that the traditional models failed to predict the financial crisis due to their inability to account for the complexity of human behavior. He proposes a model that treats the economy as a complex adaptive system, where agents' perceptions and decisions can lead to economic booms and busts.

De Grauwe's model is grounded in the understanding that agents do not fully comprehend the world they live in. This cognitive limitation leads them to use simple rules or "heuristics" to guide their behavior. This approach is not because they are irrational but because the complexity of the world is overwhelming. According to De Grauwe, using heuristics is a rational response of agents aware of their limited capacity to understand the world.

One of the significant implications of De Grauwe's model is the introduction of heterogeneity in the use and processing of information. Unlike DSGE models, which assume a representative agent to describe how all agents in the model process information, De Grauwe's model acknowledges the dynamics of interacting agents with limited understanding but often with different strongly held beliefs. This heterogeneity, he argues, is what drives the business cycle.

De Grauwe's model also highlights the concept of "anchoring" effects, where agents are highly selective in how they use information due to their limited understanding. They tend to concentrate on the information they understand or new information in their minds. This anchoring effect explains why agents often extrapolate recent movements in prices.

The book of De Grauwe can be thought to be crucial for several reasons. Firstly, De Grauwe's work is a seminal contribution to the field of behavioral macroeconomics, offering a comprehensive and innovative perspective on how macroeconomic phenomena can be understood through the lens of behavioral economics. His critique of mainstream macroeconomic models and the introduction of a behavioral macroeconomic model provide a valuable theoretical framework for this survey and further research in the field. Secondly, his model, which incorporates elements of bounded rationality and the concept of "animal spirits," offers a unique approach to understanding the non-normal distributions of macroeconomic variables and provides unique insights into the conduct of monetary policy. Lastly, a thorough understanding of De Grauwe's book provides an important opportunity for more aware investigations of real data, as the empirical analysis in Chapter 3 aims to do. This kind of surveys allows to build upon his ideas and contribute to the ongoing discourse in the field. For this reason, the discussion will now delve into the contents of the book, explaining synthetically the insights of each chapter.

2.4.2 The Premise

De Grauwe's work begins with a reflection on the state of macroeconomics prior to the 2007 financial crisis. The period was marked by macroeconomic stability, low and stable inflation, high and sustained economic growth, and low volatility of many economic and financial variables. This stability was largely attributed to the insights provided by modern macroeconomic theory, which was based on the concept of the rational agent who continuously optimizes his utility using all available information.

However, the financial and economic upheavals following the crash in the US subprime market have undermined this idyllic view of stability created in a world of entirely rational and fully informed agents. These upheavals have also strengthened the view of those who have argued that macroeconomics must consider departures from rationality, particularly from the assumption of RE.

De Grauwe argues that it is possible to depart from the traditional formulation of rationality without having to wander into the territory of irrationality. He suggests that once we accept that individuals have cognitive limitations and are incapable of understanding the full complexity of the world, it is possible to develop models based on a different notion of rationality. This leads to richer macroeconomic dynamics that come closer to the observed dynamics of output and inflation than the ones produced by the mainstream macroeconomic models.

A discussion follows on the New Keynesian Macroeconomic model (DSGE-model). The model is characterized by its micro-foundations, rational expectations, and the assumption of price stickiness.

In more detail, consumers are assumed to maximize their utilities and produce their profits in a dynamic, multi-period context. Secondly, consumers and producers are assumed to have RE: they make forecasts using all available information, including the information embedded in the model. The assumption of RE also implies that agents know the actual statistical distribution of all shocks hitting the economy. They then use this information in their optimization procedure. Since consumers and producers use the same information, we can take one representative consumer and producer to model the whole economy. There is no heterogeneity among economic agents. Thirdly, and this is the New Keynesian feature, it is assumed that prices do not adjust instantaneously. Although firms continuously optimize, there are institutional constraints on the speed with which they can adjust prices to their optimal level. This feature contrasts with the New Classical model (sometimes called the "Real Business Cycle" model), which assumes perfect price flexibility.

The author critiques this assumption following a close pattern to the academic works already discussed in section 2.1. In fact, he notes that while macroeconomic theory enthusiastically embraced the view that agents fully understand the structure of the underlying models in which they operate, other sciences like psychology and neurology increasingly uncovered the cognitive limitations of individuals. This cognitive problem leads agents to use simple rules ("heuristics") to guide their behavior.

Then, according to the author, the lack of heterogeneity in the use and processing of information in these models makes the latter of less interest when used to analyze short-term and medium-term macroeconomic problems.

Also, the author notes that DSGE models fail to predict dynamics that come close to the observed output movements, except when the step is taken to assume that the unexplained dynamics in the error terms is an exogenous force driving an otherwise correct model.

De Grauwe calls for a shift from top-down models, where one or more agents fully understand the system, to bottom-up models, where each individual understands only a small part of the whole. The author suggests that it might be preferable to admit that heuristics guide agents' behavior and to incorporate these heuristics into the model from the start rather than to pretend that agents are entirely rational but rely in a nontransparent way on statistical tricks to improve the fit of the model.

2.4.3 The Model

De Grauwe then presents his behavioral model. The model built in this chapter uses the same equations as the standard macroeconomic model previously discussed, including an aggregate demand equation, an aggregate supply equation, and a Taylor rule equation, here reported:

$$\text{AD: } y_t = a_1 E_t\, y_{t+1} + (1 - a_1)y_{t-1} + a_2(r_t\ - E_t\pi_{t+1} + \varepsilon_t)$$

$$\text{AS: } \pi_t = b_1 E_t\, \pi_{t+1} + (1 - b_1)\pi_{t-1} + b_2 y_t + \eta_t$$

$$\text{TR: } r_t = c_1(\pi_t - \pi^*) + c_2 y_t + c_3 r_{t-1} + u_t$$

Where y_{it} is the output gap in period t, r_{it} is the nominal interest rate, π_t is the rate of inflation, π^* and ε_t, η_t, and u_t are white noise disturbance terms. In addition, the Taylor Rule presents a "smoothing" behavior, given by the lagged interest rate (r_{t-1}).

The difference between the New Keynesian and the Behavioral lies in how agents use information to make forecasts. In the Behavioral model, agents are assumed to use simple rules or heuristics to forecast the future.

De Grauwe emphasizes that agents using simple rules of behavior are not foolish. They use simple rules because the real world is too complex to understand fully, but they are willing to learn from their mistakes. They regularly subject the rules they use to some criterion of success. This can be done in two ways: statistical learning and "adaptive" learning. Statistical learning, pioneered by Sargent (1993) and Evans and Honkapohja (2001), assumes that agents learn as econometricians do. They estimate a regression equation explaining the variable forecasted by several exogenous variables. This equation is then used to make forecasts. When new data become available, the equation is re-estimated, updating the forecasting rule each time new information becomes available.

Instead, adaptive learning, also referred to as "trial and error" learning, is a process where agents use simple forecasting rules and subject these rules to a "fitness" test. In this context, agents endogenously select the forecasting rules that have delivered the highest performance in the past. If a rule performs well, they keep it; if not, they switch to another rule. This process is iterative and continuous, allowing agents to learn from their past mistakes and adjust their behavior accordingly.

In this model, agents are assumed to use two types of forecasting rules: a "fundamentalist" one and an "extrapolative" one. For the first rule, agents estimate the steady state value of the output gap, normalized at 0, and use this to forecast the future output gap. The second rule does not presuppose that agents know the steady state output gap. Instead, they extrapolate the previously observed output gap into the future (the rules are also valid for inflation).

The two rules are:

$$\text{Fundamentalist: } E_t^f y_{t+1} = 0$$

$$\text{Extrapolative: } E_t^e y_{t+1} = y_{t-1}$$

The market forecast is then obtained as a weighted average of the two:

$$E_t y_{t+1} = \alpha_{f,t} E_t^f y_{t+1} + \alpha_{c,t} E_t^e = \alpha_{f,t} 0 + \alpha_{c,t} y_{t-1} \text{ and } \alpha_{f,t} + \alpha_{c,t} = 1$$

As mentioned before, agents are assumed not to be fools. They are willing to learn, i.e., they continuously evaluate their forecast performance. Indeed, rational behavior is defined as this willingness to learn and change one's behavior. Thus agents in the model can be said to be rational, but not in the sense of having rational expectations. The latter assumption has been rejected because it is an implausible assumption about individuals' capacity to understand the world. Instead, in the model, agents are rational in the sense that they learn from their mistakes. The concept of "bounded rationality" is used to characterize this behavior.

Agents are assumed to evaluate the performance of their forecasts by computing the mean squared forecasting errors for each rule:

$$U_{f,t} = -\sum_{k=0}^{\infty} \omega_t \left[y_{t-k-1} - E_{f,t-k-2} y_{t-k-1} \right]^2$$

$$U_{e,t} = -\sum_{k=0}^{\infty} \omega_t \left[y_{t-k-1} - E_{e,t-k-2} y_{t-k-1} \right]^2$$

In addition, agents are assumed to give less importance to errors made far in the past; this is modeled by ω_t, a geometrically declining weight.

In this model of “bounded rationality," agents are not simply comparing these two utilities (performances) to choose one of the two rules. In fact, as psychologists have found out, individuals are influenced by their state of mind when choosing between two options. This factor is hardly predictable and is formalized by adding a deterministic component to the above-presented utilities. Hence, this is the probability of choosing the fundamentalist rule:

$$\alpha_{f,t} = P[U_{f,t} + \varepsilon_{f,t} > U_{e,t} + \varepsilon_{e,t}]$$

De Grauwe then assumes that the random variables $\varepsilon_{f,t}$ and $\varepsilon_{e,t}$ are logistically distributed, relying on Anderson, Palma, and Thisse (1992). Therefore:

$$\alpha_{f,t} = \frac{\exp(\gamma U_{f,t})}{\exp(\gamma U_{f,t}) + \exp(\gamma U_{e,t})}, \alpha_{e,t} = 1 - \alpha_{f,t}$$

The parameter γ can be interpreted as the expression of the willingness to learn from past performance. It is directly related to the variance of the random components. If the variance is very high, γ approaches 0. In that case, the probability of being a fundamentalist (or extrapolator) is exactly 0.5. When $\gamma = \infty$, the variance of the random components is zero, and utility is entirely deterministic. In this case, the probability of using a fundamentalist rule is either 1 or 0.

The selection mechanism in adaptive learning acts as a disciplining device on the kind of rules that are acceptable. Not every rule is acceptable; it has to perform well. This mechanism is similar to the disciplining role of rational expectations in traditional models but without assuming that agents have superior cognitive capacities. In the context of forecasting inflation or output gap, agents compute past forecasting errors and apply weights to these past forecast errors. These weights decline as the past recedes, indicating a degree of forgetting. This willingness to learn from past performance and avoid making systematic mistakes ensures that the market forecasts are unbiased.

Then, the concept of "animal spirits" is explained, a term introduced by Keynes (1936) to describe waves of optimism and pessimism that have a self-fulfilling nature and drive the movements of investment and output. It is shown how these waves of optimism and pessimism can lead to movements in the output gap that are not normally distributed, deviating significantly from a normal distribution with excess kurtosis. This non-normality is attributed to the dynamics of "animal spirits," where beliefs get correlated, and optimism breeds optimism, pessimism breeds pessimism. This can lead to situations where everybody has become either optimist or pessimist, characterized by extreme positive or negative movements in the output gap (booms and busts).

According to the author, waves of optimism and pessimism have important implications for the nature of uncertainty in macroeconomic models. It critiques mainstream macroeconomic and finance models for producing movements in output and asset prices that are normally distributed, arguing that this is due to the fact that these models assume that the shocks hitting the economy are normally distributed. The chapter argues that in the real world, the movements in the output gap are not normally distributed and that the behavioral macroeconomic model also produces movements of output that are not normally distributed.

Another fundamental assumption of the model is related to the conditions for animal spirits to arise, namely, the willingness to learn and the capacity to forget of agents.

As mentioned above, the willingness to learn is represented by the intensity of choice parameter, γ. This parameter determines the intensity with which agents switch from one rule to the other when the performances of these rules change. When γ is zero, the switching mechanism is purely stochastic, learning nothing from past mistakes. As γ increases, agents become increasingly sensitive to past performances of the rule they use and are, therefore, increasingly willing to learn from past errors. Animal spirits arise in an environment where agents learn from their mistakes. Surprisingly, animal spirits arise not because agents are irrational. On the contrary, animal spirits can only emerge if agents are sufficiently rational.

The capacity to forget is represented by the weights that agents apply to past forecast errors when testing the performance of the forecasting rules. These weights decline as the past recedes, and these weights are assumed to decline exponentially. If agents are assumed to assign the same weight to all past observations (infinite memory), animal spirits do not arise. Hence, some “forgetfulness” (a cognitive limitation) is necessary to have animal spirits.

In summary, animal spirits only emerge if agents behave rationally, in the sense that they are willing to learn from mistakes, and if, at the same time, they have a form of cognitive limitation, such as a capacity to forget.

2.4.4 The Implications

After having presented the behavioral model, the discussion in the book follows by analyzing the impact of various types of shocks on the economy and how they are transmitted through different economic systems. First, the author focuses on the transmission of monetary policy if the parameters of the model are known with precision. Then, monetary and fiscal shocks are discussed, mainly focusing on the transmission under perfect credibility of inflation targeting. The author argues that when the inflation-targeting regime is perfectly credible, the power of animal spirits to shape the business cycle is greatly diminished. This raises the question of whether a perfectly credible inflation-targeting regime may not also significantly affect the transmission of shocks.

The author then analyzes this question by computing the impulse responses to exogenous shocks under the assumption that perfect credibility of inflation targeting prevails. The impulse response functions describe the path of one of the endogenous variables of the model following the occurrence of the shock. Two series are estimated. One is without the shock (the baseline series); the other is the series with the shock. Then the first is subtracted from the second one. The new obtained series is the impulse response that shows how the endogenous variable that embodies the shock evolves relative to the benchmark.

The author first shows the impulse responses to a positive productivity shock. The results show that the short-term impact of the productivity shock on output is significantly reduced in a regime of perfect credibility. This is because the amplification effect of exogenous shocks disappears in the absence of animal spirits. Under perfect credibility, the time it takes for the endogenous variables (output gap, inflation, interest rate) to return to their long-term values is much shorter than under imperfect credibility. Furthermore, the uncertainty surrounding the short-term effects of exogenous shocks is significantly reduced under perfect credibility.

The chapter on monetary policy implications begins by stating that a central bank that cares about inflation should also be concerned with output stabilization. Strict inflation targeting, where the central bank only cares about inflation, is never optimal. This is illustrated through a simulation of the model under perfect credibility and assuming that the central bank ceases to stabilize output stabilization (c2=0 in the Taylor Rule). In the simulation, animal spirits work with full force, leading to pronounced fat tails and large extreme values for the output gap, i.e., large booms and busts. In fact, output variability intensifies the waves of optimism and pessimism (animal spirits), which in turn feed back on output volatility. These large waves lead to higher inflation variability. As the output coefficient (c2) in the Taylor rule increases from 0 to 1, output variability tends to decrease, indicating that output variability decreases as inflation targeting becomes less strict. However, this decline in output variability comes at the cost of more inflation variability.

Interestingly, under the behavioral model, the relationship between output and inflation variability is non-linear, with inflation variability first declining as the output coefficient increases from zero. Inflation variability increases only when the output coefficient increases beyond a specific value (in a range of 0.6-0.8). Thus, the central bank can reduce both output and inflation variability when it moves away from strict inflation targeting (c2=0) and engages in some output stabilization. However, too much output stabilization increases inflation variability.

This type of dynamics is because, by stabilizing output, the central bank also reduces the amplitude of the waves of optimism and pessimism (animal spirits), thereby stabilizing output and inflation. Inflation credibility is maximized when c2 is in a range between 0.5 and 1. Beyond that range, further attempts to stabilize output reduce inflation credibility. The optimal values of c2 are in a range often found in econometric studies of the Taylor equation, suggesting that central banks seem to apply a degree of output stabilization that is consistent with the theory of animal spirits.

In the following chapter, De Grauwe discusses the impact of price flexibility on the nature of business cycles. Two indicators of the capacity of the behavioral model to generate endogenous business cycles are computed: the autocorrelation coefficient of the output gap and the correlation coefficient between the output gap and animal spirits. The results show that as flexibility increases, the degree of autocorrelation of output declines. This decline is associated with a decline in the correlation between output and animal spirits. Thus, an increase in price flexibility reduces and even eliminates the occurrence of animal spirits, thereby eliminating an important source of business cycle movements. It also contributes to less volatility in output.

However, the increase in flexibility comes at a price. When flexibility increases, inflation volatility also increases. For low levels of flexibility, the movements of output are dominated by the movements of animal spirits, while the effect of exogenous demand and supply shocks on output is relatively small. As flexibility increases, the influence of exogenous shocks on output increases while the animal spirits become less critical. The chapter concludes by discussing the drastically different macroeconomic regimes produced by flexibility, which also translate into very different monetary policy regimes. The impulse responses to analogous interest rate shocks illustrate these differences.

Afterward, the relationship between stock prices, monetary policy, and macroeconomic stability is analyzed. The author discusses how "animal spirits" can lead to periods of bullish and bearish behavior in the stock market. He also mentions that the model under discussion can create bubbles and crashes in the stock market. "Leaning against the wind" strategies in monetary policy are then discussed. These strategies involve using monetary policy to counteract the cyclical behavior of the economy. The author suggests that these strategies do not improve macroeconomic stability when inflation targeting has no credibility.

Then, De Grauwe presents an overview of possible extensions of the model, including introducing different forecasting rules and considering agents using fundamentalist rules. He also explores the implications of allowing agents to use biased rules (either optimistic or pessimistic) and others to use an unbiased estimate of the equilibrium output gap. The paper also contains a section on the monetary policy trade-offs in the three-agent model, which exhibits the same non-linearity as in the basic model. This non-linearity is interpreted to mean that there is scope for active stabilization of the output gap. The author concludes by highlighting the need for further research, particularly in the area of agent-based models that use a large number of agents with an extensive menu of heuristics.

In the last chapter of the book, named "Empirical Issues," De Grauwe outlines three predictions of the model:

1. The correlation between output movements and animal spirits or waves of optimism and pessimism.
2. A temporary decline in output and inflation due to an increase in interest rates. However, these effects are time-dependent and depend on market sentiments, leading to different impulse responses depending on the timing of the shock.
3. The non-normality of the effects of policy shocks are not deviations from the rule, but rather, they are the rule. This contrasts DSGE models, which attribute deviations from normality to special events occurring outside the model.

The author criticizes the traditional empirical testing approach in macroeconomics, which involves estimating an econometric model that embodies the equations of the theoretical model and then performing dynamic simulations given the exogenous variables. Instead, the author proposes an approach of indirect inference, where the predictions of the theoretical model are directly confronted with the data.

To test his results, De Grauwe uses survey-based consumer and/or business sentiment indicators as empirical counterparts of the concept of animal spirits. The author discusses the Michigan Consumer Confidence indicator in the US and similar indicators in other countries. These indicators are based on questions about how individuals perceive present and future economic conditions and are used as tools for analyzing the business cycle and as predictive instruments.

Then, distribution graphs of the output gap for the US, UK, and Germany are shown. The graphs show that the output gap is not normally distributed and exhibits fat tails, which is consistent with the predictions of the behavioral model.

In summary, the behavioral model makes predictions that stand the test of confrontation with the data. However, the author acknowledges that the empirical tests discussed in the chapter are preliminary and that more empirical testing will be necessary to elevate the behavioral model to the status of a serious alternative to mainstream macroeconomic models. This is exactly what motivates the empirical analysis of the following chapter.

3. Empirical Analysis

3.1 Data Sources and Methodology

This section will focus on the collection and analysis of data. In the first part of the empirical analysis, data about the output gap, Consumer Confidence Index (CCI), and inflation were gathered and analyzed. That was done to verify if the results of the simulation of the model in De Grauwe (2012) have empirical validation, mainly to check if distributions of key macroeconomic variables are non-normal and if the correlation among them and "animal spirits" are similar to the simulations of the behavioral model. In addition, in this work, expected inflation fluctuations are taken into account. The distributions of the variables and the correlations among them are computed for all the available time frequencies (annual, quarterly, and monthly data).

All the results of this part are available in Appendix A.

In the second part of the empirical analysis, the Taylor Rule was estimated implementing a linear regression model to check if the sign and the magnitude of the coefficient on the output gap and inflation deviation correspond to the analysis of De Grauwe (2012), seen in the previous chapter. Strong Ordinary Least Squares (OLS) hypotheses have been assumed, namely linearity, endogeneity of regressors, homoskedasticity, no autocorrelation, no multicollinearity and normality of the error term. Furthermore, these estimations have been repeated using expected inflation deviation to see if the model can be improved. The inflation target was assumed to be 2% for the FED, the ECB, and the BoE all over the period analyzed. The output gap target is, instead, assumed to be 0. The full results of this analysis are in Appendix B.

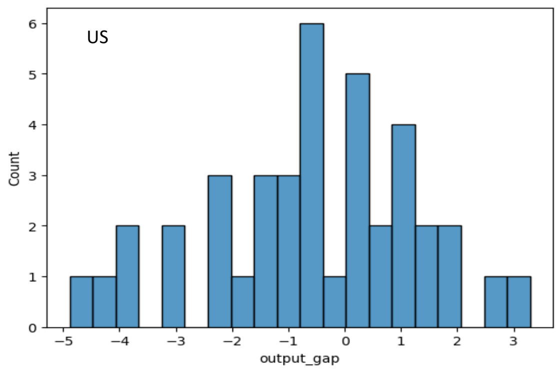
Quarter data are used, and the output gap (for which only annual frequency is available) is assumed to be constant throughout the same solar year. For each country, the Taylor rule has been estimated across three time periods: first, on the whole available timespan; second, on all periods before 2008 (excluded for the US, included for the other countries) and lastly, from 2009 until 2020. This is done to understand if significant differences in the conduct of monetary policy are present for the period before and after the Great Recession. Instead, post-pandemic data are excluded from the estimation of post-great recession Taylor Rule because the large fluctuations of the variables can significantly impact the results on the smaller timespan, even because there are not enough observations for the recovery after the crisis to understand if and how monetary policy drivers have changed. For US and European countries (Germany, France, Italy, and Greece), estimations with inflation expectations are also available.

Data have been collected on the United States, Germany, France, Italy, Greece, the United Kingdom, and Japan. The main source was the OECD Statistics Database. Output gap data are measured as a percentage of the yearly potential output. Inflation is measured as the rate of growth of the Consumer Price Index (CPI) with respect to the same period one year before. For EU countries, the rate of growth of the Harmonised Index of Consumer Prices (HICP) was taken. Data were available on an annual, quarterly, and monthly basis. Data on inflation expectations were gathered based on the Livingston Survey for the US and from the Survey of Professional Forecasters (SPF) for EU countries. The mean expected growth rate of the CPI (HICP for EU Countries) after a year from the survey was used. In Livingston, data were available on a semestral basis (when quarter data was needed, it was assumed a constant value throughout each semester). For EU data, there was an annual and quarterly availability. Data about the short-term interest rate on an annual and quarterly basis have been gathered. EURIBOR was used for the EU, Federal Funds Target Rate for the US.

To measure "animal spirits", as De Grauwe (2012) did to test his model, an index of market sentiment is used, namely the Consumer Confidence Index (CCI). Data have been sourced from the Michigan Index of Consumer Sentiment for the United States. For the European Union, the data was part of the Joint Harmonised EU Programme on Business and Consumer Surveys. Data on CCI were observed monthly, and when aggregated, the mean was taken. In particular, the OECD standardized one has been used. When the index has a value greater than 100, we can call that moment in time "optimistic", otherwise, it is "pessimistic".

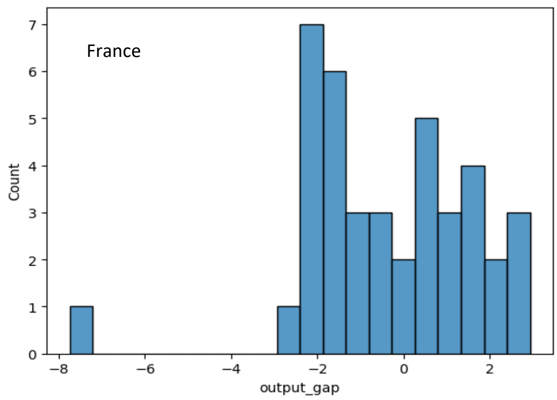
3.2 Results

The main results are reported here. First, the distribution of the US annual output gap.



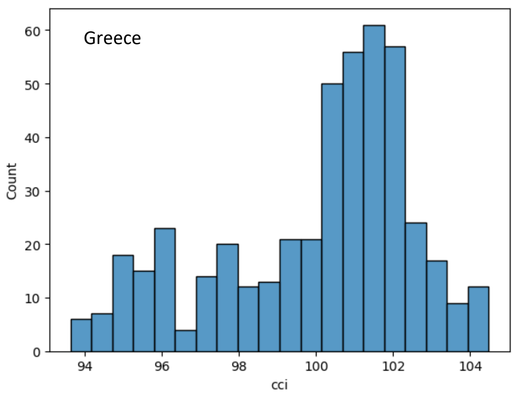

```
Period: 1985 : 2024
Observations: 40
Mean: -0.5848054885309623
Median: -0.528322093576167
Max: 3.28945657931188
Min: -4.88412437161886
Standard Deviation: 1.885196220482
Skewness: -0.26280969536377996
Kurtosis: -0.20600141007151374
Jarque_beraResult(
statistic=0.6049571233392901,
pvalue=0.7389843306793344)
```

The same for France:

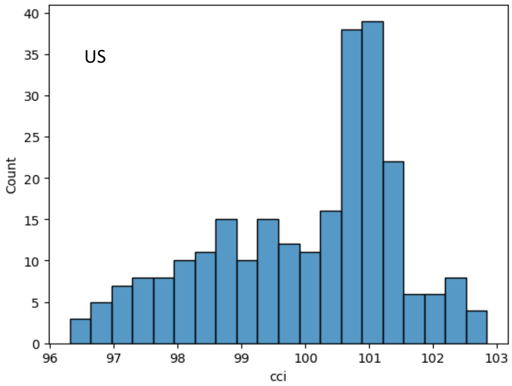



```
Period: 1985 : 2024
Observations: 40
Mean: -0.3626604366804167
Median: -0.5059695810644524
Max: 2.92743628715266
Min: -7.74656038455748
Standard Deviation: 2.01660012817
Skewness: -0.9882638266485979
Kurtosis: 3.1436756635944056
Jarque_beraResult(
statistic=17. 449200670462975,
pvalue=0.000162537740288
```

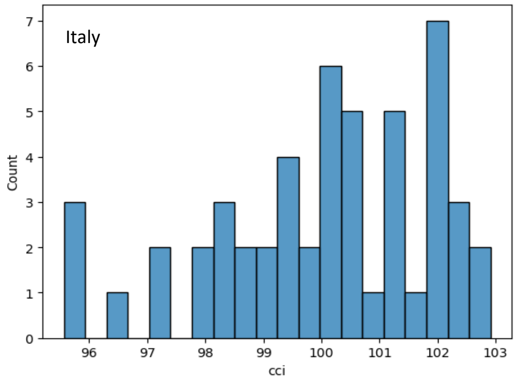
Here is the reported CCI data, in this order: monthly data for Greece, quarterly for the US, and annual data for Italy.




```
Period: 1985 : 2023
Observations: 460
Mean: 99.9999997826087
Median: 100.74585
Max: 104.4815
Min: 93.6215
Standard Deviation: 2.557578717465
Skewness: -0.748077363168076
Kurtosis: -0.34506430944997435
Jarque_beraResult(
statistic=45.03108212491653,
pvalue=1.665807491946225e-10)
```

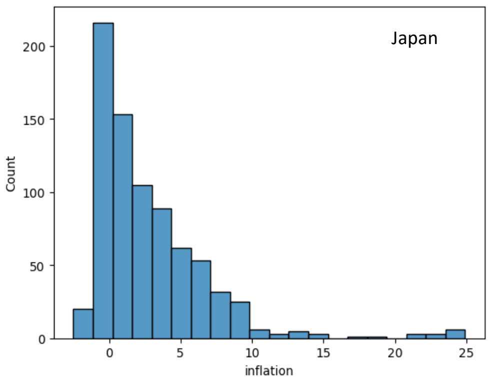



```
Period: 1960Q1 : 2023Q2
Observations: 254
Mean: 99.99282329396321
Median: 100.5233
Max: 102.84463333333333
Min: 96.30723333333333
Standard Deviation: 1.483743768850
Skewness: -0.5295755251587305
Kurtosis: -0.5294717434637022
Jarque_beraResult(
statistic=14.84865337063391,
pvalue=0.0005965624157220351)
```

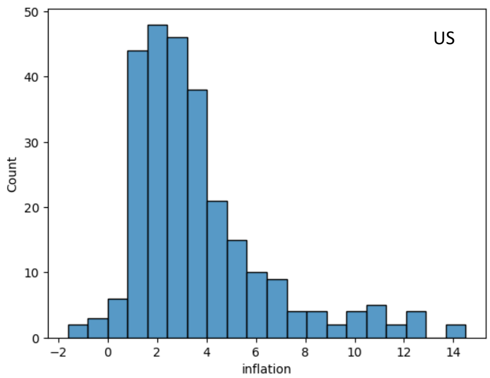



```
Period: 1973 : 2023
Observations: 51
Mean: 99.9966137745098
Median: 100.30048666666666
Max: 102.909675
Min: 95.56572833333333
Standard Deviation: 1.925387417944
Skewness: -0.6614621164409756
Kurtosis: -0.1727167383998096
Jarque_beraResult(
statistic=3.658500408487683,
pvalue=0.16053389029053944)
```

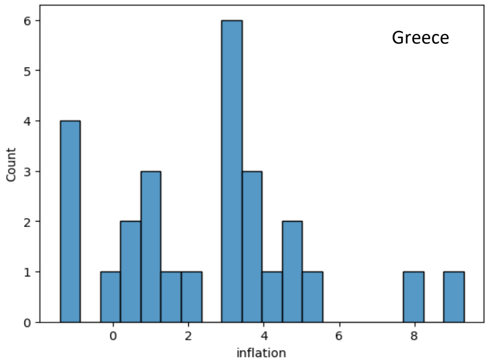
For inflation data, monthly distributions are available for Japan, quarters for the US, and annual for the UK. The graphs and the statistics are shown in the same order:




```
Period: 1956 : 2021
Observations: 786
Mean: 2.842131754707379
Median: 1.7
Max: 24.9
Min: -2.5
Standard Deviation: 4.077883560987086
Skewness: 2.3977464272655453
Kurtosis: 8.387790954477612
Jarque_beraResult(
statistic=3021.0681211761275,
pvalue=0.0)
```

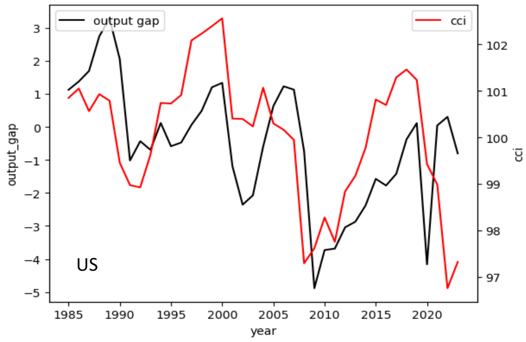


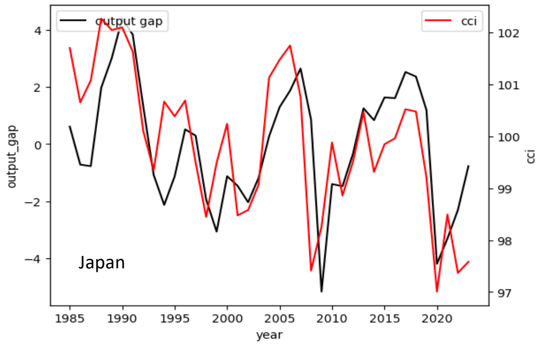

```
Period: 1956Q1 : 2023Q1
Observations: 269
Mean: 3.6780621439776953
Median: 2.991773
Max: 14.5056
Min: -1.62336
Standard Deviation: 2.789780040628
Skewness: 1.575808585397751
Kurtosis: 2.6309707614896083
Jarque_beraResult(
statistic=183.5495150590166,
pvalue=0.0)
```



Period: 1996 : 2022
Observations: 27
Mean: 2.5333333333333337
Median: 3.0
Max: 9.3
Min: -1.4
Standard Deviation: 2.622975409721
Skewness: 0.6107690504533966
Kurtosis: 0.619964559845239
Jarque_beraResult(
statistic=1.59356406019557,
pvalue=0.4507772201723784)

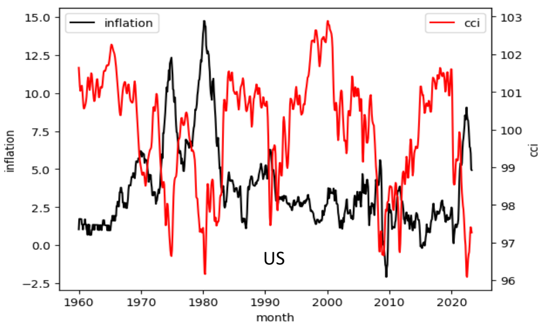
Now, the correlation between the output gap and the measure for "animal spirits," both on an annual basis, for the US (on the left) and Japan:

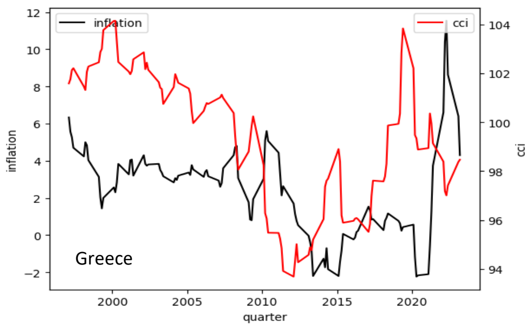




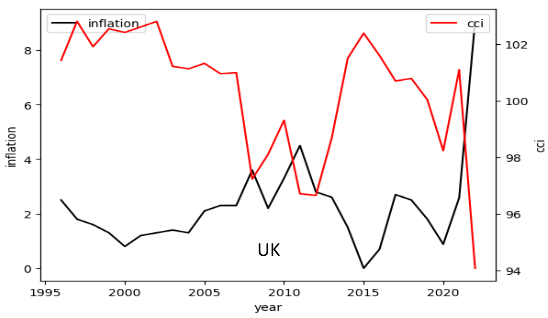
corr: 0.4609753768066784   corr: 0.6800197370758823

Below is the correlation between inflation and CCI. In this order, monthly observations are reported for the US (on the left), quarterly for Greece, and annually for the UK.



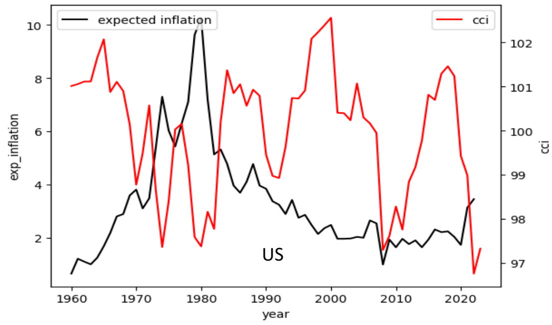


corr: -0.564640654505981   corr: 0.24461520428589734

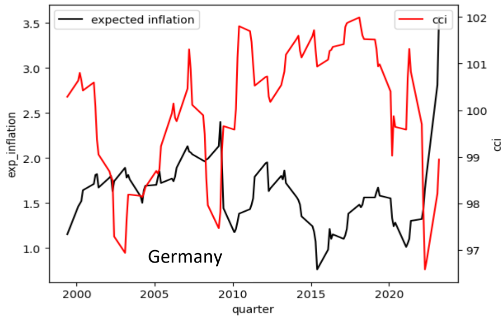


corr: -0.7786736179469979

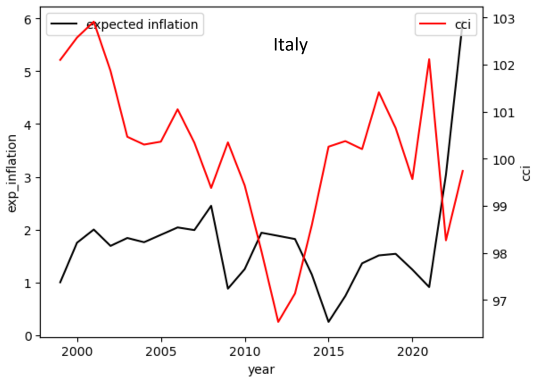
It follows the correlation between the index of market sentiment and inflation expectations. The country presented here is for the US on an annual basis and for Germany and Italy on a quarterly basis.



corr: -0.44566605057560227

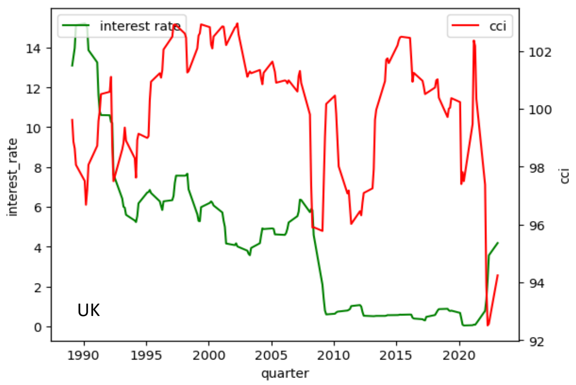


corr: -0.43879300380265285



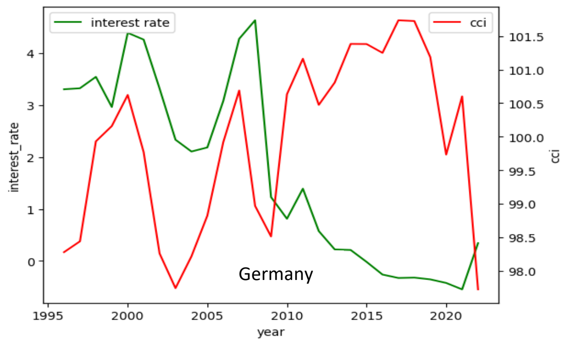
corr: -0.18178981687116888

Lastly, the movements of interest rate and CCI, output gap, and expected inflation are investigated. Specifically, the correlation between short-term interest rate and CCI on a quarterly basis is shown for the UK and on an annual basis for US and Germany. Then, the correlation between the output gap and interest rate (on an annual basis) is shown for the US. Furthermore, the correlation between expected inflation and interest rate is presented for EU countries (quarter basis) and the US (annual basis).

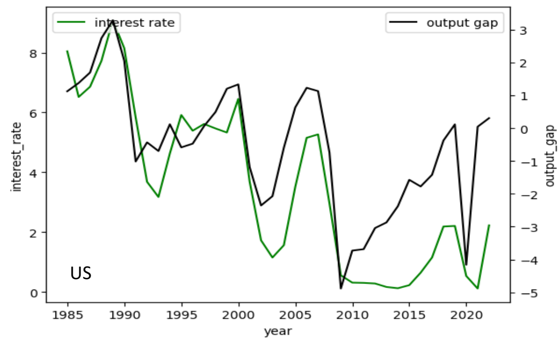


corr: 0.00027822950340974467

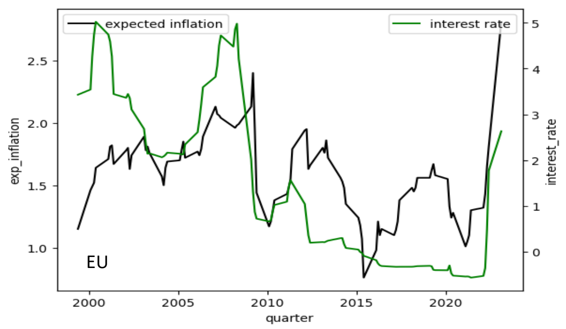
corr: 0.4270491504163415



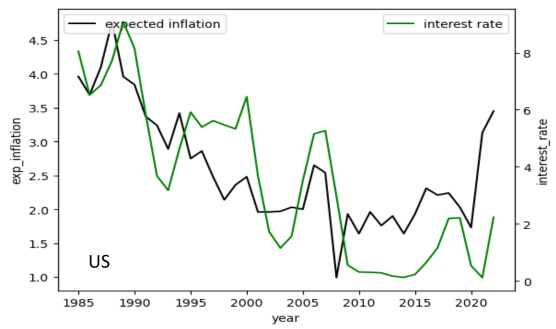
corr: -0.4535084858946735



corr: 0.8342417709943758



corr: 0.5823922831611823



corr: 0.732819964585463

For the second part of the empirical analysis, data are presented for US and Germany. The linear regression results on the whole available timespan for the US are:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        92
-------------+----------------------------------   F(3, 88)        =    853.40
       Model |  404.610062         3  134.870021   Prob > F        =    0.0000
    Residual |  13.9073412        88  .158037968   R-squared       =    0.9668
-------------+----------------------------------   Adj R-squared   =    0.9656
       Total |  418.517404        91  4.59909235   Root MSE        =    .39754

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .7983124   .0298699    26.73   0.000     .7389523    .8576726
     infl_dev |   .0479152   .0485686     0.99   0.327    -.0486046     .144435
   output_gap |   .3005165   .0438259     6.86   0.000     .2134217    .3876113
        _cons |   .8446838   .1418177     5.96   0.000     .5628509    1.126517
------------------------------------------------------------------------------
```

For Germany:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       105
-------------+----------------------------------   F(3, 101)       =   1022.31
       Model |  317.767597         3  105.922532   Prob > F        =    0.0000
    Residual |  10.4647037       101  .103610928   R-squared       =    0.9681
-------------+----------------------------------   Adj R-squared   =    0.9672
       Total |  328.232301       104  3.15607981   Root MSE        =    .32189

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9724459   .0184257    52.78   0.000     .9358943    1.008998
     infl_dev |   .0926537   .0176236     5.26   0.000     .0576932    .1276143
   output_gap |   .0500277   .0188314     2.66   0.009     .0126712    .0873842
        _cons |   .0712487   .0450359     1.58   0.117    -.0180905    .1605879
-------------------------------------------------------------------------------
```

Afterward, the regression parameters are presented for the data observed before the Great Recession (until the end of 2007 for the US and until the end of the following year for Germany). Data on the US are in the upper panel:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       153
-------------+----------------------------------   F(3, 149)       =   2233.37
       Model |  1124.83533         3   374.94511   Prob > F        =    0.0000
    Residual |  25.0145869       149  .167883133   R-squared       =    0.9782
-------------+----------------------------------   Adj R-squared   =    0.9778
       Total |  1149.84992       152  7.56480209   Root MSE        =    .40974

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |    .854193   .0187357    45.59   0.000      .817171     .891215
     infl_dev |   .0497347    .024428     2.04   0.044     .0014647    .0980047
   output_gap |   .2001691   .0299644     6.68   0.000     .1409591     .259379
        _cons |    .560986   .0908326     6.18   0.000     .3814995    .7404725
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    140.92
       Model |   35.383452         3   11.794484   Prob > F        =    0.0000
    Residual |   3.6825525        44  .083694375   R-squared       =    0.9057
-------------+----------------------------------   Adj R-squared   =    0.8993
       Total |  39.0660045        47  .831191585   Root MSE        =     .2893

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .7230018   .0797677     9.06   0.000     .5622406    .8837631
     infl_dev |   .0509492   .0664167     0.77   0.447    -.0829049    .1848032
   output_gap |   .1610445   .0522351     3.08   0.004     .0557716    .2663173
        _cons |   .9506023   .2639106     3.60   0.001     .4187255    1.482479
-------------------------------------------------------------------------------
```

The results for after the Great Recession follow (US above, Germany below):

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        49
-------------+----------------------------------   F(3, 45)        =    334.71
       Model |  57.4603831         3  19.153461   Prob > F        =    0.0000
    Residual |  2.57504544        45  .057223232   R-squared       =    0.9571
-------------+----------------------------------   Adj R-squared   =    0.9542
       Total |  60.0354286        48  1.2507381   Root MSE        =    .23921

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .6667403   .0355606    18.75   0.000     .5951177     .738363
     infl_dev |    .075365   .0299923     2.51   0.016     .0149575    .1357725
   output_gap |   .1823173   .0291719     6.25   0.000     .1235621    .2410725
        _cons |   .6896341   .0955387     7.22   0.000     .4972092    .8820589
------------------------------------------------------------------------------
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =     95.11
       Model |  15.6432864         3  5.21442879   Prob > F        =    0.0000
    Residual |  2.19292762        40  .054823191   R-squared       =    0.8771
-------------+----------------------------------   Adj R-squared   =    0.8678
       Total |   17.836214        43  .414795674   Root MSE        =    .23414

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .6082164   .0684463     8.89   0.000     .4698812    .7465516
     infl_dev |   .1809059   .0682161     2.65   0.011     .0430361    .3187757
   output_gap |   -.056703   .0403935    -1.40   0.168    -.1383415    .0249354
        _cons |   .1678455    .072776     2.31   0.026     .0207597    .3149314
------------------------------------------------------------------------------
```

Now, the same estimations, but with inflation expectations measures in place of observed inflation. Again, US data are in the upper panel.

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       152
-------------+----------------------------------   F(3, 148)       =   2302.41
       Model |  1124.25953         3  374.753178   Prob > F        =    0.0000
    Residual |  24.0892736       148  .162765362   R-squared       =    0.9790
-------------+----------------------------------   Adj R-squared   =    0.9786
       Total |  1148.34881       151  7.60495898   Root MSE        =    .40344

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .8220329   .0212655    38.66   0.000     .7800097    .8640561
 exp_infl_dev |   .1579307   .0589766     2.68   0.008     .0413857    .2744757
   output_gap |   .2078345   .0279105     7.45   0.000     .1526799     .262989
        _cons |   .6055646   .0846101     7.16   0.000     .4383648    .7727645
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        94
-------------+----------------------------------   F(3, 90)        =    670.88
       Model |  282.751914         3  94.2506381   Prob > F        =    0.0000
    Residual |  12.6439662        90  .140488514   R-squared       =    0.9572
-------------+----------------------------------   Adj R-squared   =    0.9558
       Total |  295.395881        93  3.17629979   Root MSE        =    .37482

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9563294   .0286443    33.39   0.000     .8994224    1.013236
 exp_infl_dev |   .0288249   .1465101     0.20   0.844     -.262243    .3198928
   output_gap |   .0579867   .0223656     2.59   0.011     .0135535    .1024199
        _cons |   .0900843   .1010912     0.89   0.375    -.1107509    .2909196
-------------------------------------------------------------------------------
```

Pre-Great Recession:

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        92
-------------+----------------------------------   F(3, 88)        =    866.33
       Model |  404.810722         3  134.936907   Prob > F        =    0.0000
    Residual |   13.706682        88   .15575775   R-squared       =    0.9672
-------------+----------------------------------   Adj R-squared   =    0.9661
       Total |  418.517404        91  4.59909235   Root MSE        =    .39466

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .7762897   .0350674    22.14   0.000     .7066006    .8459787
 exp_infl_dev |   .1086288   .0720075     1.51   0.135     -.034471    .2517285
   output_gap |   .3030059   .0431297     7.03   0.000     .2172947     .388717
        _cons |   .8949111   .1454114     6.15   0.000     .6059366    1.183886
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    235.51
       Model |  78.9343476         3  26.3114492   Prob > F        =    0.0000
    Residual |  4.91576022        44  .111721823   R-squared       =    0.9414
-------------+----------------------------------   Adj R-squared   =    0.9374
       Total |  83.8501078        47  1.78404485   Root MSE        =    .33425

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .8031995    .058358    13.76   0.000     .6855867    .9208124
 exp_infl_dev |  -.3098849   .2294289    -1.35   0.184    -.7722685    .1524987
   output_gap |   .1843642   .0322332     5.72   0.000     .1194025     .249326
        _cons |   .5040569   .2226229     2.26   0.029     .0553899     .952724
-------------------------------------------------------------------------------
```

And Post-Great Recession:

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        49
-------------+----------------------------------   F(3, 45)        =    299.24
       Model |  57.1697174         3  19.0565725   Prob > F        =    0.0000
    Residual |  2.86571114        45   .06368247   R-squared       =    0.9523
-------------+----------------------------------   Adj R-squared   =    0.9491
       Total |  60.0354286        48   1.2507381   Root MSE        =    .25235

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .6944871   .0361602    19.21   0.000     .6216567    .7673174
 exp_infl_dev |   .1214617   .1153121     1.05   0.298    -.1107887    .3537121
   output_gap |   .1777504   .0340555     5.22   0.000     .1091591    .2463417
        _cons |   .6322984   .1079098     5.86   0.000     .4149569    .8496398
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    110.10
       Model |   7.3880476         3  2.46268253   Prob > F        =    0.0000
    Residual |  .894678621        40  .022366966   R-squared       =    0.8920
-------------+----------------------------------   Adj R-squared   =    0.8839
       Total |  8.28272622        43   .19262154   Root MSE        =    .14956

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .7766196   .0562585    13.80   0.000     .6629169    .8903222
 exp_infl_dev |    .175547     .09846     1.78   0.082     -.023448     .374542
   output_gap |  -.0053977   .0147974    -0.36   0.717    -.0353043     .024509
        _cons |    .062666    .060048     1.04   0.303    -.0586957    .1840276
------------------------------------------------------------------------------
```

4. Discussion and conclusion

4.1 Summary and Interpretation of the main findings

The empirical findings of this study provide a partial validation for the results of De Grauwe's behavioral macroeconomic model, as presented in his "Lectures on Behavioral Macroeconomics" (2012). De Grauwe's model simulations generate non-normal distributions of macroeconomic variables, including the output gap, inflation, and animal spirits.

The empirical analysis available in the previous chapter largely aligns with these results. For instance, the Jarque-Bera test results indicate that the normality assumption cannot be rejected for the distribution of the output gap in the US. Similar results are observed for other countries (all the results are available in Appendix A), with the notable exception of France, where the null hypothesis of normal distributions can be rejected with a 99.9% level of confidence. This also applies to the UK.

However, the situation differs when considering the Consumer Confidence Index (CCI) data. For every country, monthly and quarterly CCI data distributions can be assumed to deviate significantly from a normal distribution. This is different for annual data, where the normality assumption cannot be rejected for any country at a significant confidence level.

In the case of inflation data, the insights of De Grauwe find a solid empirical foundation. For every country analyzed, the normality assumption for the distributions of observed inflation can be rejected with a highly significant level of confidence. The only notable exception is the annual inflation in Greece.

Positive correlations exist between the output gap and the market sentiment index, which is used as a measure of animal spirits. However, the correlation coefficient is lower than that of De Grauwe's model simulations (around 0.85). This suggests that De Grauwe's model may overestimate the importance of the output gap and animal spirits in determining and affecting each other's fluctuations. It should be noted, however, that real-world data is often subject to a significant amount of noise, which could, in turn, affect these correlations.

The correlation between inflation and the Consumer Confidence Index (CCI) and between expected inflation and CCI can be analyzed together. A non-trivial correlation is observed across all countries under study, even considering different frequencies for the macroeconomic variables under analysis. However, weaker correlations are noted for Italy and Greece.

A striking feature of the relationship between inflation (both actual and expected) and the market sentiment index is the variation in the sign of the correlations across different countries. This variation underscores the fact that empirical analyses and findings can differ significantly across different economic contexts. It also raises questions about the validity of this part of the theoretical framework provided by De Grauwe, who did not specify whether the correlation between inflation and animal spirits should be positive or negative.

De Grauwe's analysis of this relationship in his model simulations primarily addresses the issue of Central Bank credibility. In this context, animal spirits are examined as the proportion of agents using extrapolative rules, regardless of whether they form positive or negative expectations about inflation deviation from its target.

Our analysis in Chapter 3 reveals that periods of sudden optimism or pessimism (such as those observed in the US during the 1970s and 1980s) are typically correlated with higher deviations in inflation, assuming a Central Bank inflation target of around 2%. However, this correlation appears weak when considering the impact of the sudden change in CCI during the Great Recession across different countries. Despite significant movements in CCI, inflation and inflation expectations did not change abruptly and remained relatively close to the target.

This observation leads us to hypothesize that inflation may be a determinant of CCI (or animal spirits), but the reverse causality claim may not hold. This hypothesis should be further tested during the 2020 crisis when inflation and inflation expectations underwent significant changes. However, more data is needed to comprehensively understand the situation and further validate the proposed causality link hypothesis.

The short-term interest rate movements and the CCI exhibit a strong correlation, with a few notable exceptions, such as the quarterly data for the UK. It is also worth noting that the correlation coefficient for Germany is negative.

A strong correlation is observed for US data when examining the correlation between the interest rate and output gap fluctuations. However, the correlation coefficient is smaller in magnitude for other countries. As for the relationship between the short-term interest rate and inflation expectations, robust correlation coefficients are found for the US and EU countries. The correlation for Japan's interest rate data is significantly weak, likely due to the relatively short timespan for which data are present.

Analyzing the relationship between the interest rate and the macroeconomic variables under consideration provides valuable insights into the conduct of monetary policy across different countries and over time. For instance, the strong relationship with inflation expectations suggests that a movement in either the interest rate or expected inflation significantly affects the other variable. Historical episodes, such as the Volcker deflation in the US at the end of the 1970s, demonstrate that monetary policy can substantially impact the economy. Following a high and sustained inflation period, a rise in interest rates led to deflation.

It is intriguing to consider whether a change in the interest rate can influence the economy through its impact on animal spirits. However, it is challenging to make a definitive statement on this matter. While solid correlations are observed in all countries, Germany's negative relationship is a significant exception. Furthermore, it's evident from the graphs that the CCI often fluctuates independently of the interest rate, particularly after the Great Recession.

One of the more compelling insights from De Grauwe's work relates to the timing of monetary policy. However, it is difficult to substantiate this from the fluctuations of the macroeconomic variables. In the aftermath of the significant recession caused by the COVID-19 crisis, it would be of particular interest to conduct the same analysis. This would help us understand whether market confidence prior to a "shock" can provide any indication of the depth of the ensuing crisis or the recovery time from it.

In the second part of the empirical analysis, the validity of the model provided by the Taylor Rule is confirmed, as evidenced by the satisfaction of the F-Test on each occasion. However, the estimated parameters are not always significant, particularly those related to the deviation of inflation from its target and expected inflation deviations. It is noteworthy that only in the estimation of the post-Great Recession Taylor Rule for Germany the output gap coefficient is not significant.

For the purposes of this study, the estimations do not yield parameter magnitudes that closely align with those presented by De Grauwe. Nevertheless, the significance of the output coefficient in most estimations confirms a certain degree of output stabilization. To better understand the magnitude of these coefficients, further estimations considering different model specifications may be necessary. Also, the OLS assumptions, here taken as given, should be tested to avoid structural issues.

It is unclear whether there was a change in the conduct of monetary policy following the Great Recession. More data are needed to understand the behavior of central banks better. Additionally, it would be insightful to determine how the coefficients of inflation and output deviations changed in the aftermath of the COVID-19 crisis.

In conclusion, the empirical findings of this study provide a nuanced view of the behavioral macroeconomic model proposed by De Grauwe. While the model's predictions are partially validated, particularly in the case of inflation data, the empirical distributions of other macroeconomic variables, such as the output gap and CCI data, do not always align with the model's predictions. While existent, the correlations between these variables and market sentiment indices are not as strong as the model suggests. This discrepancy may be due to the inherent noise in real-world data and the varying economic contexts across different countries. Furthermore, the relationship between short-term interest rates and these variables provides interesting insights into the conduct of monetary policy. However, the impact of interest rate changes on the economy through animal spirits is unclear. The Taylor Rule model has been validated in this context, but further research is needed to fully understand the behavior of central banks, especially in the aftermath of significant economic events such as the Great Recession and the COVID-19 crisis.

4.2 Limitations and Suggestions for Future Research

While this work has tried to validate De Grauwe's behavioral macroeconomic model empirically, it is essential to acknowledge its limitations and identify possibilities for future research.

One of the main limitations of the study lies in the simplicity of De Grauwe's model itself. The model's emphasis on the behavioral aspect, particularly the role of the output gap and animal spirits in determining macroeconomic fluctuations, appears to be overestimated when confronted with real-world data. The empirical findings suggest that the correlation between these variables and market sentiment indices while existing, is not as strong as the model suggests. This could be due to the inherent noise in real-world data and the varying economic contexts across different countries.

The possibility of developing a model where agents employ a variety of heuristics rather than relying on a single forecasting rule presents an intriguing avenue for future research. In such a model, agents could choose to adhere to a specific forecasting rule indefinitely, particularly if they have previously experienced significant forecasting errors using a different rule. This approach would introduce a new layer of complexity to the model, allowing for the possibility that agents, while capable of forgetting past errors, may not forget everything. This “selective memory” could significantly influence their future decision-making processes and forecasting behaviors. This approach could potentially offer a more realistic representation of economic dynamics and provide more accurate predictions of economic fluctuations.

In terms of empirical work, the study was limited by the data available, particularly in the aftermath of significant economic events such as the COVID-19 crisis. More data, especially from this period, would provide valuable insights and allow for a more thorough investigation of the impact of such events and the recovery process.

The limitations identified in this work, both in the theoretical model and the empirical analysis, underscore the complexity of economic behavior and the challenges of accurately modeling and predicting it. Future research should possibly aim to develop more complex models that incorporate a wider range of heuristics and to conduct more comprehensive empirical analyses using extensive and diverse datasets.

4.3 Conclusion

This work tried to empirically validate De Grauwe's behavioral macroeconomic model. This theoretical framework diverges from traditional macroeconomic models by incorporating elements of bounded rationality and the concept of "animal spirits." The model's unique approach to understanding the non-normal distributions of macroeconomic variables and their implications for monetary policy led this study.

The distributions of key macroeconomic variables were found to deviate from normality in several instances, confirming De Grauwe's theoretical findings. However, the normality assumption could not be rejected universally, indicating that the model's predictions may not hold consistently across different economic contexts. Furthermore, the study revealed a positive correlation between the output gap and the market sentiment index, a proxy for "animal spirits." This supported the significant role of animal spirits in driving economic fluctuations. However, the correlation was weaker than the model's simulations suggested, indicating that the model might overestimate the influence of these variables in determining economic fluctuations.

The findings make the reader understand the inherent challenges in applying theoretical models to real-world data. Even a model like De Grauwe's, which is grounded in behavioral economics and is relatively simpler than mainstream models, encounters difficulties when confronted with the complexities of real-world economic data. The economic context of each country, shaped by its unique policy environment, institutional structures, and historical experiences, can significantly influence the behavior of macroeconomic variables, complicating the task of empirical validation.

Despite these challenges, this work confirms the value of De Grauwe's behavioral macroeconomic model as a theoretical tool for understanding economic fluctuations. While the model may not perfectly predict the behavior of real-world macroeconomic variables, it provides a valuable framework for conceptualizing the role of animal spirits and bounded rationality in economic dynamics. The model's emphasis on non-normal distributions of macroeconomic variables offers a compelling alternative to mainstream macroeconomic models, which often too hastily assume normally distributed variables and fully rational agents.

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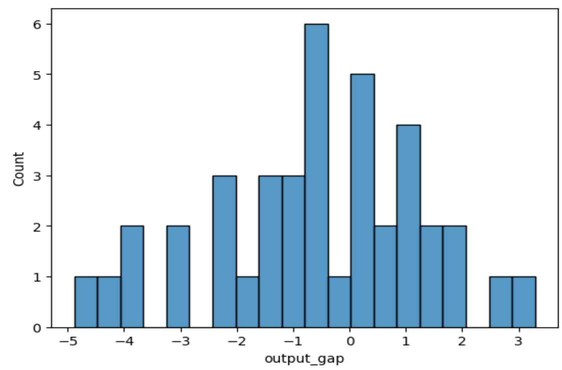
Appendix A – Results of the Empirical Analysis

United States:



Period: 1985 : 2024
Observations: 40
Mean: -0.5848054885309623
Median: -0.528322093576167
Max: 3.28945657931188
Min: -4.88412437161886
Standard Deviation: 1.885196220482
Skewness: -0.26280969536377996
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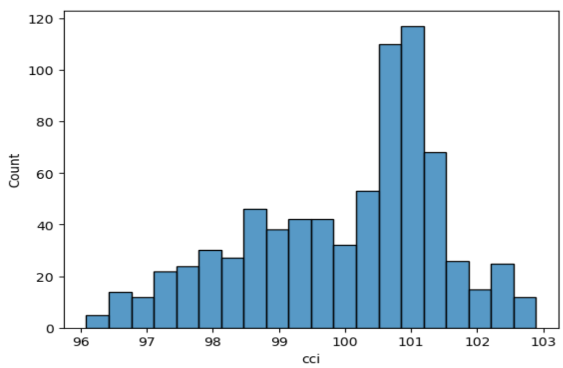

Period: 1960: 2023
Observations: 760
Mean: 99.99999948684196
Median: 100.49019999999999
Max: 102.89
Min: 96.08473
Standard Deviation: 1.487134081074
Skewness: -0.5386067647822662
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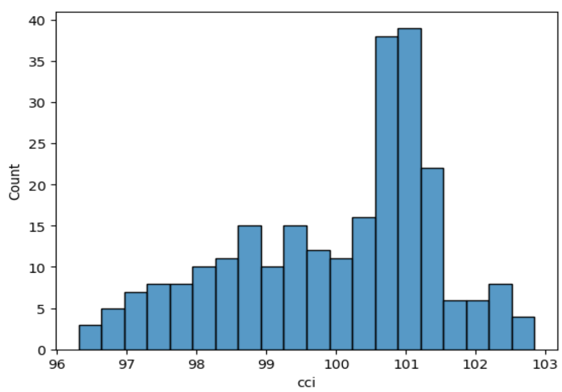
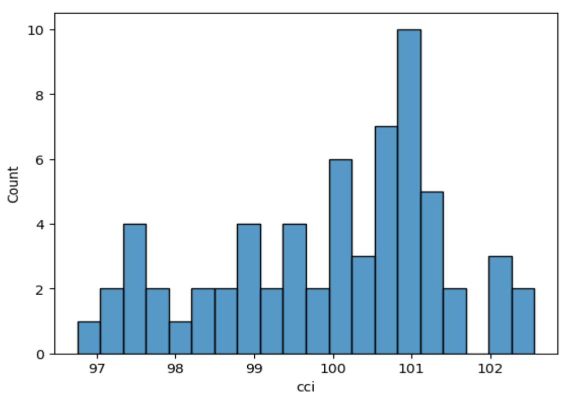


Period: 1960Q1 : 2023Q2
Observations: 254
Mean: 99.99282329396321
Median: 100.5233
Max: 102.84463333333333
Min: 96.30723333333333
Standard Deviation: 1.483743768850
Skewness: -0.5295755251587305
Kurtosis: -0.5294717434637022
Jarque_beraResult(
statistic=14.84865337063391,
pvalue=0.0005965624157220351)



Period: 1960 : 2023
Observations: 64
Mean: 99.97208365885417
Median: 100.26752041666666
Max: 102.56290833333333
Min: 96.7535975
Standard Deviation: 1.446004283
Skewness: -0.46745058923820165
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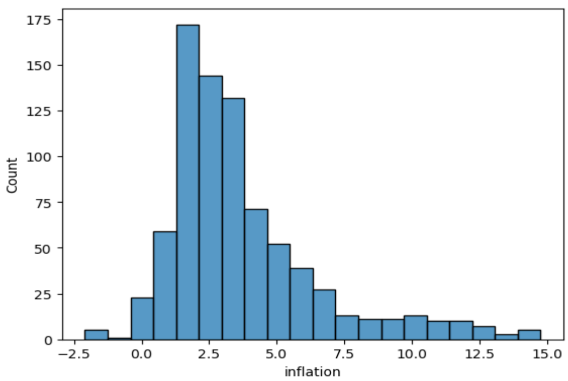

Period: 1956 : 2023
Observations: 808
Mean: 3.6799915987500014
Median: 2.9566195000000004
Max: 14.75645
Min: -2.097161
Standard Deviation: 2.79999824838
Skewness: 1.5504202510864007
Kurtosis: 2.551047434137337
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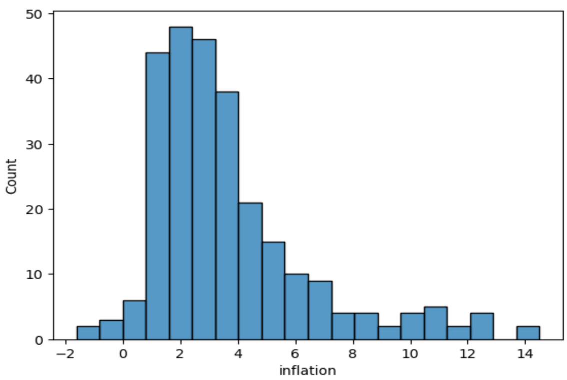

Period: 1956Q1 : 2023Q1
Observations: 269
Mean: 3.6780621439776953
Median: 2.991773
Max: 14.5056
Min: -1.62336
Standard Deviation: 2.789780040628
Skewness: 1.575808585397751
Kurtosis: 2.6309707614896083
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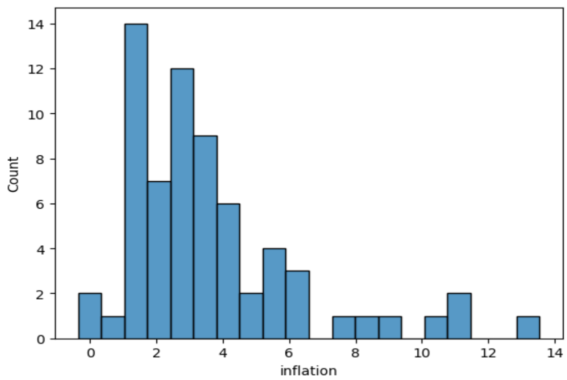

Period: 1956 : 2022
Observations: 67
Mean: 3.668527161194029
Median: 2.951657
Max: 13.5492
Min: -0.3555463
Standard Deviation: 2.735816637093
Skewness: 1.6510517797552862
Kurtosis: 2.9015515353760666
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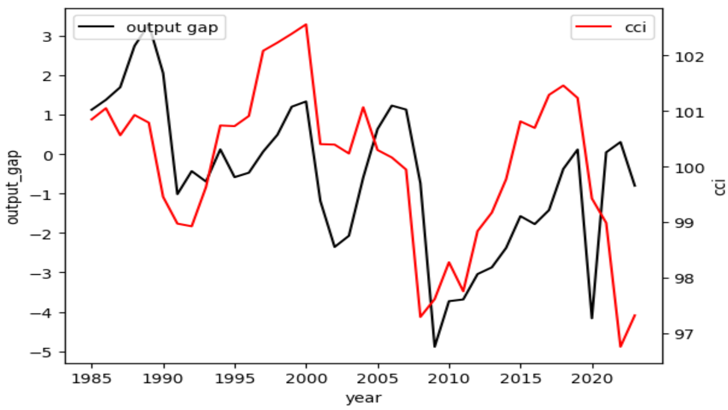

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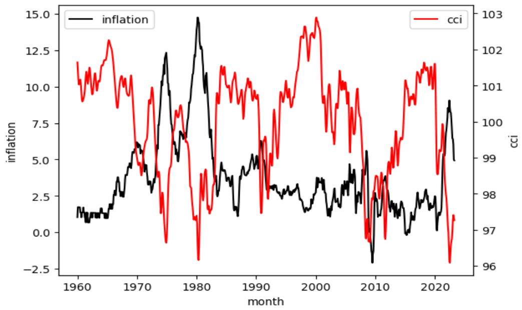

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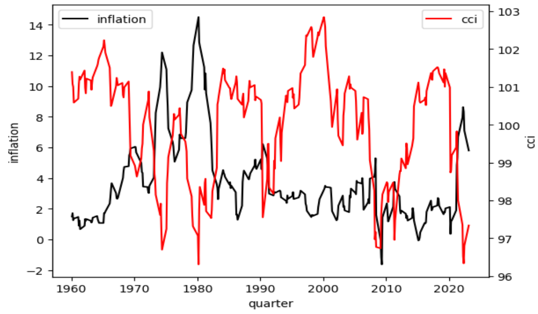

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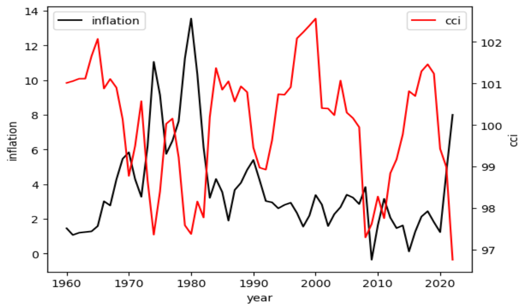

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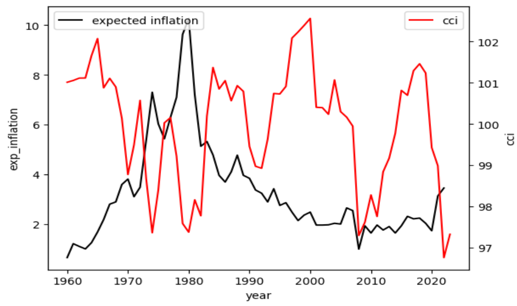

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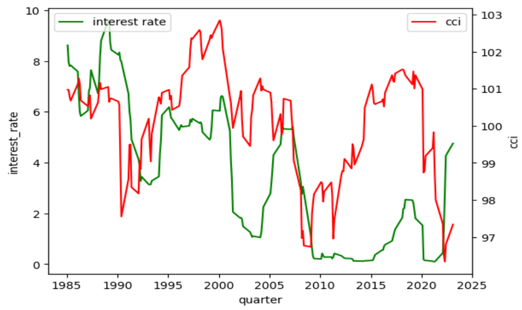

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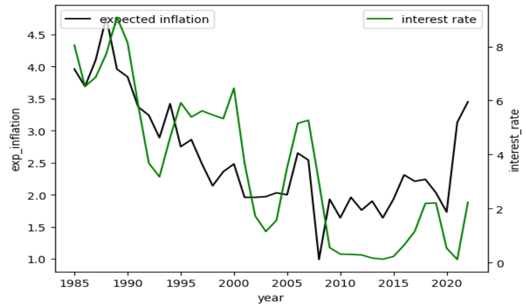

corr: 0.732819964585463

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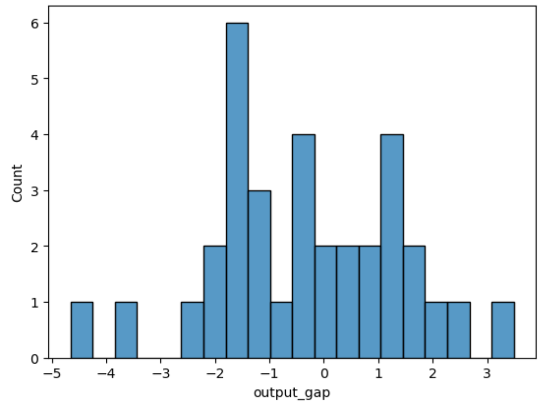


```
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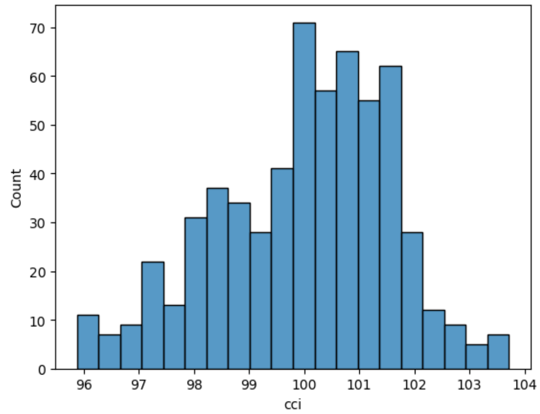
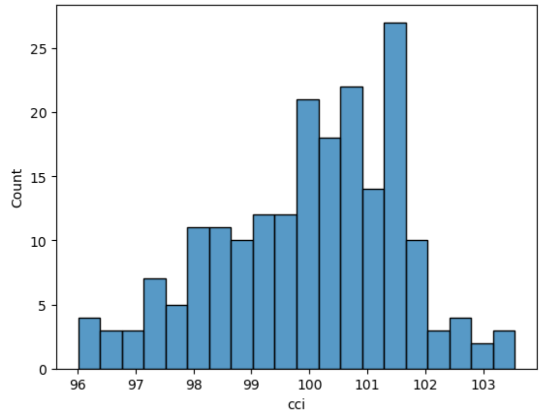
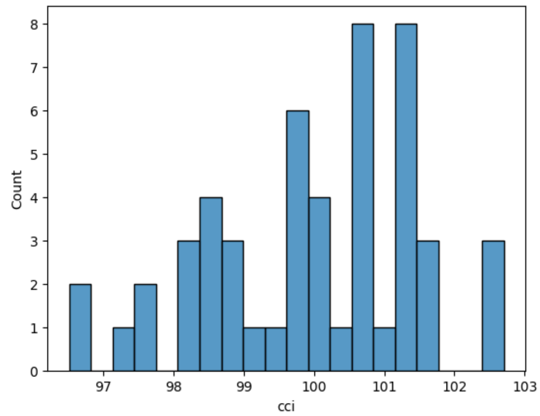
Median: -0.3332641621099365
Max: 3.48937708760628
Min: -4.65642185040223
Standard Deviation: 1.795541788062
Skewness: -0.11849649288708826
Kurtosis: -0.037320655757196786
Jarque_beraResult(
statistic=0.13127541292308398,
pvalue=0.9364700798990038)
```



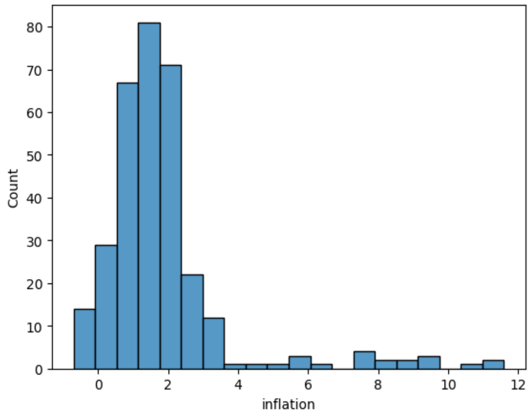

```
Period: 1973 : 2023
Observations: 604
Mean: 100.0000008278146
Median: 100.18825
Max: 103.7203
Min: 95.8793
Standard Deviation: 1.581599730566
Skewness: -0.39205690787477226
Kurtosis: -0.25828740770760916
Jarque_beraResult(
statistic=17.17817354334823,
pvalue=0.00018612598558775 95)
```



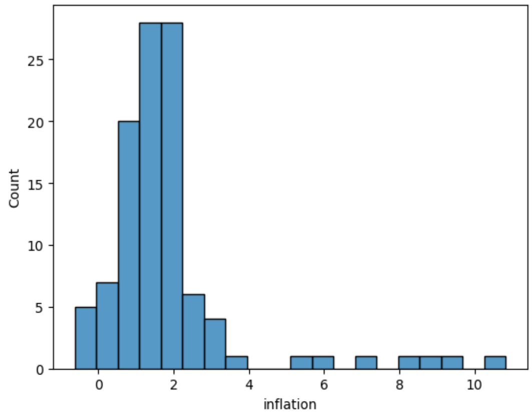

```
Period: 1973Q1 : 2023Q2
Observations: 202
Mean: 99.99650762376245
Median: 100.17157
Max: 103.54506666666667
Min: 96.01001333333333
Standard Deviation: 1.572358082944
Skewness: -0.385355894051372
Kurtosis: -0.27259373861143743
Jarque_beraResult(statistic=5.6600
40292408981,
pvalue=0.05901166479640596)
```



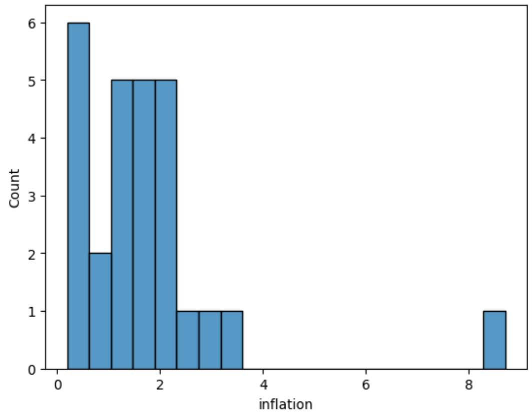

```
Period: 1973 : 2023
Observations: 51
Mean: 99.978986372549
Median: 100.11982833333333
Max: 102.70249166666667
Min: 96.51100416666667
Standard Deviation: 1.495438942527
Skewness: -0.364861111652172
Kurtosis: -0.380129906866955
Jarque_beraResult(
statistic=1.513629403740023,
pvalue=0.46915845902719144)
```



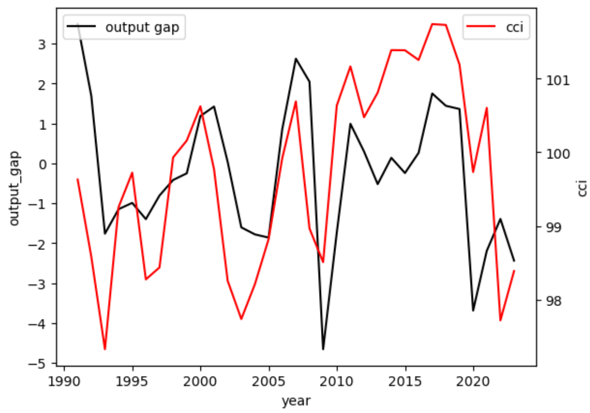

```
Period: 1997 : 2023
Observations: 317
Mean: 1.8536277602523663
Median: 1.5
Max: 11.6
Min: -0.7
Standard Deviation: 1.859791338571
Skewness: 2.8838981649433615
Kurtosis: 9.90594659352549
Jarque_beraResult(
statistic=1686.116288820403,
pvalue=0.0)
```



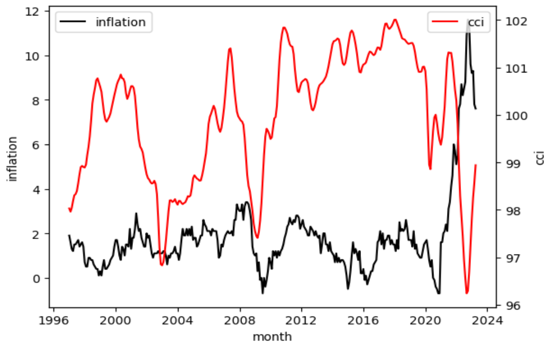

```
Period: 1997Q1 : 2023Q2
Observations: 106
Mean: 1.8696540880503139
Median: 1.5666666666666667
Max: 10.833333333333334
Min: -0.6333333333333333
Standard Deviation: 1.860336200442
Skewness: 2.8504851035191097
Kurtosis: 9.469958140076487
Jarque_beraResult(
statistic=495.1071240459648,
pvalue=0.0)
```



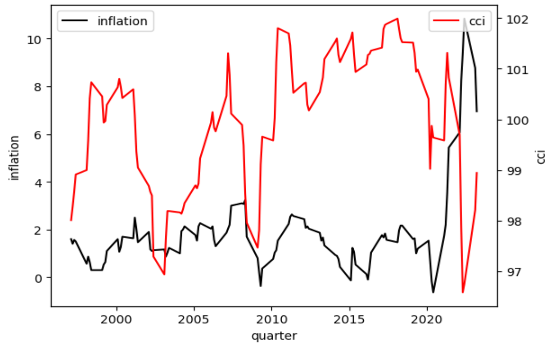

```
Period: 1996 : 2022
Observations: 27
Mean: 1.7185185185185188
Median: 1.5
Max: 8.7
Min: 0.2
Standard Deviation: 1.593505337066
Skewness: 3.3965914078340314
Kurtosis: 14.662867001774853
Jarque_beraResult(
statistic=204.7435139832068,
pvalue=0.0)
```



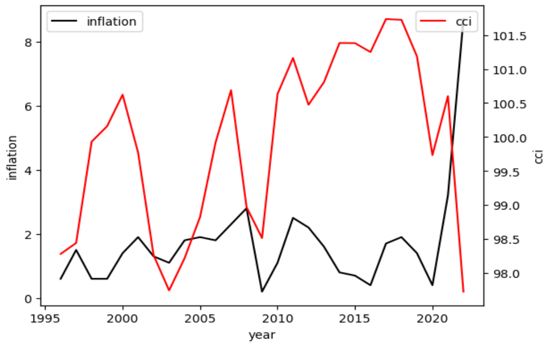

```
corr: 0.44211520237026114
```



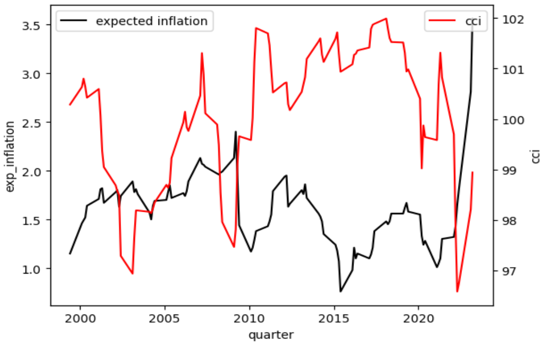
corr: -0.30251239071005553



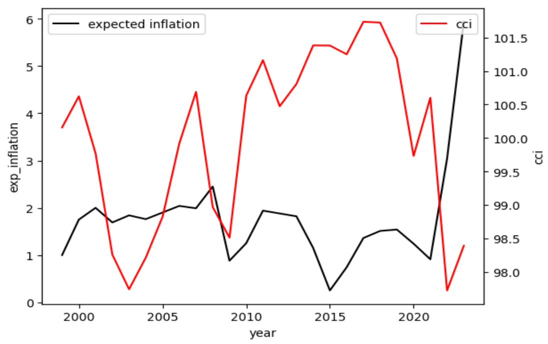
corr: -0.3091354796648426



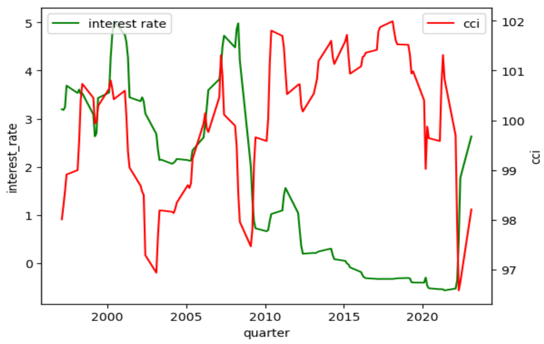
corr: -0.2469895743570168



corr: -0.43879300380265285

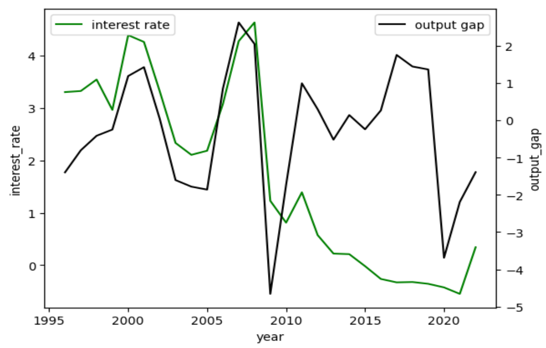


corr: -0.466939170781212

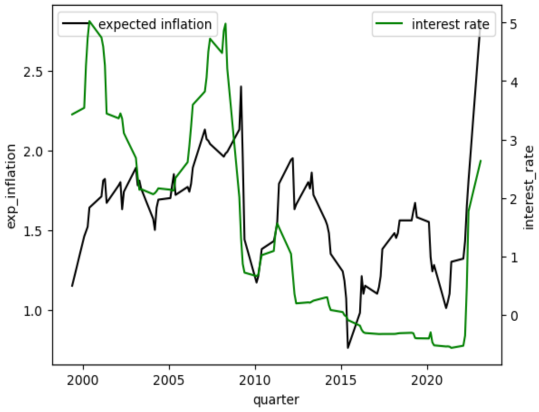


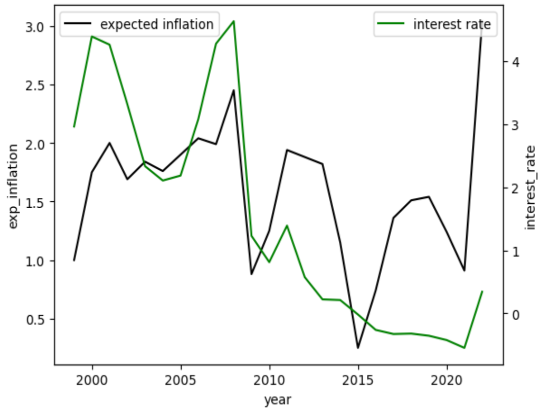
corr: -0.40690058784303423

corr: -0.4535084858946735



corr: 0.2819615466655948

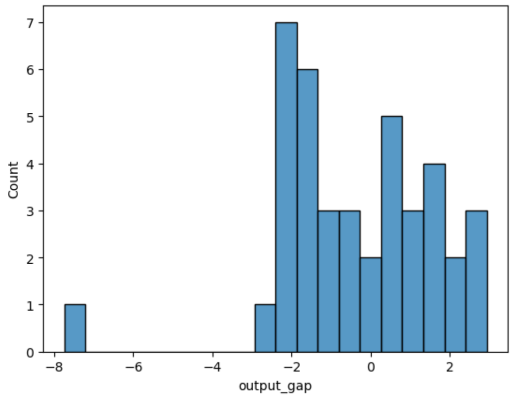




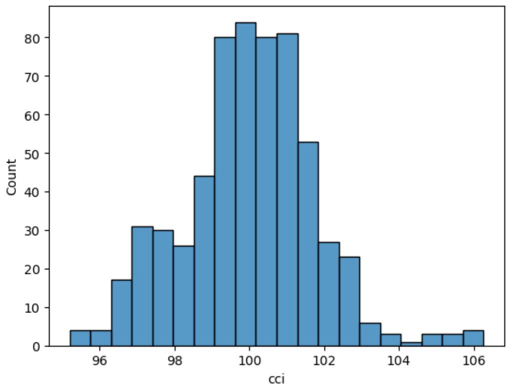

```
corr: 0.5823922831611823
```

```
corr: 0.44884012539410645
```

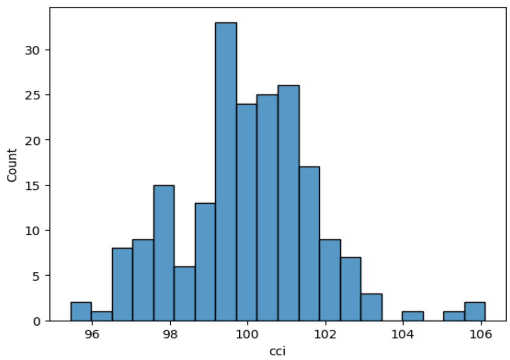
France:



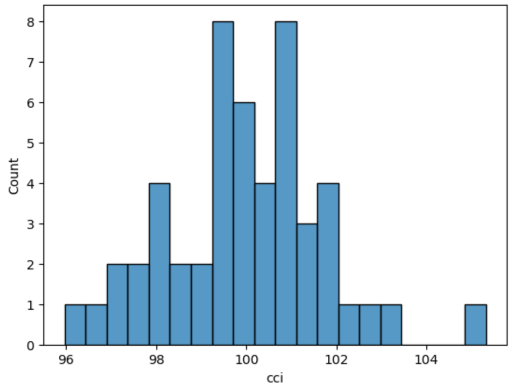

```
Period: 1985 : 2024
Observations: 40
Mean: -0.3626604366804167
Median: -0.5059695810644524
Max: 2.92743628715266
Min: -7.74656038455748
Standard Deviation: 2.01660012817
Skewness: -0.9882638266485979
Kurtosis: 3.1436756635944056
Jarque_beraResult(
statistic=17. 449200670462975,
pvalue=0.000162537740288
```



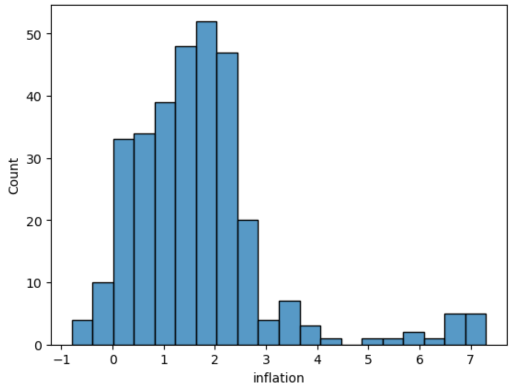

```
Period: 1973 : 2023
Observations: 604
Mean: 99.99999956953639
Median: 100.05075
Max: 106.2664
Min: 95.19255
Standard Deviation: 1.762564273193
Skewness: 0.1685177569704577
Kurtosis: 0.7833963452381076
Jarque_beraResult(
statistic=17.650182427034345,
pvalue=0.00014699805339013494)
```



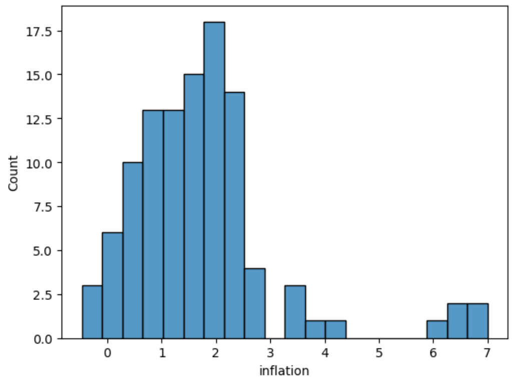

```
Period: 1973Q1 : 2023Q2
Observations: 202
Mean: 99.99014363036312
Median: 99.99838
Max: 106.11740000000002
Min: 95.44135
Standard Deviation: 1.759039058322
Skewness: 0.17728975222327936
Kurtosis: 0.820546092207013
Jarque_beraResult(
statistic=6.04337441187709,
pvalue=0.04871895007786897)
```



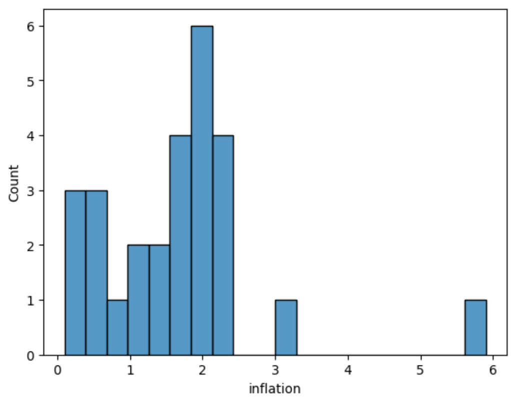

```
Period: 1973 : 2023
Observations: 51
Mean: 99.95815300653597
Median: 100.04343
Max: 105.31543333333333
Min: 95.96296666666666
Standard Deviation: 1.715519150098
Skewness: 0.21546599448898127
Kurtosis: 1.0122242079741457
Jarque_beraResult(
statistic=1.732542205502376 7,
pvalue=0.4205166928432704)
```



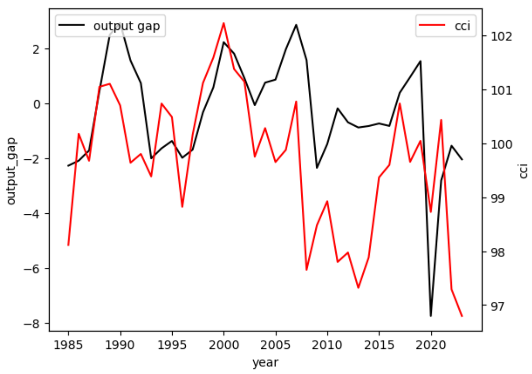

```
Period: 1997 : 2023
Observations: 317
Mean: 1.7176656151419554
Median: 1.6
Max: 7.3
Min: -0.8
Standard Deviation: 1.387809804112
Skewness: 1.8485737410068757
Kurtosis: 4.888703868783274
Jarque_beraResult(
statistic=482.27807985555035,
pvalue=0.0)
```



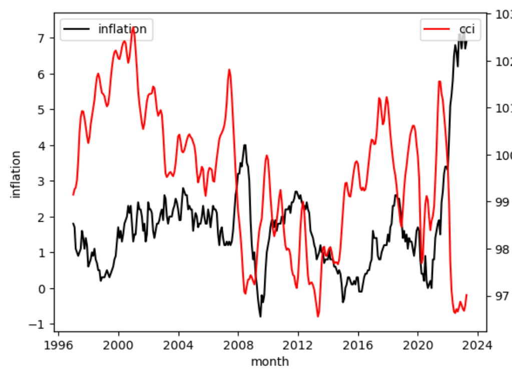

```
Period: 1997Q1 : 2023Q2
Observations: 106
Mean: 1.7325471698113208
Median: 1.5333333333333332
Max: 7.0
Min: -0.46666666666666673
Standard Deviation: 1.398404953187
Skewness: 1.8965615555813624
Kurtosis: 4.998597986202583
Jarque_beraResult(
statistic=159.72613411608444,
pvalue=0.0)
```



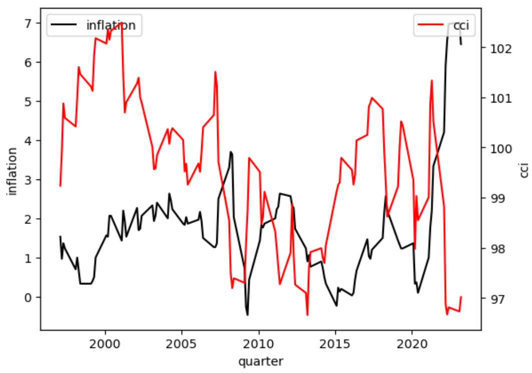

```
Period: 1996 : 2022
Observations: 27
Mean: 1.6555555555555557
Median: 1.8
Max: 5.9
Min: 0.1
Standard Deviation: 1.155033577046
Skewness: 1.780954688109498
Kurtosis: 6.186261696697772
Jarque_beraResult(
statistic=39.545763244277,
pvalue=2.586703296003634e-09)
```



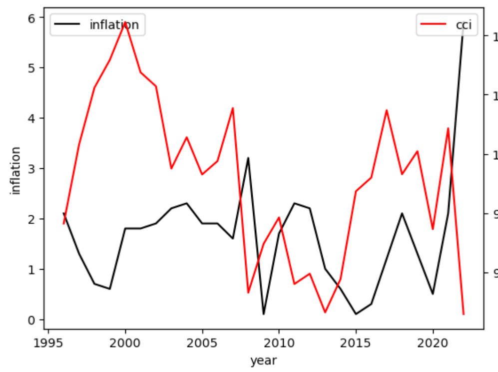
corr: 0.434506314497801



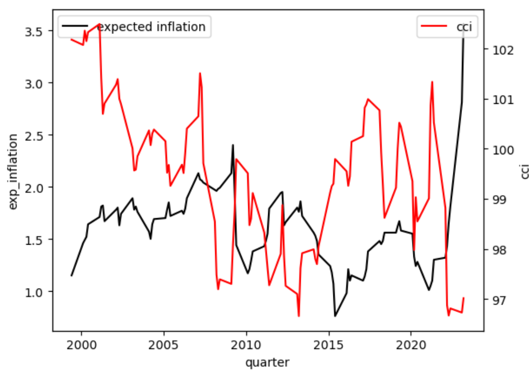
corr: -0.3219216896498525



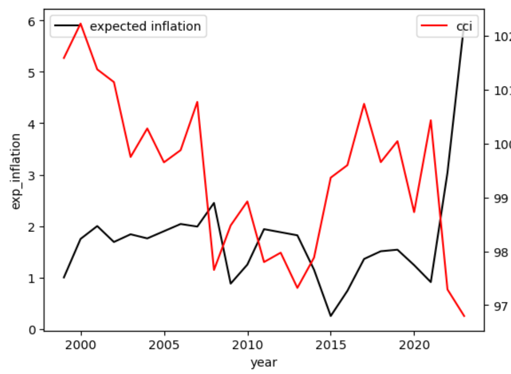
corr: -0.3442536434343438



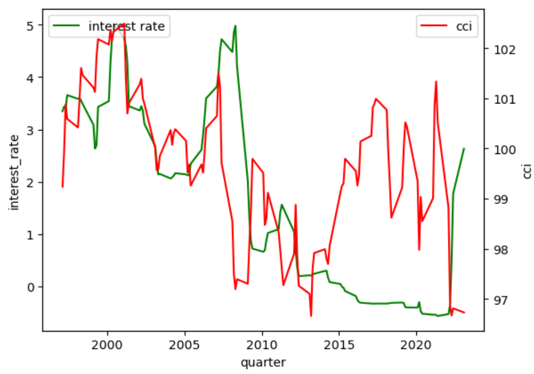
corr: -0.27258186943194657



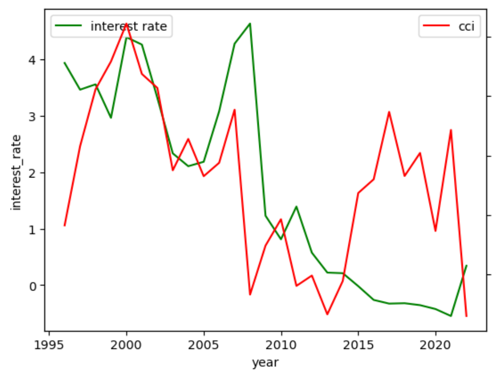
corr: -0.25806007178827733



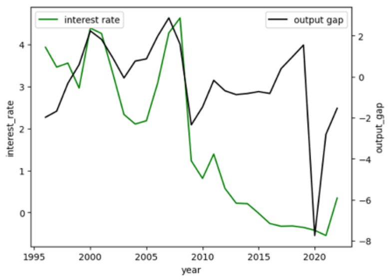
corr: -0.4169409243573116



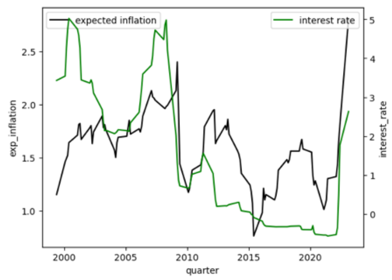
corr: 0.3890377719517636



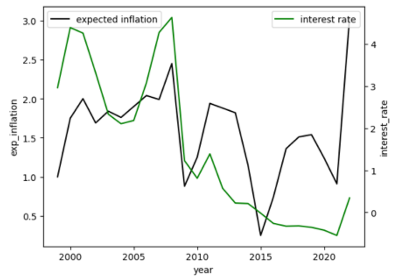
corr: 0.40822933103036446



corr: 0.48883180694379375

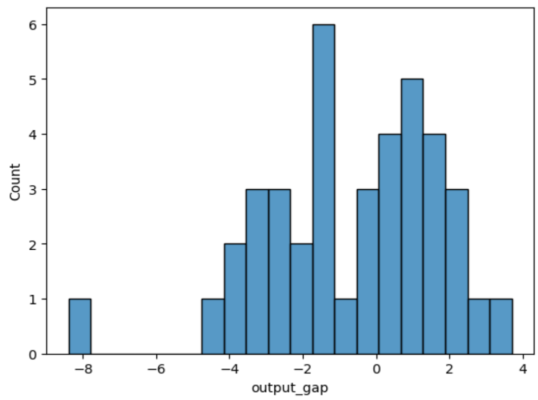


corr: 0.5823922831611823

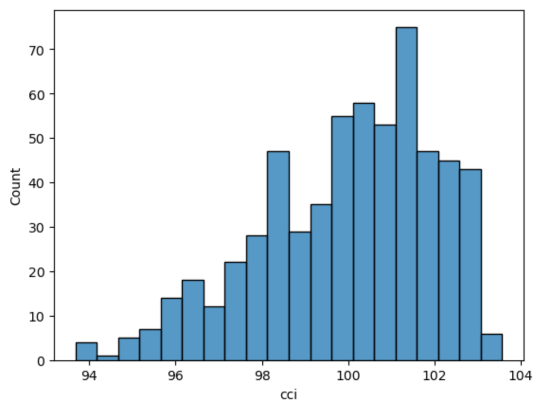


corr: 0.44884012539410645

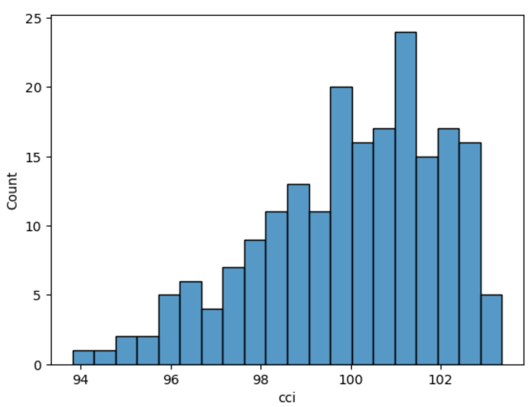
Italy:



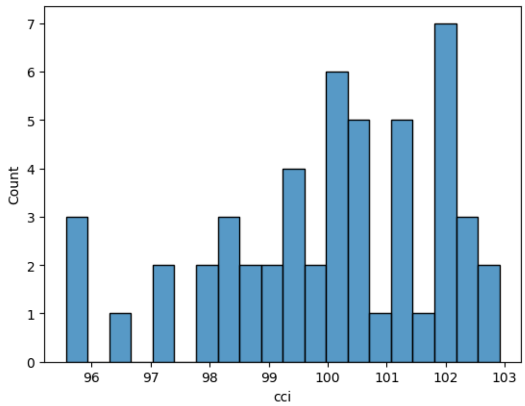
Period: 1985 : 2024
Observations: 40
Mean: -0.7052387933469797
Median: -0.4893354860992015
Max: 3.69917837114431
Min: -8.39211734611194
Standard Deviation: 2.438417733400
Skewness: -0.7179603561760093
Kurtosis: 1.0143355247377435
Jarque_beraResult(
statistic=4.1073575733073815,
pvalue=0.12826218539044532)



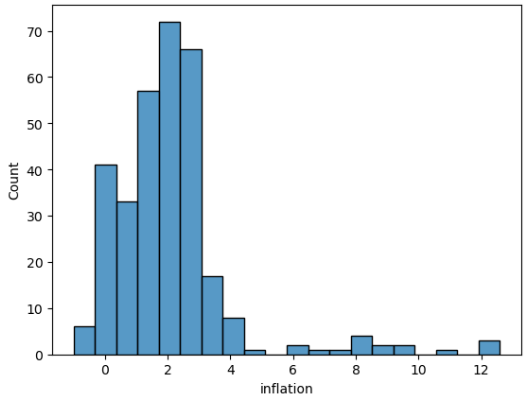
Period: 1973 : 2023
Observations: 604
Mean: 100.00000057947027
Median: 100.37165
Max: 103.5685
Min: 93.68179
Standard Deviation: 2.018342901629
Skewness: -0.644337496216801
Kurtosis: -0.15658978059125017
Jarque_beraResult(
statistic=42.273330581040504,
pvalue=6.613980474412529e-10)



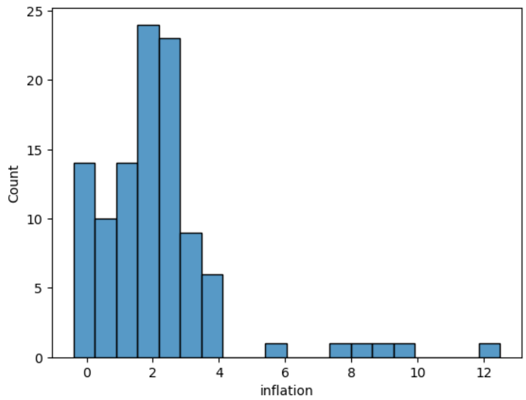
Period: 1973Q1 : 2023Q2
Observations: 202
Mean: 100.00001608910893
Median: 100.33849999999998
Max: 103.36053333333332
Min: 93.81393333333334
Standard Deviation: 2.006297534267
Skewness: -0.6527188521772554
Kurtosis: -0.12996096423740422
Jarque_beraResult(
statistic=14.336419963600083,
pvalue=0.0007707010661719416)



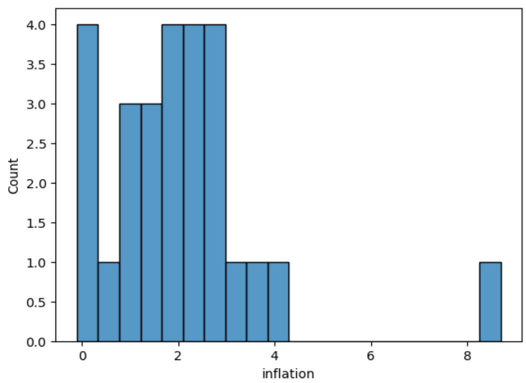
Period: 1973 : 2023
Observations: 51
Mean: 99.9966137745098
Median: 100.30048666666666
Max: 102.909675
Min: 95.56572833333333
Standard Deviation: 1.925387417945
Skewness: -0.6614621164409756
Kurtosis: -0.1727167383998096
Jarque_beraResult(
statistic=3.658500408487683,
pvalue=0.16053389029053944)



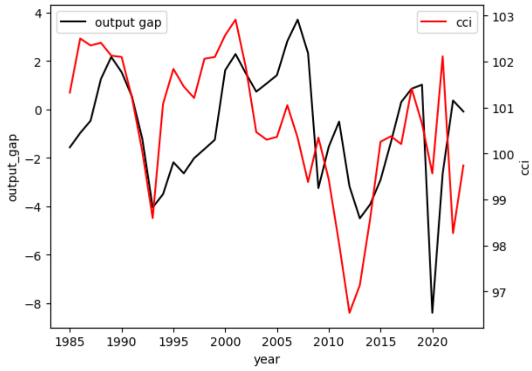
Period: 1997 : 2023
Observations: 317
Mean: 2.113249211356467
Median: 2.0
Max: 12.6
Min: -1.0
Standard Deviation: 1.989214870652
Skewness: 2.558954428253487
Kurtosis: 9.35009523901467
Jarque_beraResult(
statistic=1456.8601524813519,
pvalue=0.0)



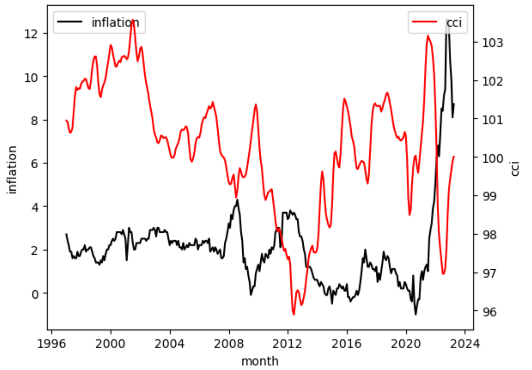
Period: 1997Q1 : 2023Q2
Observations: 106
Mean: 2.133018867924528
Median: 2.0166666666666666
Max: 12.5
Min: -0.39999999999999997
Standard Deviation: 2.006357595156
Skewness: 2.5506725715887915
Kurtosis: 9.17770500607631
Jarque_beraResult(
statistic=445.56269227344853,
pvalue=0.0)



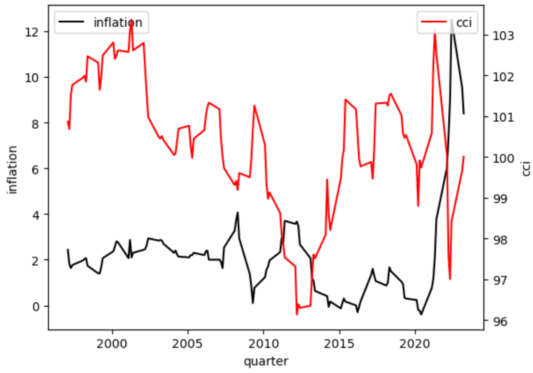
Period: 1996 : 2022
Observations: 27
Mean: 2.0555555555555554
Median: 1.9
Max: 8.7
Min: -0.1
Standard Deviation: 1.713820144350
Skewness: 2.196350746127785
Kurtosis: 8.131565520861336
Jarque_beraResult(
statistic=66.67615072492514,
pvalue=3.3306690738754696e-15)



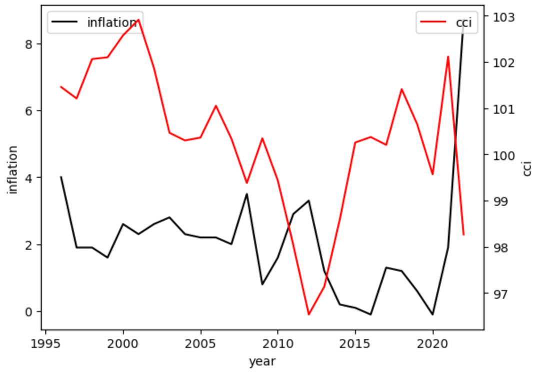
corr: 0.37831535453832926



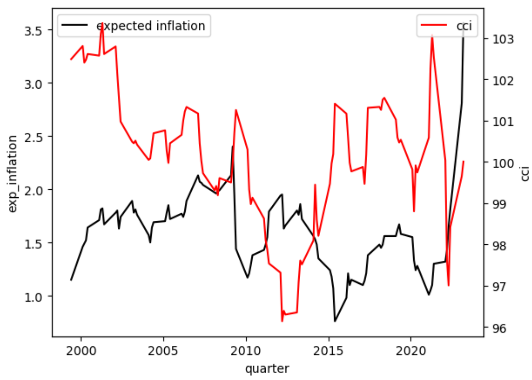
corr: -0.1909330537882259



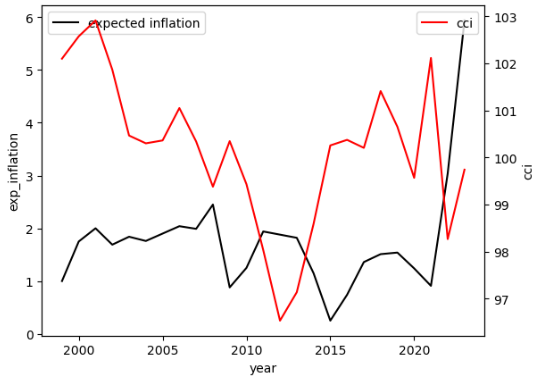
corr: -0.18711563873730536



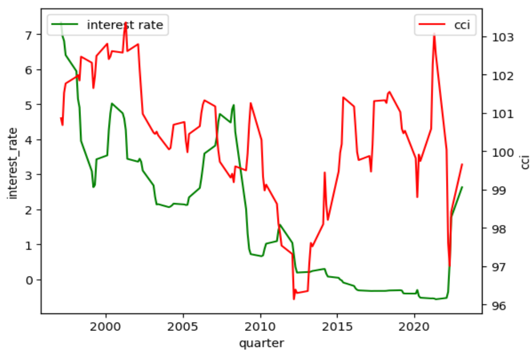
corr: -0.1597905315202495



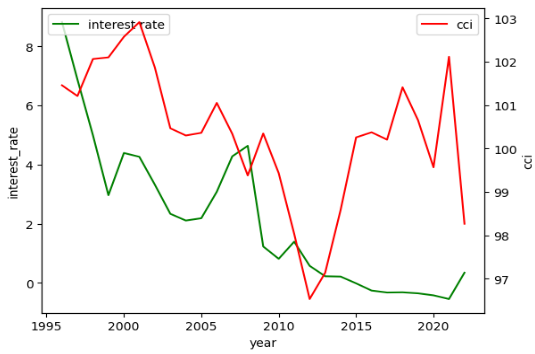
corr: -0.12686442680815718



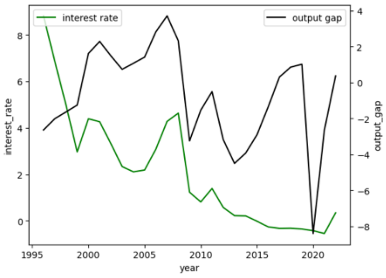
corr: -0.18178981687116888



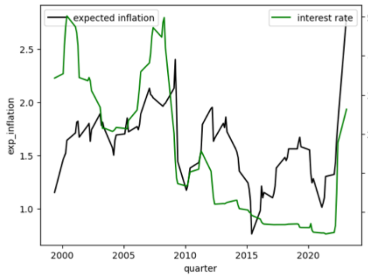
corr: 0.3983319827969095



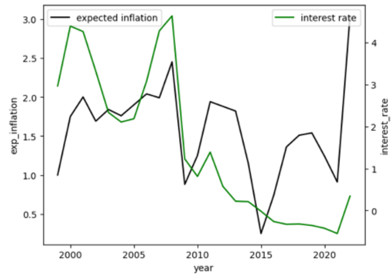
corr: 0.4380241403719528



corr: 0.29949130801623897

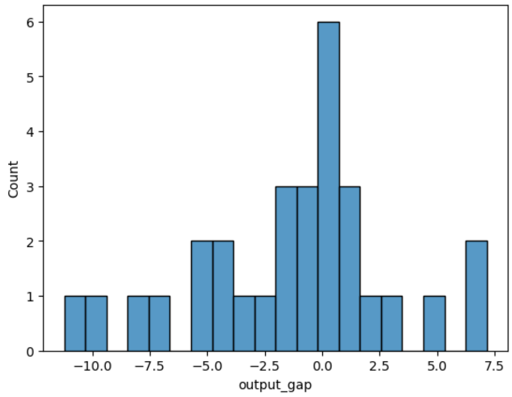


corr: 0.5823922831611823

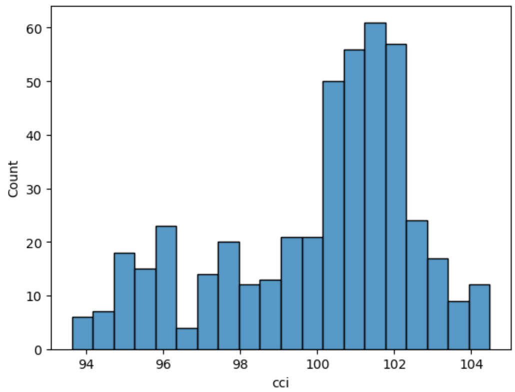


corr: 0.4488401253941065

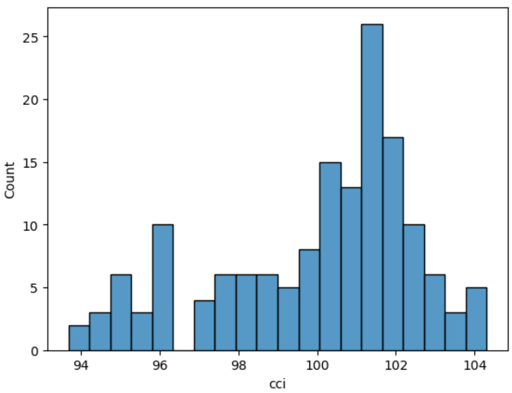
Greece:



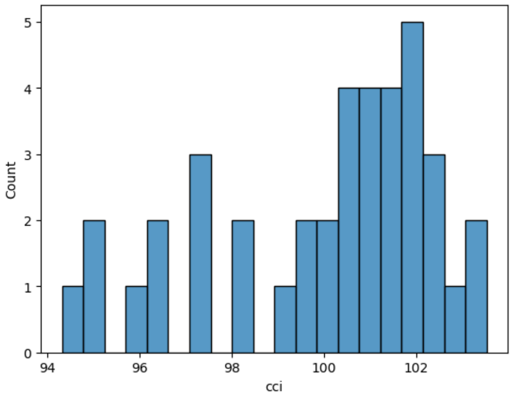
Period: 1995 : 2024
Observations: 30
Mean: -1.254824210970766
Median: -0.4148225375620925
Max: 7.16178248285473
Min: -11.2158352999479
Standard Deviation: 4.287597968626
Skewness: -0.3859216207950702
Kurtosis: 0.33919634717913194
Jarque_beraResult(
statistic=0.68157530725112,
pvalue=0.7112099150198878)



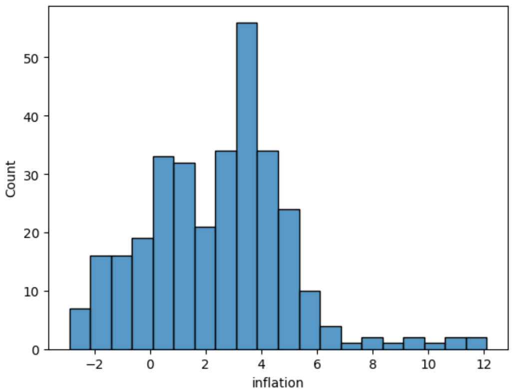
Period: 1985 : 2023
Observations: 460
Mean: 99.9999997826087
Median: 100.74585
Max: 104.4815
Min: 93.6215
Standard Deviation: 2.557578717465
Skewness: -0.748077363168076
Kurtosis: -0.34506430944997435
Jarque_beraResult(
statistic=45.03108212491653,
pvalue=1.665807491946225e-10)



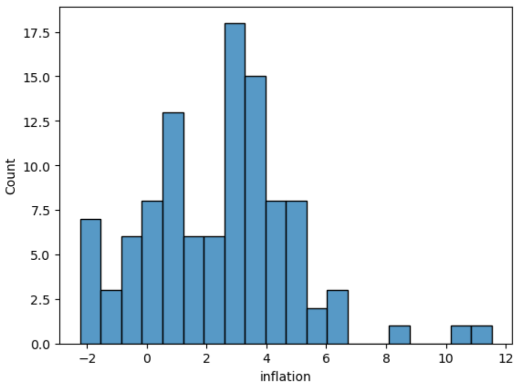
Period: 1985Q1 : 2023Q2
Observations: 154
Mean: 99.99336770562763
Median: 100.71311666666665
Max: 104.31139999999999
Min: 93.68356999999999
Standard Deviation: 2.550227533672
Skewness: -0.753723864354521
Kurtosis: -0.3314961544694568
Jarque_beraResult(
statistic=15.127271552965746,
pvalue=0.000518984896445529)



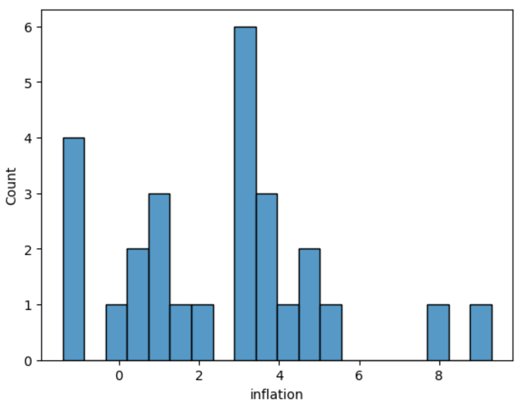
Period: 1985 : 2023
Observations: 39
Mean: 99.97263914529915
Median: 100.74049000000001
Max: 103.524825
Min: 94.3237125
Standard Deviation: 2.484190039889
Skewness: -0.8079588889375147
Kurtosis: -0.2870258684995517
Jarque_beraResult(
statistic=4.181635215849104,
pvalue=0.12358604956513697)



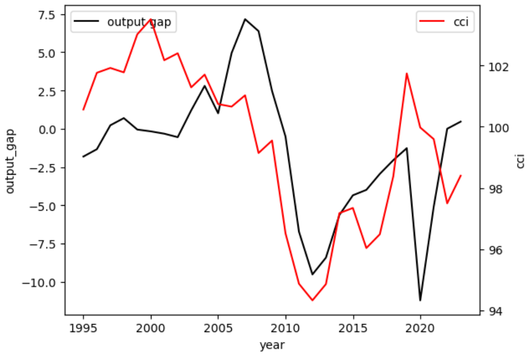
Period: 1997 : 2023
Observations: 317
Mean: 2.395899053627762
Median: 2.8
Max: 12.1
Min: -2.9
Standard Deviation: 2.558656607548
Skewness: 0.5410393778765759
Kurtosis: 1.3341746423070187
Jarque_beraResult(
statistic=37.44802543837619,
pvalue=7.383539446514931e-09)



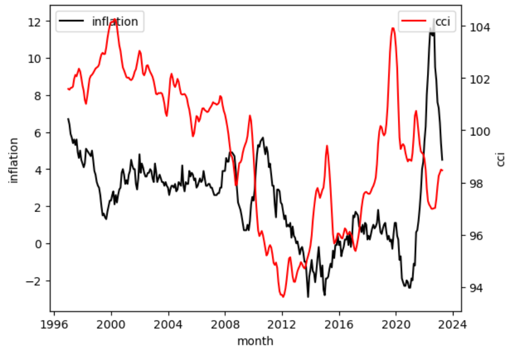
Period: 1997Q1 : 2023Q2
Observations: 106
Mean: 2.4018867924528307
Median: 2.8333333333333335
Max: 11.533333333333333
Min: -2.2333333333333333
Standard Deviation: 2.540507095107
Skewness: 0.5321199580641335
Kurtosis: 1.3213432473303066
Jarque_beraResult(
statistic=11.261123930498579,
pvalue=0.0035865592392423373)



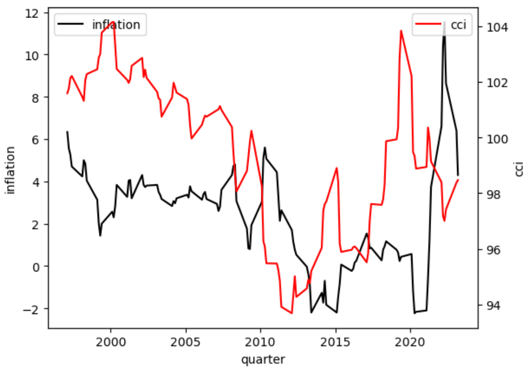
Period: 1996 : 2022
Observations: 27
Mean: 2.5333333333333337
Median: 3.0
Max: 9.3
Min: -1.4
Standard Deviation: 2.622975409721
Skewness: 0.6107690504533966
Kurtosis: 0.619964559845239
Jarque_beraResult(
statistic=1.59356406019557,
pvalue=0.4507772201723784)



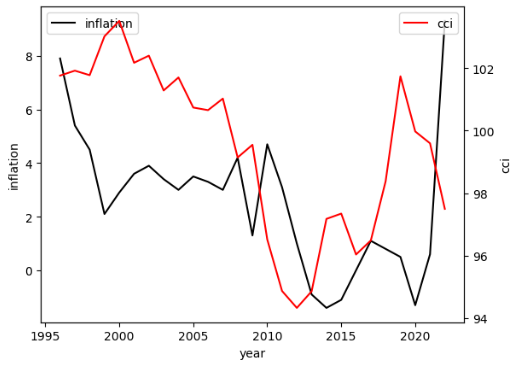
corr: 0.5465235357149822



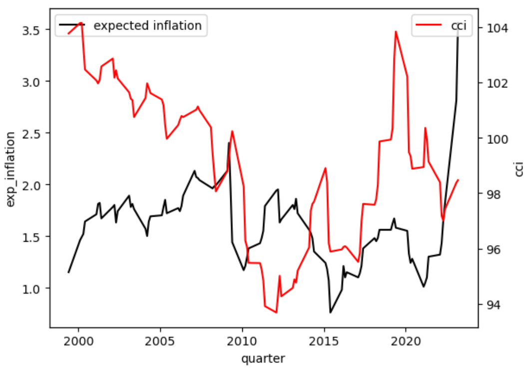
corr: 0.24044718849601915



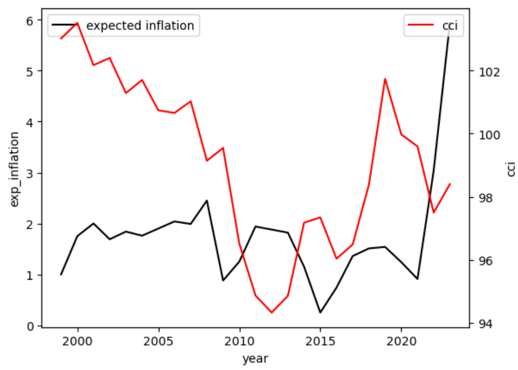
corr: 0.24461520428589734



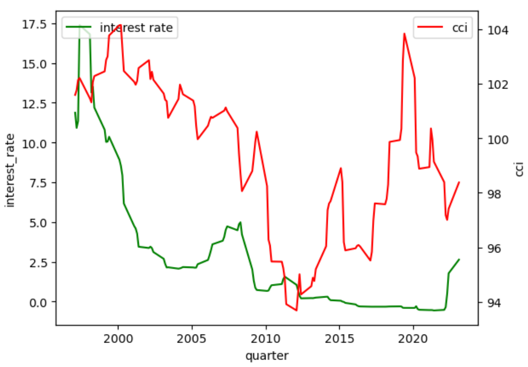
corr: 0.3314396897036187



corr: 0.174605752658979

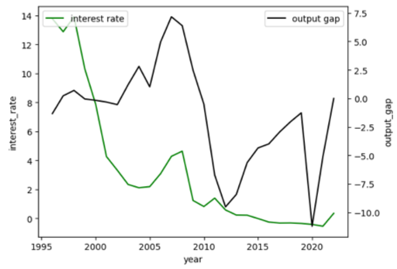


corr: -0.0018140455596834292

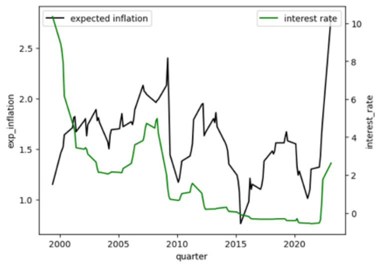


corr: 0.5711938101300612

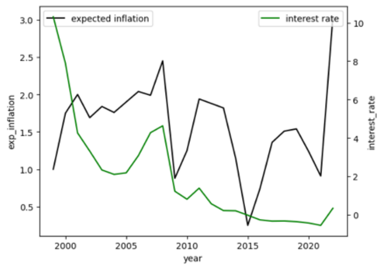
corr: 0.6020954797716008



corr: 0.3627580787037638

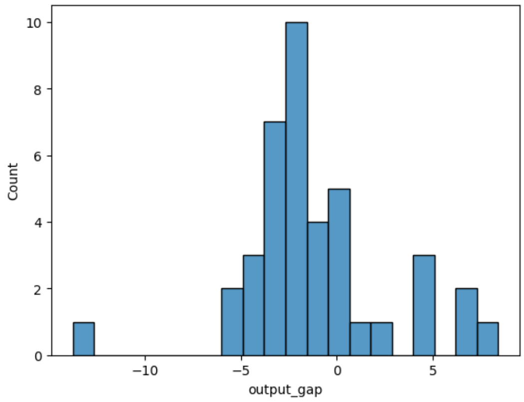


corr: 0.3874329646165711

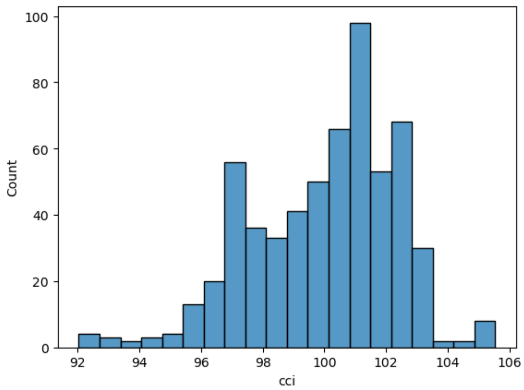


corr: 0.19153615826677847

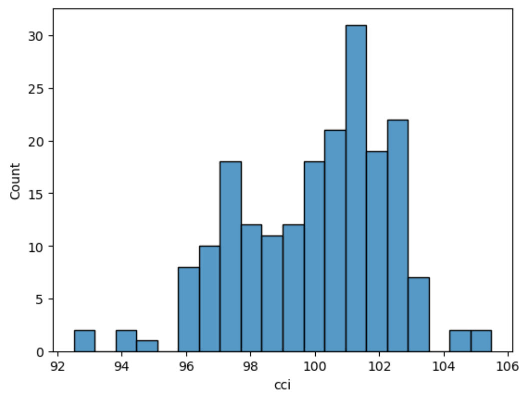
United Kingdom:



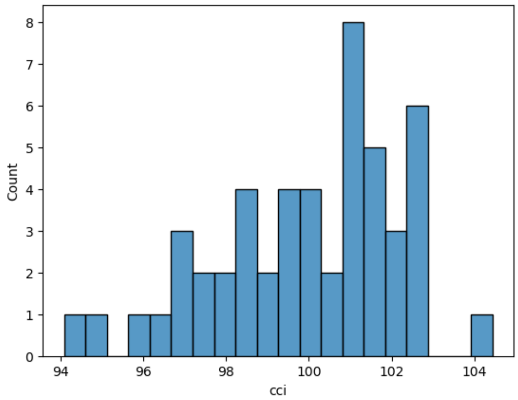
Period: 1985 : 2024
Observations: 40
Mean: -1.180338215405677
Median: -1.63158535181014
Max: 8.40195393770722
Min: -13.7414125424186
Standard Deviation: 3.901801466855
Skewness: 0.05952321155119926
Kurtosis: 2.654869214731032
Jarque_beraResult(
statistic=8.001382125231775,
pvalue=0.01830298600788205)



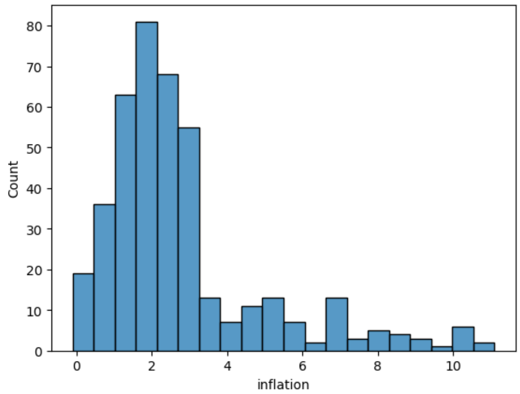
Period: 1974 : 2023
Observations: 592
Mean: 99.99999854729727
Median: 100.5349
Max: 105.5421
Min: 92.03677
Standard Deviation: 2.343975665102
Skewness: -0.5412412735136986
Kurtosis: 0.183405467469266
Jarque_beraResult(
statistic=29.484785195722406,
pvalue=3.957858329961539e-07)



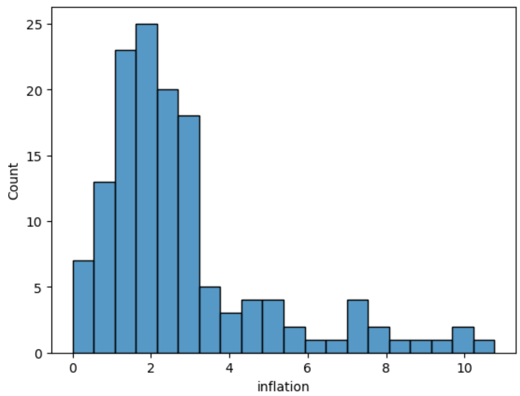
Period: 1974Q1 : 2023Q2
Observations: 198
Mean: 99.98715047138055
Median: 100.48176666666666
Max: 105.49073333333332
Min: 92.50532
Standard Deviation: 2.335738929049
Skewness: -0.5343669671678386
Kurtosis: 0.15567780688306954
Jarque_beraResult(
statistic=9.402589647462205,
pvalue=0.009083507942201363)



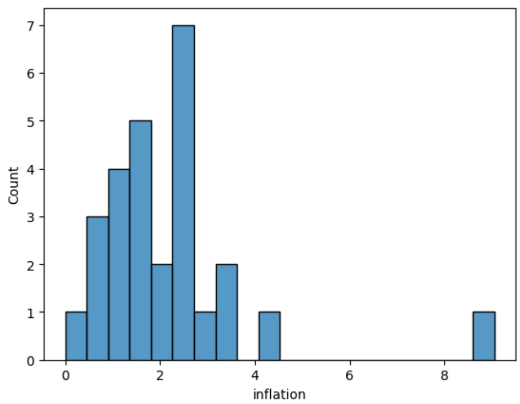

```
Period: 1974 : 2023
Observations: 50
Mean: 99.92967673333334
Median: 100.36945333333333
Max: 104.43470833333333
Min: 94.08241166666666
Standard Deviation: 2.250130091976
Skewness: -0.5740058904160853
Kurtosis: -0.08296256128748158
Jarque_beraResult(
statistic=2.659303552628907,
pvalue=0.26456937458357976)
```



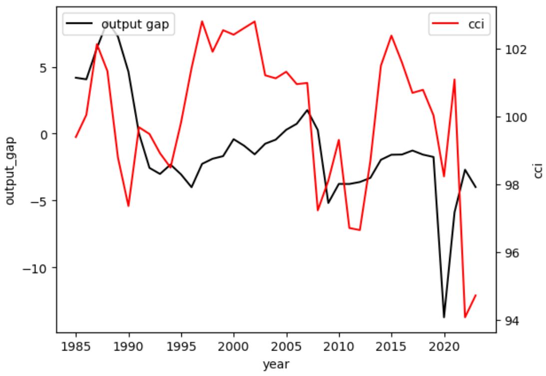

```
Period: 1989 : 2023
Observations: 412
Mean: 2.7643203883495153
Median: 2.2
Max: 11.1
Min: -0.1
Standard Deviation: 2.157669233217
Skewness: 1.724830029082248
Kurtosis: 2.893643430372252
Jarque_beraResult(
statistic=341.66093166773413,
pvalue=0.0)
```



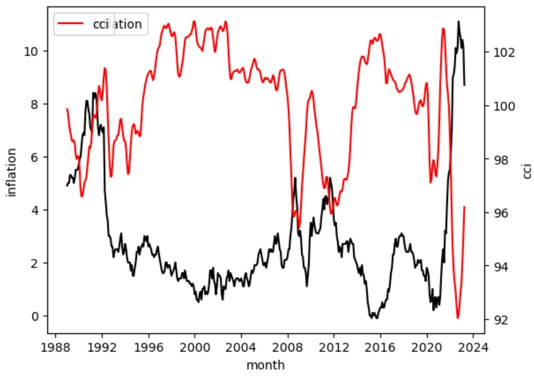

```
Period: 1989Q1 : 2023Q2
Observations: 138
Mean: 2.7929951690821286
Median: 2.25
Max: 10.766666666666666
Min: 0.0
Standard Deviation: 2.187327851267
Skewness: 1.7203192987159852
Kurtosis: 2.8128574071184076
Jarque_beraResult(
statistic=107.5468206192013,
pvalue=0.0)
```



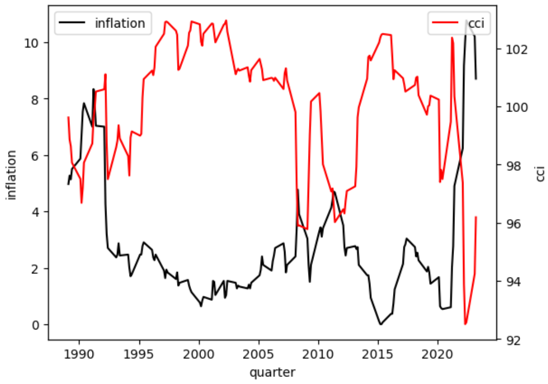

```
Period: 1996 : 2022
Observations: 27
Mean: 2.2450813555555556
Median: 2.1
Max: 9.053559
Min: 0.0
Standard Deviation: 1.670233521982
Skewness: 2.722803023956340З
Kurtosis: 10.46316819180046
Jarque_beraResult(
statistic=109.25621004579888,
pvalue=0.0)
```



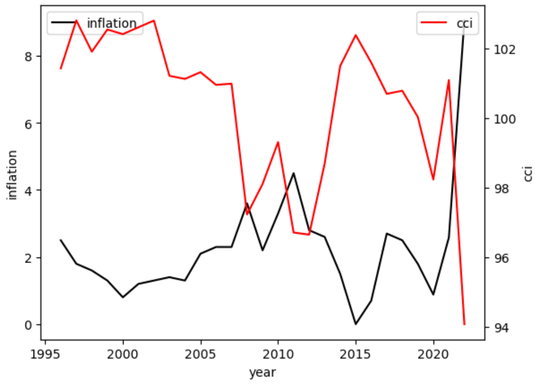
corr: 0.20821355825890595



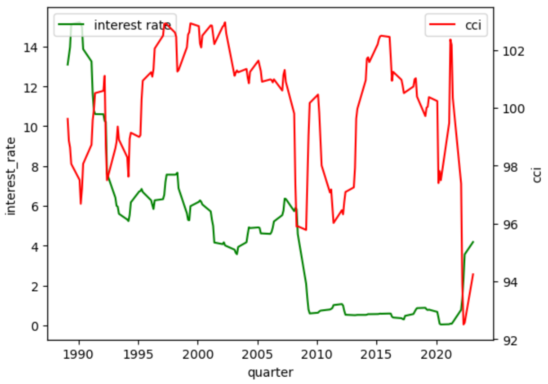
corr: -0.663158551328091



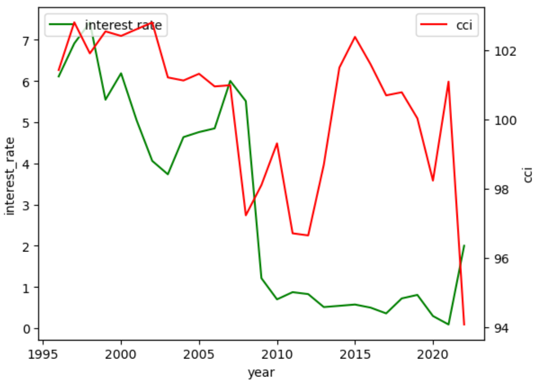
corr: -0.6742087436254499



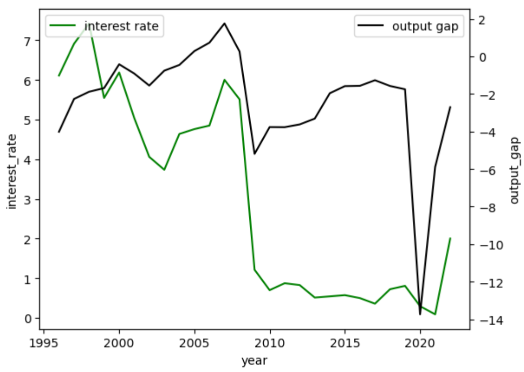
corr: -0.7786736179469979



corr: 0.00027822950340974467

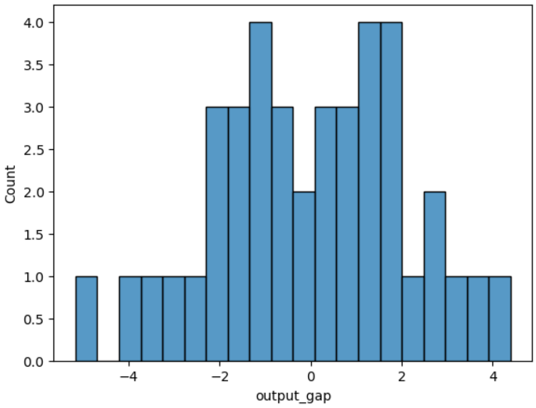


corr: 0.4206470926527181

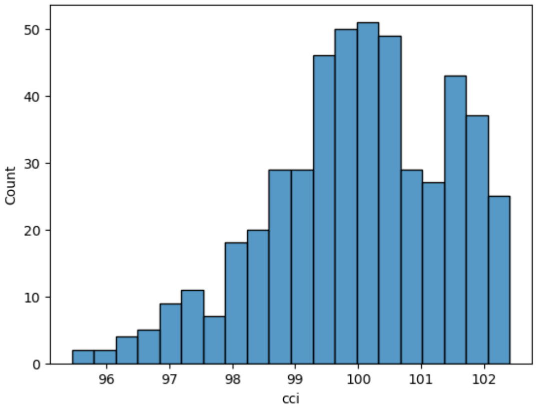


corr: 0.4705977217294618

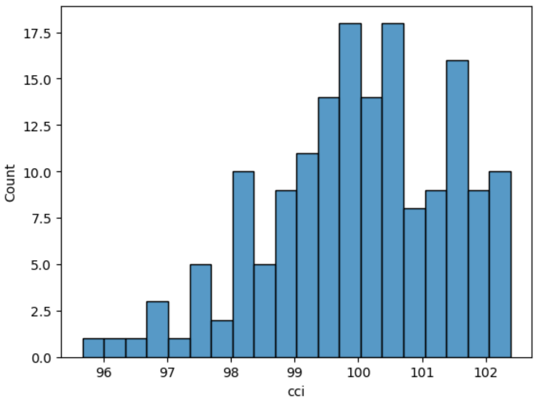
Japan:



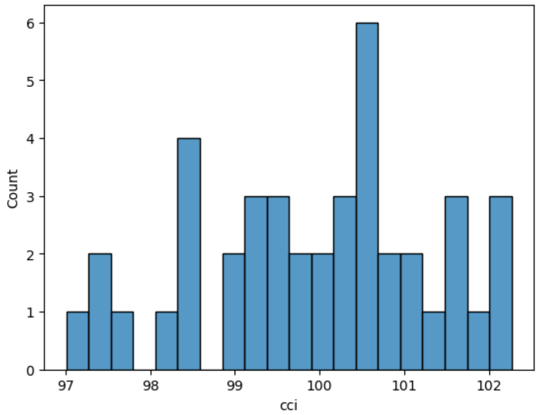

```
Period: 1985 : 2024
Observations: 40
Mean: -0.03940093891573572
Median: 0.083059074404007
Max: 4.38933347164145
Min: -5.16790183789893
Standard Deviation: 2.141327063568833
Skewness: -0.17311318641039158
Kurtosis: -0.16809754010094569
Jarque_beraResult(
statistic=0.329138419843807,
pvalue=0.8482590469703117)
```



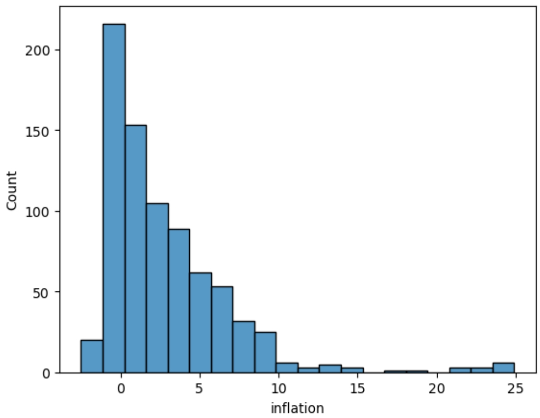

```
Period: 1982 : 2023
Observations: 493
Mean: 99.99999862068971
Median: 100.0497
Max: 102.409
Min: 95.45394
Standard Deviation: 1.429712919315144
Skewness: -0.5100720102495189
Kurtosis: -0.06286477010384228
Jarque_beraResult(
statistic=21.361215375925124,
pvalue=2.298640306430677e-05)
```



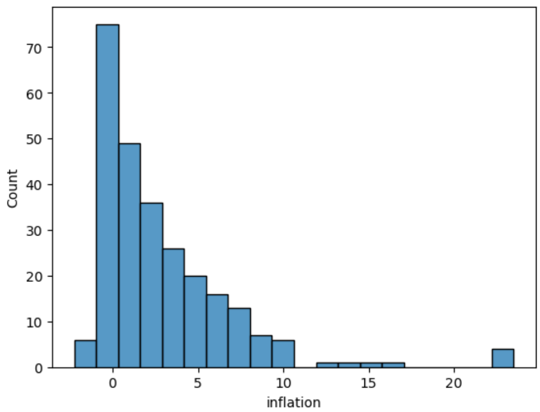

```
Period: 1982Q2 : 2023Q2
Observations: 165
Mean: 99.99270400000003
Median: 100.05097
Max: 102.3843
Min: 95.67483
Standard Deviation: 1.425389411210525
Skewness: -0.48348705247628027
Kurtosis: -0.09919893192391305
Jarque_beraResult(
statistic=6.43219979758539,
pvalue=0.04011119130103502)
```




```
Period: 1982 : 2023
Observations: 42
Mean: 99.96274424603176
Median: 100.14830291666667
Max: 102.26721666666667
Min: 97.0077525
Standard Deviation: 1.381369680558364
Skewness: -0.32974291939842415
Kurtosis: -0.6029452018734496
Jarque_beraResult(
statistic=1.4999429174987182,
pvalue=0.47238003486558844)
```




```
Period: 1956 : 2021
Observations: 786
Mean: 2.842131754707379
Median: 1.7
Max: 24.9
Min: -2.5
Standard Deviation: 4.077883560987086
Skewness: 2.3977464272655453
Kurtosis: 8.387790954477612
Jarque_beraResult(
statistic=3021.0681211761275,
pvalue=0.0)
```




```
Period: 1956Q1 : 2021Q2
Observations: 262
Mean: 2.8402757045801503
Median: 1.658715
Max: 23.48936
Min: -2.251791
Standard Deviation: 4.064981658354189
Skewness: 2.4110471255021984
Kurtosis: 8.490510026602276
Jarque_beraResult(
statistic=1004.1704100164457,
pvalue=0.0)
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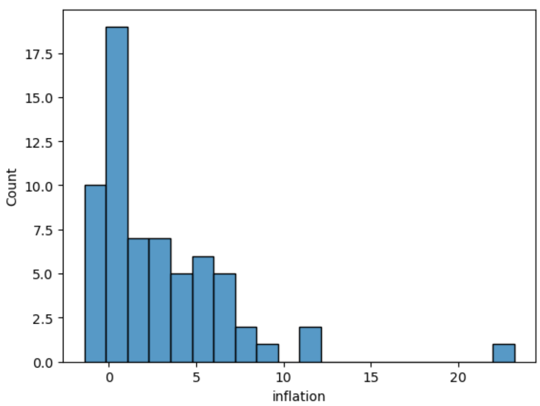
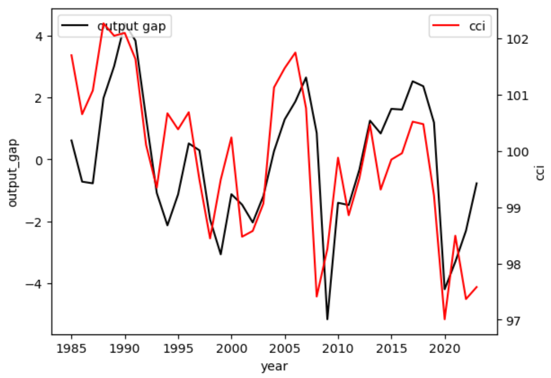
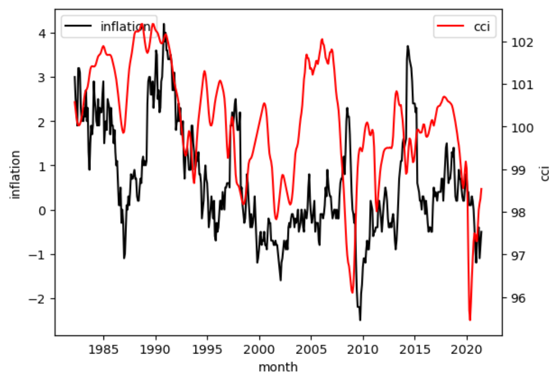


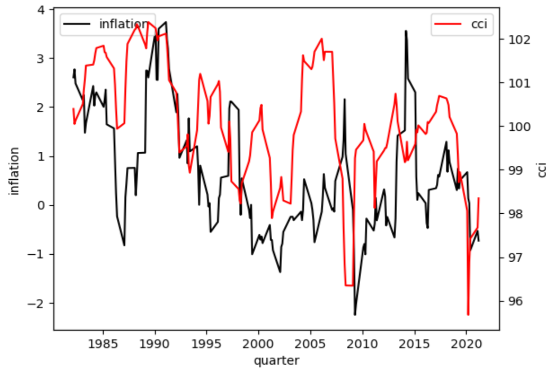

```
Period: 1956 : 2020
Observations: 65
Mean: 2.8637128410769233
Median: 1.6
Max: 23.2
Min: -1.4
Standard Deviation: 4.010835110115631
Skewness: 2.4754106265726814
Kurtosis: 9.45294130152175
Jarque_beraResult(
statistic=265.9969816601277,
pvalue=0.0)
```



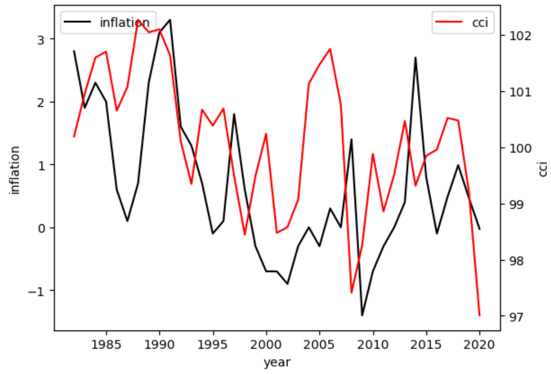
corr: 0.6800197370758823



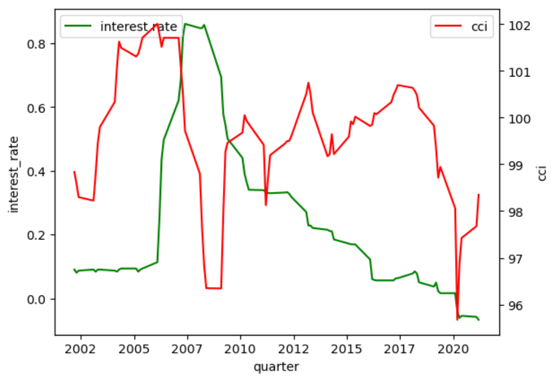
corr: 0.34766561064119794



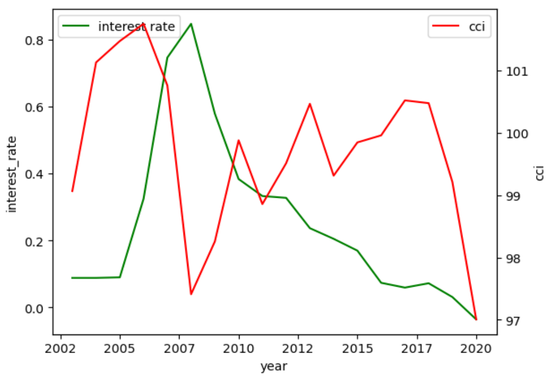
corr: 0.35284899494743344



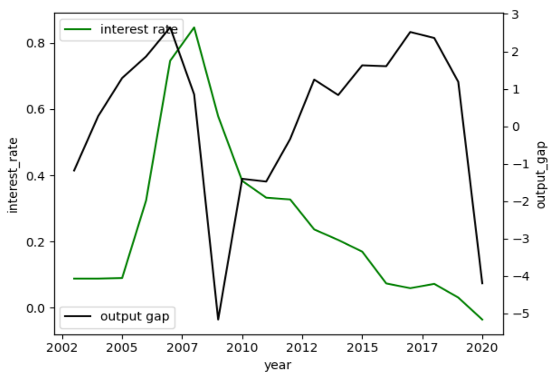
corr: 0.40118495129785303



corr: -0.13407135221324934



corr: -0.2004900672180824



corr: -0.06327421597308588

Appendix B – Taylor Rule Estimations

United States:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        92
-------------+----------------------------------   F(3, 88)        =    853.40
       Model |  404.610062         3  134.870021   Prob > F        =    0.0000
    Residual |  13.9073412        88  .158037968   R-squared       =    0.9668
-------------+----------------------------------   Adj R-squared   =    0.9656
       Total |  418.517404        91  4.59909235   Root MSE        =    .39754

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .7983124   .0298699    26.73   0.000     .7389523    .8576726
     infl_dev |   .0479152   .0485686     0.99   0.327    -.0486046     .144435
   output_gap |   .3005165   .0438259     6.86   0.000     .2134217    .3876113
        _cons |   .8446838   .1418177     5.96   0.000     .5628509    1.126517
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       153
-------------+----------------------------------   F(3, 149)       =   2233.37
       Model |  1124.83533         3   374.94511   Prob > F        =    0.0000
    Residual |  25.0145869       149  .167883133   R-squared       =    0.9782
-------------+----------------------------------   Adj R-squared   =    0.9778
       Total |  1149.84992       152  7.56480209   Root MSE        =    .40974

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |    .854193   .0187357    45.59   0.000      .817171     .891215
     infl_dev |   .0497347    .024428     2.04   0.044     .0014647    .0980047
   output_gap |   .2001691   .0299644     6.68   0.000     .1409591     .259379
        _cons |    .560986   .0908326     6.18   0.000     .3814995    .7404725
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        49
-------------+----------------------------------   F(3, 45)        =    334.71
       Model |  57.4603831         3   19.153461   Prob > F        =    0.0000
    Residual |  2.57504544        45  .057223232   R-squared       =    0.9571
-------------+----------------------------------   Adj R-squared   =    0.9542
       Total |  60.0354286        48   1.2507381   Root MSE        =    .23921

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .6667403   .0355606    18.75   0.000     .5951177     .738363
     infl_dev |    .075365   .0299923     2.51   0.016     .0149575    .1357725
   output_gap |   .1823173   .0291719     6.25   0.000     .1235621    .2410725
        _cons |   .6896341   .0955387     7.22   0.000     .4972092    .8820589
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       152
-------------+----------------------------------   F(3, 148)       =   2302.41
       Model |  1124.25953         3  374.753178   Prob > F        =    0.0000
    Residual |  24.0892736       148  .162765362   R-squared       =    0.9790
-------------+----------------------------------   Adj R-squared   =    0.9786
       Total |  1148.34881       151  7.60495898   Root MSE        =    .40344

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .8220329   .0212655    38.66   0.000     .7800097    .8640561
 exp_infl_dev |   .1579307   .0589766     2.68   0.008     .0413857    .2744757
   output_gap |   .2078345   .0279105     7.45   0.000     .1526799     .262989
        _cons |   .6055646   .0846101     7.16   0.000     .4383648    .7727645
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        92
-------------+----------------------------------   F(3, 88)        =    866.33
       Model |  404.810722         3  134.936907   Prob > F        =    0.0000
    Residual |   13.706682        88   .15575775   R-squared       =    0.9672
-------------+----------------------------------   Adj R-squared   =    0.9661
       Total |  418.517404        91  4.59909235   Root MSE        =    .39466

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .7762897   .0350674    22.14   0.000     .7066006    .8459787
 exp_infl_dev |   .1086288   .0720075     1.51   0.135     -.034471    .2517285
   output_gap |   .3030059   .0431297     7.03   0.000     .2172947     .388717
        _cons |   .8949111   .1454114     6.15   0.000     .6059366    1.183886
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        49
-------------+----------------------------------   F(3, 45)        =    299.24
       Model |  57.1697174         3  19.0565725   Prob > F        =    0.0000
    Residual |  2.86571114        45   .06368247   R-squared       =    0.9523
-------------+----------------------------------   Adj R-squared   =    0.9491
       Total |  60.0354286        48   1.2507381   Root MSE        =    .25235

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .6944871   .0361602    19.21   0.000     .6216567    .7673174
 exp_infl_dev |   .1214617   .1153121     1.05   0.298    -.1107887    .3537121
   output_gap |   .1777504   .0340555     5.22   0.000     .1091591    .2463417
        _cons |   .6322984   .1079098     5.86   0.000     .4149569    .8496398
------------------------------------------------------------------------------
```

Germany:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       105
-------------+----------------------------------   F(3, 101)       =   1022.31
       Model |  317.767597         3  105.922532   Prob > F        =    0.0000
    Residual |  10.4647037       101  .103610928   R-squared       =    0.9681
-------------+----------------------------------   Adj R-squared   =    0.9672
       Total |  328.232301       104  3.15607981   Root MSE        =    .32189

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .9724459   .0184257    52.78   0.000     .9358943    1.008998
     infl_dev |   .0926537   .0176236     5.26   0.000     .0576932    .1276143
   output_gap |   .0500277   .0188314     2.66   0.009     .0126712    .0873842
        _cons |   .0712487   .0450359     1.58   0.117    -.0180905    .1605879
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    140.92
       Model |   35.383452         3   11.794484   Prob > F        =    0.0000
    Residual |   3.6825525        44  .083694375   R-squared       =    0.9057
-------------+----------------------------------   Adj R-squared   =    0.8993
       Total |  39.0660045        47  .831191585   Root MSE        =     .2893

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .7230018   .0797677     9.06   0.000     .5622406    .8837631
     infl_dev |   .0509492   .0664167     0.77   0.447    -.0829049    .1848032
   output_gap |   .1610445   .0522351     3.08   0.004     .0557716    .2663173
        _cons |   .9506023   .2639106     3.60   0.001     .4187255    1.482479
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =     95.11
       Model |  15.6432864         3  5.21442879   Prob > F        =    0.0000
    Residual |  2.19292762        40  .054823191   R-squared       =    0.8771
-------------+----------------------------------   Adj R-squared   =    0.8678
       Total |   17.836214        43  .414795674   Root MSE        =    .23414

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .6082164   .0684463     8.89   0.000     .4698812    .7465516
     infl_dev |   .1809059   .0682161     2.65   0.011     .0430361    .3187757
   output_gap |   -.056703   .0403935    -1.40   0.168    -.1383415    .0249354
        _cons |   .1678455    .072776     2.31   0.026     .0207597    .3149314
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        94
-------------+----------------------------------   F(3, 90)        =    670.88
       Model |  282.751914         3  94.2506381   Prob > F        =    0.0000
    Residual |  12.6439662        90  .140488514   R-squared       =    0.9572
-------------+----------------------------------   Adj R-squared   =    0.9558
       Total |  295.395881        93  3.17629979   Root MSE        =    .37482

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .9563294   .0286443    33.39   0.000     .8994224    1.013236
 exp_infl_dev |   .0288249   .1465101     0.20   0.844     -.262243    .3198928
   output_gap |   .0579867   .0223656     2.59   0.011     .0135535    .1024199
        _cons |   .0900843   .1010912     0.89   0.375    -.1107509    .2909196
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    235.51
       Model |  78.9343476         3  26.3114492   Prob > F        =    0.0000
    Residual |  4.91576022        44  .111721823   R-squared       =    0.9414
-------------+----------------------------------   Adj R-squared   =    0.9374
       Total |  83.8501078        47  1.78404485   Root MSE        =    .33425

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .8031995    .058358    13.76   0.000     .6855867    .9208124
 exp_infl_dev |  -.3098849   .2294289    -1.35   0.184    -.7722685    .1524987
   output_gap |   .1843642   .0322332     5.72   0.000     .1194025     .249326
        _cons |   .5040569   .2226229     2.26   0.029     .0553899     .952724
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    110.10
       Model |   7.3880476         3  2.46268253   Prob > F        =    0.0000
    Residual |  .894678621        40  .022366966   R-squared       =    0.8920
-------------+----------------------------------   Adj R-squared   =    0.8839
       Total |  8.28272622        43   .19262154   Root MSE        =    .14956

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .7766196   .0562585    13.80   0.000     .6629169    .8903222
 exp_infl_dev |    .175547     .09846     1.78   0.082     -.023448     .374542
   output_gap |  -.0053977   .0147974    -0.36   0.717    -.0353043     .024509
        _cons |    .062666    .060048     1.04   0.303    -.0586957    .1840276
-------------------------------------------------------------------------------
```

France:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       105
-------------+----------------------------------   F(3, 101)       =    988.98
       Model |  319.344595         3  106.448198   Prob > F        =    0.0000
    Residual |  10.8710685       101  .107634341   R-squared       =    0.9671
-------------+----------------------------------   Adj R-squared   =    0.9661
       Total |  330.215664       104  3.17515061   Root MSE        =    .32808

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9493219   .0209096    45.40   0.000      .907843    .9908009
     infl_dev |    .118208   .0244686     4.83   0.000      .069669     .166747
   output_gap |   .0336551   .0180856     1.86   0.066    -.0022219    .0695321
        _cons |   .1216224   .0497022     2.45   0.016     .0230267    .2202181
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    122.71
       Model |  34.8230731         3   11.607691   Prob > F        =    0.0000
    Residual |  4.16220401        44  .094595546   R-squared       =    0.8932
-------------+----------------------------------   Adj R-squared   =    0.8860
       Total |  38.9852771        47  .829473981   Root MSE        =    .30756

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9081303   .0526648    17.24   0.000     .8019913    1.014269
     infl_dev |  -.0080644   .0624439    -0.13   0.898    -.1339119    .1177831
   output_gap |   .0895167   .0409904     2.18   0.034      .006906    .1721275
        _cons |   .2367001   .1765534     1.34   0.187      -.11912    .5925201
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    118.55
       Model |  16.0330126         3  5.34433753   Prob > F        =    0.0000
    Residual |  1.80320139        40  .045080035   R-squared       =    0.8989
-------------+----------------------------------   Adj R-squared   =    0.8913
       Total |   17.836214        43  .414795674   Root MSE        =    .21232

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .5557058   .0540365    10.28   0.000      .446494    .6649177
     infl_dev |   .1989577   .0476677     4.17   0.000     .1026176    .2952977
   output_gap |  -.1515467   .0485452    -3.12   0.003    -.2496601   -.0534332
        _cons |    .163061   .0507979     3.21   0.003     .0603946    .2657275
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        94
-------------+----------------------------------   F(3, 90)        =    662.10
       Model |   282.59149         3  94.1971633   Prob > F        =    0.0000
    Residual |  12.8043908        90  .142271009   R-squared       =    0.9567
-------------+----------------------------------   Adj R-squared   =    0.9552
       Total |  295.395881        93  3.17629979   Root MSE        =    .37719

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9420333   .0316792    29.74   0.000      .879097     1.00497
 exp_infl_dev |  -.0115078    .146046    -0.08   0.937    -.3016537    .2786381
   output_gap |   .0514225   .0219065     2.35   0.021     .0079015    .0949435
        _cons |   .0900178   .1024771     0.88   0.382    -.1135708    .2936064
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    328.14
       Model |  80.2626919         3  26.7542306   Prob > F        =    0.0000
    Residual |   3.5874159        44   .08153218   R-squared       =    0.9572
-------------+----------------------------------   Adj R-squared   =    0.9543
       Total |  83.8501078        47  1.78404485   Root MSE        =    .28554

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .7553551   .0507595    14.88   0.000     .6530561    .8576541
 exp_infl_dev |  -.4374664   .1895609    -2.31   0.026    -.8195012   -.0554315
   output_gap |   .3093308   .0395665     7.82   0.000     .2295897    .3890719
        _cons |   .3292679   .1680491     1.96   0.056    -.0094128    .6679485
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    109.88
       Model |  7.38644867         3  2.46214956   Prob > F        =    0.0000
    Residual |  .896277555        40  .022406939   R-squared       =    0.8918
-------------+----------------------------------   Adj R-squared   =    0.8837
       Total |  8.28272622        43   .19262154   Root MSE        =    .14969

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .7718732   .0557922    13.83   0.000     .6591131    .8846334
 exp_infl_dev |   .1706688    .098967     1.72   0.092     -.029351    .3706885
   output_gap |   .0024269   .0097893     0.25   0.805    -.0173581    .0222119
        _cons |   .0633972   .0602712     1.05   0.299    -.0584155    .1852098
-------------------------------------------------------------------------------
```

Italy:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       105
-------------+----------------------------------   F(3, 101)       =   1316.34
       Model |  443.282583         3  147.760861   Prob > F        =    0.0000
    Residual |    11.33741       101  .112251584   R-squared       =    0.9751
-------------+----------------------------------   Adj R-squared   =    0.9743
       Total |  454.619993       104  4.37134609   Root MSE        =    .33504

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9204659   .0164983    55.79   0.000     .8877377    .9531942
     infl_dev |   .0747839   .0182776     4.09   0.000     .0385261    .1110418
   output_gap |   .0413632   .0140776     2.94   0.004      .013437    .0692894
        _cons |   .1256025   .0485152     2.59   0.011     .0293613    .2218437
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    240.10
       Model |  87.3094576         3  29.1031525   Prob > F        =    0.0000
    Residual |  5.33328316        44  .121210981   R-squared       =    0.9424
-------------+----------------------------------   Adj R-squared   =    0.9385
       Total |  92.6427408        47  1.97112214   Root MSE        =    .34815

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |    .940357   .0373657    25.17   0.000     .8650513    1.015663
     infl_dev |    .029882   .1041927     0.29   0.776    -.1801045    .2398685
   output_gap |   .0796396   .0351557     2.27   0.028      .008788    .1504912
        _cons |   .0670665   .1674765     0.40   0.691    -.2704602    .4045932
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        45
-------------+----------------------------------   F(3, 41)        =    162.98
       Model |  30.3819096         3  10.1273032   Prob > F        =    0.0000
    Residual |  2.54772509        41  .062139636   R-squared       =    0.9226
-------------+----------------------------------   Adj R-squared   =    0.9170
       Total |  32.9296347        44  .748400789   Root MSE        =    .24928

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .7112998   .0389126    18.28   0.000     .6327142    .7898854
     infl_dev |   .0918261   .0380927     2.41   0.020     .0148963    .1687559
   output_gap |   .0114823   .0195963     0.59   0.561    -.0280933     .051058
        _cons |    .109524   .0595638     1.84   0.073    -.0107674    .2298155
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        94
-------------+----------------------------------   F(3, 90)        =    717.28
       Model |  283.537054         3  94.5123513   Prob > F        =    0.0000
    Residual |  11.8588266        90   .13176474   R-squared       =    0.9599
-------------+----------------------------------   Adj R-squared   =    0.9585
       Total |  295.395881        93  3.17629979   Root MSE        =    .36299

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .9186585   .0312433    29.40   0.000     .8565882    .9807287
 exp_infl_dev |  -.0140521   .1404694    -0.10   0.921    -.2931191    .2650149
   output_gap |   .0615791    .016997     3.62   0.000     .0278115    .0953466
        _cons |   .1463904     .10058     1.46   0.149    -.0534293    .3462101
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    239.31
       Model |  79.0078391         3  26.3359464   Prob > F        =    0.0000
    Residual |  4.84226875        44  .110051563   R-squared       =    0.9423
-------------+----------------------------------   Adj R-squared   =    0.9383
       Total |  83.8501078        47  1.78404485   Root MSE        =    .33174

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .8457226   .0530991    15.93   0.000     .7387084    .9527367
 exp_infl_dev |  -.7200539    .216084    -3.33   0.002    -1.155543   -.2845653
   output_gap |   .1943773   .0333948     5.82   0.000     .1270746      .26168
        _cons |   .0313245   .1806168     0.17   0.863    -.3326846    .3953337
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    112.06
       Model |  7.40199226         3  2.46733075   Prob > F        =    0.0000
    Residual |  .880733957        40  .022018349   R-squared       =    0.8937
-------------+----------------------------------   Adj R-squared   =    0.8857
       Total |  8.28272622        43   .19262154   Root MSE        =    .14839

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .7823943   .0560321    13.96   0.000     .6691493    .8956394
 exp_infl_dev |   .1660101   .0978702     1.70   0.098    -.0317929    .3638132
   output_gap |   .0073825   .0084215     0.88   0.386    -.0096379    .0244029
        _cons |   .0750235   .0613259     1.22   0.228    -.0489207    .1989677
------------------------------------------------------------------------------
```

Greece:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       105
-------------+----------------------------------   F(3, 101)       =    806.44
       Model |  1654.54223         3  551.514077   Prob > F        =    0.0000
    Residual |  69.0725868       101  .683886998   R-squared       =    0.9599
-------------+----------------------------------   Adj R-squared   =    0.9587
       Total |  1723.61482       104  16.5732194   Root MSE        =    .82697

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .9339508   .0215145    43.41   0.000     .8912718    .9766298
     infl_dev |   .0652438   .0389537     1.67   0.097    -.0120299    .1425176
   output_gap |   .0036946   .0221722     0.17   0.868     -.040289    .0476782
        _cons |   .0738716   .1120322     0.66   0.511    -.1483703    .2961134
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    185.93
       Model |  781.049491         3   260.34983   Prob > F        =    0.0000
    Residual |  61.6107331        44  1.40024393   R-squared       =    0.9269
-------------+----------------------------------   Adj R-squared   =    0.9219
       Total |  842.660224        47  17.9289409   Root MSE        =    1.1833

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .9410844   .0448987    20.96   0.000     .8505969    1.031572
     infl_dev |   .0919599   .1919732     0.48   0.634    -.2949367    .4788565
   output_gap |   .0469261    .070446     0.67   0.509    -.0950486    .1889007
        _cons |  -.0622233   .4374113    -0.14   0.888    -.9437679    .8193214
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    141.79
       Model |  16.3031157         3  5.43437191   Prob > F        =    0.0000
    Residual |  1.53309828        40  .038327457   R-squared       =    0.9140
-------------+----------------------------------   Adj R-squared   =    0.9076
       Total |   17.836214        43  .414795674   Root MSE        =    .19577

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .6354155   .0370218    17.16   0.000     .5605917    .7102393
     infl_dev |   .0860125    .018006     4.78   0.000     .0496209    .1224041
   output_gap |  -.0324271   .0091186    -3.56   0.001    -.0508564   -.0139978
        _cons |   .0101531   .0510373     0.20   0.843    -.0929972    .1133034
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        94
-------------+----------------------------------   F(3, 90)        =    995.62
       Model |  484.835511         3  161.611837   Prob > F        =    0.0000
    Residual |  14.6091113        90  .162323459   R-squared       =    0.9707
-------------+----------------------------------   Adj R-squared   =    0.9698
       Total |  499.444622        93  5.37037228   Root MSE        =    .40289

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .8905501   .0200227    44.48   0.000     .8507715    .9303287
 exp_infl_dev |   .0514374   .1420452     0.36   0.718    -.2307602     .333635
   output_gap |   .0301045   .0109092     2.76   0.007     .0084315    .0517775
        _cons |    .183249   .0853005     2.15   0.034     .0137847    .3527133
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        48
-------------+----------------------------------   F(3, 44)        =    310.32
       Model |   214.68447         3    71.56149   Prob > F        =    0.0000
    Residual |  10.1468013        44  .230609122   R-squared       =    0.9549
-------------+----------------------------------   Adj R-squared   =    0.9518
       Total |  224.831271        47  4.78364407   Root MSE        =    .48022

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .8850875   .0296963    29.80   0.000     .8252385    .9449365
 exp_infl_dev |  -.7822871   .3336646    -2.34   0.024    -1.454744   -.1098302
   output_gap |   .0691219   .0259921     2.66   0.011     .0167382    .1215056
        _cons |  -.1041225   .1674386    -0.62   0.537    -.4415728    .2333278
------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate exp_infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    122.34
       Model |  7.46873185         3  2.48957728   Prob > F        =    0.0000
    Residual |  .813994371        40  .020349859   R-squared       =    0.9017
-------------+----------------------------------   Adj R-squared   =    0.8944
       Total |  8.28272622        43   .19262154   Root MSE        =    .14265

------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
prev_int_rate |   .8181689   .0573752    14.26   0.000     .7022094    .9341285
 exp_infl_dev |   .1736181   .0937425     1.85   0.071    -.0158425    .3630786
   output_gap |   .0148822   .0073399     2.03   0.049     .0000478    .0297166
        _cons |   .1413491   .0692937     2.04   0.048     .0013013    .2813968
------------------------------------------------------------------------------
```

United Kingdom:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =       137
-------------+----------------------------------   F(3, 133)       =   3017.08
       Model |  2032.03824         3  677.346081   Prob > F        =    0.0000
    Residual |  29.8589836       133  .224503636   R-squared       =    0.9855
-------------+----------------------------------   Adj R-squared   =    0.9852
       Total |  2061.89723       136   15.161009   Root MSE        =    .47382

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9375226   .0134083    69.92   0.000     .9110016    .9640437
     infl_dev |   .0444788   .0206509     2.15   0.033     .0036321    .0853255
   output_gap |   .0606111   .0156103     3.88   0.000     .0297344    .0914877
        _cons |   .2943258   .0871304     3.38   0.001     .1219853    .4666662
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        80
-------------+----------------------------------   F(3, 76)        =    963.02
       Model |  742.652257         3  247.550752   Prob > F        =    0.0000
    Residual |  19.5363067        76  .257056668   R-squared       =    0.9744
-------------+----------------------------------   Adj R-squared   =    0.9734
       Total |  762.188564        79  9.64795651   Root MSE        =    .50701

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9548833   .0367309    26.00   0.000     .8817274    1.028039
     infl_dev |  -.0607496   .0574041    -1.06   0.293    -.1750797    .0535806
   output_gap |   .0991204   .0263417     3.76   0.000     .0466563    .1515845
        _cons |   .3128121   .2383884     1.31   0.193    -.1619796    .7876037
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =     80.10
       Model |  3.34214996         3  1.11404999   Prob > F        =    0.0000
    Residual |  .556363419        40  .013909085   R-squared       =    0.8573
-------------+----------------------------------   Adj R-squared   =    0.8466
       Total |  3.89851338        43  .090663102   Root MSE        =    .11794

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .4070667   .0332532    12.24   0.000     .3398594    .4742739
     infl_dev |   .0432577    .017493     2.47   0.018     .0079031    .0786124
   output_gap |   .0030507   .0200817     0.15   0.880    -.0375359    .0436373
        _cons |    .374616   .0462232     8.10   0.000     .2811954    .4680366
-------------------------------------------------------------------------------
```

Japan:

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        76
-------------+----------------------------------   F(3, 72)        =    893.69
       Model |  4.53638301         3  1.51212767   Prob > F        =    0.0000
    Residual |  .121824025        72     .001692   R-squared       =    0.9738
-------------+----------------------------------   Adj R-squared   =    0.9728
       Total |  4.65820703        75  .062109427   Root MSE        =    .04113

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9980941   .0192864    51.75   0.000     .9596474    1.036541
     infl_dev |  -.0048499    .005489    -0.88   0.380    -.0157921    .0060923
   output_gap |   .0109637   .0024611     4.45   0.000     .0060575    .0158699
        _cons |  -.0113947    .012222    -0.93   0.354    -.0357589    .0129695
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        26
-------------+----------------------------------   F(3, 22)        =    398.78
       Model |  2.65642744         3  .885475814   Prob > F        =    0.0000
    Residual |  .04885004         22  .002220456   R-squared       =    0.9819
-------------+----------------------------------   Adj R-squared   =    0.9795
       Total |  2.70527748        25  .108211099   Root MSE        =    .04712

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .9797545   .0480462    20.39   0.000     .8801128    1.079396
     infl_dev |  -.0054811   .0209412    -0.26   0.796    -.0489106    .0379483
   output_gap |   .0251108   .0074386     3.38   0.003     .0096842    .0405375
        _cons |   .0065873   .0513543     0.13   0.899    -.0999149    .1130895
-------------------------------------------------------------------------------
```

```
. reg interest_rate prev_int_rate infl_dev output_gap

      Source |       SS           df       MS      Number of obs   =        44
-------------+----------------------------------   F(3, 40)        =    766.75
       Model |  1.15994111         3  .386647038   Prob > F        =    0.0000
    Residual |  .02017081         40   .00050427   R-squared       =    0.9829
-------------+----------------------------------   Adj R-squared   =    0.9816
       Total |  1.18011192        43  .027444463   Root MSE        =    .02246

-------------------------------------------------------------------------------
interest_rate | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+----------------------------------------------------------------
prev_int_rate |   .8259742   .0482681    17.11   0.000     .7284207    .9235277
     infl_dev |   .0028922   .0036014     0.80   0.427    -.0043865     .010171
   output_gap |  -.0058299   .0043919    -1.33   0.192    -.0147062    .0030465
        _cons |    .030146    .015378     1.96   0.057    -.0009341     .061226
-------------------------------------------------------------------------------
```