Essays on Contemporary Issues in Macroeconomics

by

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Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other university. This dissertation is my own work, joint with others as specified in the text.

Nicolás Blampied

Preface

This PhD thesis is the result of a three-year research process carried out as part of the completion of the PhD program in Economics and Political Economy at the University of Genoa. The thesis is composed of three chapters/essays, and the common link that ties them together is their relevance in the field of contemporary macroeconomics. Each chapter addresses from a different macroeconomic perspective, theoretical or applied, a high impact topic identified in the literature.

More precisely, each essay of this thesis builds on a contemporary and relevant issue in the field of macroeconomics and, in particular, in the subfields of environmental economics, monetary economics and at the intersection between monetary economics and finance. The issue covered in each essay is approached from an original and novel perspective, contributing to the advancement of knowledge and providing specific policy recommendations. The last two chapters are highly related, since they are applied essays and both of them analyze the asymmetric effects of monetary policy across business cycle phases and resort to the same macroeconometric empirical strategy (i.e. local projections).

Specifically, the thesis consists of the following three essays/chapters:

1. **Economic growth, environmental constraints and convergence: the declining growth premium for developing economies.**[1]

This paper aims to model the connection between economic growth and the environment, assuming that developing economies face an environmental constraint that developed economies did not suffer when they started their processes of economic development. Following the model of Lucas (2000), this paper simulates world income dynamics since the

[1] Published in the journal *Ecological Economics*, Vol. 181, March 2021, 106919.

year 1800, setting up the parameters such that the model accurately describes the world economy by the year 2020. The original model is enriched by adding an environmental constraint so that follower economies face a declining growth premium after 1970. The model also forecasts income dynamics until the end of the 21st century, which allows testing the effects of the environmental constraint on followers in the future. The simulations predict that convergence to upper-middle and high-income per capita levels will slow down and so will the pace of reduction in across income inequality worldwide. These results suggest that a strategy of "grow first, then clean up", typically derived from the existence of an environmental Kuznets curve, is not necessarily valid for today developing countries. Instead, the results would suggest the implementation of a policy of "clean up in order to grow", but growing less.

2. Asymmetric responses of the markup to monetary shocks over the business cycle.[2]

A rich literature has long studied the asymmetric effects of monetary policy over the business cycle, generally presenting mixed results. Most of the empirical work, however, focuses on the responses of output and prices. Given the key role it plays in the transmission of monetary policy and the relatively scarce studies on the subject, this paper centers the analysis on the dynamics of the markup. Recent empirical findings suggest that, even when the New Keynesian models are not able to reproduce such dynamic, the markup decreases in response to a monetary policy tightening shock. This paper, by putting forward a local projections approach and analyzing the response of the markup during the period 1990m2-2016m12, argues that the dynamic of the markup may depend on whether the monetary policy tightening shock takes place during a period of expansion or recession. In this latter case, for instance, the New Keynesian model seems to do a good job, suggesting that only tightening mistakes may be successfully addressed within the basic New Keynesian framework. Given that New Keynesian

[2] Co-authored with Scott Mahadeo.

models constitute the main tool central banks use for policy analysis, these results have important policy implications, providing evidence that the mechanism of transmission of monetary policy through the markup would not be operative during booms.

3. Uncertainties under monetary tightening and easing shocks and different market states.[3]

This paper examines the impact of monetary shocks on monetary policy and stock market uncertainties. In this context, this work also seeks to determine which types of shocks and market states elevate uncertainties. Therefore, monetary actions are disentangled into tightening and easing shocks, so to explore whether business cycle phases and stock market volatility regimes matter. To identify monetary shocks, a theoretical vector autoregressive model of the US economy that accounts for the interconnectedness between monetary policy and the stock market is put forward. This model is augmented in order to accommodate for unconventional monetary policy actions at the zero lower bound. Then, with local projections, the responses of monetary policy and stock market uncertainties to such shocks are estimated. The main results suggest that monetary tightening shocks reduce uncertainties, while easing shocks either increase uncertainties or are negligible. In addition, when checking volatility regimes and business cycle phases, results suggest that tightening shocks reduce uncertainty under the tranquil volatility regime and business cycle expansions, while the responses in turbulent volatility and recessions are not robust across empirical specifications. Easing shocks, on its part, increase uncertainty in tranquil volatility and expansions, reducing it in recessions after a year, and display non-robust responses during turbulent volatility. These results are helpful in appraising the role of monetary actions on uncertainties, in alternative states of the market.

[3] Co-authored with Scott Mahadeo. Published in the journal *Finance Research Letters*, Vol. 55, Part A, July 2023, 103834.

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Chapter 1

Economic growth, environmental constraints and convergence: the declining growth premium for developing economies

Economic growth, environmental constraints and convergence: the declining growth premium for developing economies

Abstract

This paper aims to model the connection between economic growth and the environment, assuming that developing economies face an environmental constraint that developed economies did not suffer when they started their processes of economic development. Following the model of Lucas (2000), this paper simulates world income dynamics since the year 1800, setting up the parameters such that the model accurately describes the world economy by the year 2020. The original model is enriched by adding an environmental constraint so that follower economies face a declining growth premium after 1970. The model also forecasts income dynamics until the end of the 21st century, which allows testing the effects of the environmental constraint on followers in the future. The simulations predict that convergence to upper-middle and high-income per capita levels will slow down and so will the pace of reduction in across income inequality worldwide. These results suggest that a strategy of "grow first, then clean up", typically derived from the existence of an environmental Kuznets curve (EKC), is not necessarily valid for today developing countries. Instead, the results would suggest the implementation of a policy of "clean up in order to grow", but growing less.

***JEL classification**:* O44, O47, Q56

Keywords: Economic growth; environmental Kuznets curve; environmental constraint; developing economies; growth premium; convergence; across income inequality

1. Introduction

During the summit of leaders from the Group of Seven (G7), on August 2019, French president Mr. Emmanuel Macron sent a message to the Brazilian president, Mr. Jair Bolsonaro: "The Amazon forest is a subject for the whole planet. We can help you reforest. We can find the means for your economic development that respects the natural balance. But we cannot allow you to destroy everything".

Macron accused Bolsonaro of fostering economic growth (especially soy production) by destroying the environment and called for a stop in intentional fires that deforest the Amazon in order to expand agriculture. This simple message provides a hint on how the link between economic growth and the environment may be different in developing countries from developed countries nowadays.

During the last three decades approximately, the link between economic growth and the environment has been approached from the theoretical framework of the environmental Kuznets curve (EKC). The EKC, firstly introduced by Grossman and Krueger (1991), describes an inverted-U relationship between some pollutants and GDP per capita. The idea of this inverted-U relationship is that at early stages of economic growth the environment deteriorates, but after a certain level of income per capita pollution starts decreasing.

Evidence regarding the existence of the EKC is weak and, as pointed out by Stern (2017), most empirical estimations are not statistically robust. The debate, in general, has moved between those researchers supporting and those questioning its existence. There is also a third view, such as that of Dasgupta et al. (2002), for which the EKC holds, but due to technological progress and the effects of globalization, has become flatter in developing countries.

If it could be proven that the EKC actually holds, then it would be possible to break the link between economic growth and environment deterioration. Indeed, pollution would reach a peak after which countries would experience an improvement in environmental quality. If the EKC did not hold, instead, economic growth would always imply higher levels of pollution and, hence, contamination would eventually constrain the economy. These conclusions, however, seem to fit better the case of developed countries. Indeed, they are not straightforward when focusing the attention on developing economies since, a *priori*, the following three scenarios are possible:

1) If the EKC holds, then the later a country starts to grow the more countries will stand on the right side of the curve, where pollution is low and deterioration has stopped. If this is the case, it may be assumed that the income elasticity of demand of goods that are intensive in the use of the environment should decrease as more countries develop, reducing the production possibilities for new entrants and developing economies.[1] This is just the extrapolation to the case of environmental goods of the hypothesis of Prebisch (1950) and Singer (1950) regarding the elasticity of demand of primary goods. Under this hypothesis, new entrants would be forced to integrate to the international market by producing goods that are less intensive in the use of the environment.

2) If the EKC is flatter, such as Dasgupta et al. (2002) propose, then this would be due to technological progress and the effects of globalization over the ways of production in developing countries. However, these technologies are more expensive than polluting technologies and sometimes difficult to adapt in developing economies. Moreover, the cost of having to produce in a less polluting way reduces the relative rate of return of investments for multinational companies in developing economies.

3) If the EKC does not hold, then for sure economic growth hurts the environment and the constraint is a fact not only for followers but also for developed economies.

[1] Please note that "entrants" are lagged economies that start their catching-up processes, while "developing economies" are "late entrants" or "followers" that today are still far away from convergence to high levels of income per capita.

In either scenario, the environment would pose a restriction to developing economies that today developed countries did not face when they started growing. Indeed, most of today developed economies, in the past, used the environment without limitations to foster economic growth.

It seems challenging, then, to find a proper way to model the environmental constraint developing economies face nowadays. This paper aims at modelling this constraint by resorting to the model of Lucas (2000). In a simplified version of the model of Tamura (1996), Lucas tries to explain world income dynamics since the Industrial Revolution until the end of the 21st century. It assumes that a leader economy starts growing in 1800, with the Industrial Revolution, and after that followers start growing in different years, according to a certain probability that depends on the world average income and the fraction of economies that are already growing. When a follower starts to grow, it does it at a higher rate than the leader, since it can benefit from technological diffusion and departs from a lower level of income per capita. The higher rate of growth constitutes a premium that depends on the distance between the income level of the follower and the leader. The later a follower starts to grow, the higher the gap in GDP per capita will be and, thus, the initial rate of growth.

In contrast to this latter assumption, it is assumed in this paper that the premium, since 1970, decreases due to the existence of an environmental constraint. In consequence, from that year on, the later an economy starts to grow, the lower the initial rate of economic growth will be. Overall, the assumption will be that the environmental constraint depends on the world aggregate consumption and the relative global scarcity of environmental goods, using the Ecological Footprint (EF) as a proxy variable for global consumption of environmental goods. Since EF surpassed the value of one earth in 1970, it seems the right year to introduce the constraint.

The introduction of the environmental constraint implies, then, a lower rate of economic growth for developing economies, reducing their pace of convergence to high levels of income per capita. Moreover, it gives rise to a flatter EKC in developing economies and challenges the idea of "grow first, then clean up", a policy implication derived from the existence of a pronounced EKC.

This paper is organized as follows: Section 2 outlines the literature review; Section 3 presents a modified version of the model of Lucas (2000), which includes the aforementioned environmental constraint; Section 4 condenses the main findings of the simulations and compares them with those of the original model; Section 5 presents the policy implications and concluding remarks.

2. Literature review

The economic literature focused on the analysis of the link between economic growth and the environment is certainly vast and difficult to cover completely. However vast, the literature has not been able to shed light on this relationship and come up with an incontestable conclusion. Indeed, like Brock and Taylor (2004) state, the relationship between economic growth and the environment is and maybe will always remain controversial.

Starting back in the 1970s, Meadows et al. (1972) pointed out that continuous economic growth was not desirable since it had detrimental effects over the environment, increasing pollution, exhausting non-renewable resources and overexploiting renewable resources. Georgescu-Roegen (1976) also stressed that, maybe, reaching long-term sustainable economic growth was neither possible nor desirable. This first literature considered that the only way to reduce the negative impact of economic activities over the environment was by reducing economic growth.

Almost immediately, many scholars reacted, pointing out that such a sceptical view was missing the fact that when countries become richer the population calls for environmental improvements and governments have to invest resources in order to reduce pollution. This is, for example, the view of Beckerman (1992). In addition, some authors like Simon (1981), affirmed that the market would play its role as well, increasing the price of the environmental goods and reducing their demand. Grossman and Krueger (1991, 1995) also supported the idea that economic growth was a necessary condition for countries to be in the position to carry out environmental policies to mitigate its negative impact. Moreover, they found an inverted-U relationship between some pollutants and GDP per capita, which later was called the environmental Kuznets curve (EKC) by Panayotou (1993). According to the EKC, when countries are in their early stages of economic growth, the environment deteriorates, but after a certain threshold of income per capita pollution starts decreasing. Thus, economic growth and the environment are not necessarily in conflict.

During the last decades, the EKC has become the dominant theoretical framework to model the relationship between economic growth and pollution. According to Pasten and Figueroa (2012), the two main theoretical explanations for the EKC are those based in the roles played by technology and preferences. As Pasten and Figueroa identify, the typical approach has consisted on resorting to static general equilibrium models in which a representative agent maximizes a utility function that is increasing in consumption and decreasing in pollution. Additionally, pollution constitutes also a factor of production for consumer goods. In this framework, it can be proven that if the elasticity of substitution between factors is constant and the elasticity of the marginal utility of consumption is increasing, then preferences will be the drivers of the EKC relationship. Instead, if the elasticity of substitution is increasing, then the driver will be the technological progress. Plainly explained, when income per capita increases, it will be possible to find an EKC the easier it is to substitute other production factors for pollution and the lower it is the increase in utility when consumption increases.

Brock and Taylor (2010) find a connection between the EKC and the Solow model and propose a “Green Solow Model”. In this model, it is assumed that economic growth creates pollution, but it is possible to find an EKC by investing part of the output in pollution reduction. This approach, however, presents important problems. Stefanski (2013), for instance, indicates that the model assigns all the weight to changing GDP growth and does not consider changes in the intensity of emissions.

Along with the theory, empirical applications on the EKC have proliferated as well. Shafik (1994) works with a panel of up to 147 countries and finds that local air pollutant concentrations decrease after a turning point of around $4.000 in income per capita. Selden and Song (1994), focusing on OECD countries and a small sample of developing economies, found a somewhat higher turning point, or around $10.000, similar to the estimates of Cole et al. (1997), which focuses only on OECD countries. List and Gallet (1998) find a turning point in the United States of over $22.000 for sulfur emissions.[2]

A large literature has found that, instead, the relationship between emissions of some pollutants such as carbon dioxide and sulfur and income per capita is monotonic. Stern and Common (2001) include time effects in their estimation and find a monotonic relationship between sulfur emissions and income per capita in a wide sample covering both developed and developing countries. Stern et al. (2017) estimate the relationship between emissions and income using long-run growth rates and find that, even when the EKC term is significant for carbon and sulfur dioxide emissions, the turning points are out of sample for the whole data set.

Overall, as Stern (2017) points out, the only robust result from the empirical applications is that concentrations of pollutants tend to decrease while emissions tend to increase monotonically with income per capita.

Now, what role do developing countries play in this analysis? Arrow et al. (1995) and Stern et al. (1996) affirm that, even if the EKC existed, that would be due to the effects of free trade, which distributed the polluting industries among developing countries. This argument has important consequences for developing economies since, if this was the case, it should be noted,

[2] All turning points estimated in PPP 1990 US dollars.

the process would eventually come to a stop. Indeed, in order for the EKC to hold in developing countries, these would have, at some point, to distribute their polluting industries among even less developed countries. Evidently, this process cannot last forever. There should always exist a group of countries in which the EKC does not hold. These countries would concentrate the world polluting industries and they would increasingly deteriorate their environment. Hence, global consumption of environmental goods would not decrease and the EKC at world level would not hold.

Moreover, the conclusions of Arrow et al. (1995) and Stern et al. (1996) contradict the empirical evidence. Dasgupta et al. (2002) affirmed that the EKC is flatter in developing countries due to the effects of economic liberalization and the pressure from market agents. On the one hand, economic liberalization derived, mostly, in the outsourcing of labor-intensive economic activities and information services, which are not particular pollution-intensive. In addition, economic liberalization would have facilitated the diffusion of clean technologies to developing countries (which are available at incremental costs, of course). On the other hand, pressure from market agents takes the form of scrutiny of multinational firms from consumers, environmental organizations and investors in developed countries not to increase pollution in developing countries.

More recently, Zhao et al. (2013) show that energy conservation policies and emission control during the period 2005-2010 in China led to improved energy efficiency and the reduction of emissions for some pollutants, such as sulfur dioxide and primary particulate matter.

Evidence from developing countries would suggest that they adopt clean technologies before, in comparison to what developed economies did in the past. Hence, a strategy of “grow first, then clean up”, derived from the existence of a pronounced EKC, is not necessarily valid. The model developed in the next section provides a possible theoretical framework for this empirical evidence.

3. The model

Following Lucas (2000), it is possible to think of a world in the year 1800 in which many economies are all stuck at pre-industrial levels of GDP per capita. For simplicity, it is assumed that all of them have the same population and the same GDP per capita, which for the purposes of this paper is set at $1,200 (in international dollars in 2011 prices). This level of income per capita is estimated using the available data retrieved from the Maddison Project Database (2018) and approximately represents the world average GDP per capita in the year 1800.[3]

The world of the year 1800 has then many stagnant economies ready to start to industrialize. However, not all the economies start growing at the same time. One of all the economies starts first while the rest must wait until period 1800 + t in order to begin the race to development.

The first economy that starts growing, it is assumed, does it at a constant rate of 1.7% per year (per capita growth)[4]. The calibration of the model is such that an economy that starts growing in the year 1800 will have by the year 2020 a GDP per capita of around $50.000. This value is a bit lower than that of the US, which is the leader economy nowadays. However, it is a fairly close reflection of the current per capita GDP of the top three to five industrialized economies.

When a stagnant economy begins to grow, it does not grow at the same rate of the leader. The rate of growth of the entrant will be that of the leader plus a premium that depends on the gap between the income per capita of the leader and the entrant. The later a country starts to grow, the larger the income gap is and, hence, the higher the initial rate of GDP per capita growth will be. Additionally, as the follower converges to the leader's income per capita level, the premium vanishes and the rate of growth converges to 1.7% per year, the same of the leader. Unfortunately, the model will not be able to account for the US economy surpass over the UK

[3] Calculations are made using the simple average for countries for which there is available data for the year 1800. In Lucas' original model, this value is set at $600 in 1985 US dollars. Adjusting Lucas' value for inflation results in a similar value to the $1.200 used in here.
[4] In Lucas' original model, per capita growth is set at 2% per year.

economy. Nevertheless, this is a necessary limitation the model has to deal with for the sake of simplicity.

The model, up to know and letting aside the different calibration, works exactly like proposed by Lucas (2000), at least until the year 1970. Until then, only the calibration suffered minor changes with respect to Lucas' so to better fit the data, given that two decades passed since Lucas firstly introduced this simple and straightforward model. After 1970, further changes other than calibration are assumed. In particular, until 1970 it is assumed that the growth premium works in the same way it does it in Lucas' model, adding a fix premium that, given the calibration of the model, is around 0.015 every fifty years[5]. This implies that an economy that starts growing in 1850 will do it at 0.017 + 0.015 ≈ 0.032 ≈ 3.2%; an economy that starts in 1900 will do it at 0.017 + 2*0.015 ≈ 0.047 ≈ 4.7% and so on.

After 1970 the story changes. The choice is a bit arbitrary but is founded on the fact that the Ecological Footprint (EF) reached the value of one earth that year, and then continued to increase. As a result, it is assumed that from that year on, as EF increases, followers cannot use environmental goods with the same intensity that leader economies did it in the past. The EF measures the amount of productive land and water the world population needs in order to produce all the goods it consumes and to absorb all the waste it generates every year. If it surpasses the value of one earth, that means that the world population is consuming more productive capacity than the one available. Hence, it is assumed that after 1970, just like in the case of any other intertemporal budget constraint, it is impossible to spend more environmental goods than those the earth regenerates. Scarcity constitutes a restriction that developed economies did not face in the past and that now are in a better position to deal with than developing economies. Thus, a model assumption will be that the growth premium has a negative relationship with EF starting in 1970, reducing the rate of growth of followers.

[5] In Lucas' original model, the premium is 0.025 instead of 0.015.

Both stories are better understood when presenting the equations of the model. The notation used is the same proposed in Lucas (2000). Firstly, $y(s,t)$ is the income per capita of the economy s at time t. The leader's income per capita is given by

$$y\,(0,t) = y_0(1\ +\ \alpha)^t \qquad (1)$$

where s = 0 and $y_0 = 1.2$ ($1,200).

For s = 1, 2, 3… it is assumed that

$$\frac{y(s,t+1)}{y(s,t)} = (1+\ \alpha)(\frac{y(0,t)}{y(s,t)})^{\beta} \qquad (2)$$

where $\alpha = 0.017$ and β = 0.017 for $t < 1970$, while for $t \geq 1970$, instead, depends on EF and is given by

$$\beta(\mathrm{EF}) =\ \beta\,[1 - (W_m \exp(1 - \mathrm{EF}) +\ W_M\,(1 -\ \exp(1 - \mathrm{EF}))\,)\,] \qquad (3)$$

In equations (2), β constitutes the variable that relates the income gap between the leader and the followers to their relative growth rates. Equation (3), basically, is the one that makes this model differ from that of Lucas (2000). In equation (3), EF is nothing but the Ecological Footprint, which was below 1 until 1969 but then kept on growing until reaching 1.75 in 2019. The variable W is what Lucas calls a hazard rate, which in this setup reduces β depending on the value of EF. When EF ≤ 1, it is assumed that β is not affected. However, when EF > 1, the hazard rate tends to W_M as EF grows, reducing β and, through β, the growth premium. The model is calibrated with two possible hazard rates, $W_m = 0.001$ and $W_M = 1$.

Equation (3) accounts for the fact that the environment poses a constraint to the economic growth of the followers, but not of the leader, who will keep on growing at 1.7% per year. In addition, followers that started their catching-up processes before 1970 suffer less the premium reduction the earlier they started to grow, since the reduction only affects the years after 1970, in which most followers starting way before have already converged.

The story after 1970, hence, goes on in the following way: if a country that started growing in 1950 could do it at 0.017 + 3*0.015 ≈ 0.062 ≈ 6.2% per year, one starting in the 2000 would start growing at around 5.9% per year. Moreover, with an EF=1.75, like in the year 2019, a country that starts growing today would experience a rate of economic growth of around 4.8%. It is clear, then, that starting later implies less initial economic growth.

Now, the probability that an economy starts to grow at time t is $\pi(t)$ and is given by

$$\pi(t) = \lambda(t)[1 - \textstyle\sum_{s<t} \pi(s)] \qquad (4)$$

where $\lambda(t)$ is the probability that growth begins in period t given the fact that the economy was stagnant up to time t.

It is also possible to define $x(t)$ as the average world income in period t:

$$x(t) = \textstyle\sum_{s\leq t}(\pi(s)y(s,t)) + [1 - \sum_{s\leq t} \pi(s)\,]\,y_0 \qquad (5)$$

Just like in the original model, it is assumed that the fraction of economies that starts to grow in each period depends on the average world income in every period such that

$$\lambda(t) = \lambda_m \exp\big(-\delta(x(t) - y_0)\big) + \lambda_M[1 - \exp\big(-\delta(x(t) - y_0)\big)] \qquad (6)$$

where λ_m and λ_M are positive. When $t = 0$, $x(t) = y_0$ and then $\lambda(0) = \lambda_m$. As t increases and approximate infinite, then $\lambda(t)$ tends to λ_M.

In equation (6) λ_m= 0.00005 and $\lambda_M = 0.03$.[6] This set up tries to account for the fact that development spread slowly during the 19th century and speeded up after World War II.

Finally, the following formula defines the log standard deviation $V(t)$ of income levels and is calculated in order to have a rough measure of across income inequality:

$$[V(t)]^2 = \textstyle\sum_{s\leq t} \pi(s)\,[\ln\,(\frac{y(s,t)}{x(t)})]^2 + [1 - \sum_{s\leq t} \pi(s)][\ln\,(\frac{y_0}{x(t)})]^2 \qquad (7)$$

[6]In Lucas' original model, $\lambda_m = 0.001$ and $\lambda_M = 0.03$.

The model is solved in the following way: $y(s,t)$ and $y(0,t)$ are calculated using equations (1) and (2), in which $\beta = 0.017$ for $t < 1970$ or is given by equation (3) afterwards. Using equations (4), (5) and (6), $\pi(t)$, $x(t)$ and $\lambda(t)$ are calculated recursively. For $t = 0$, $x(0) = y_0 = 1.2$. Hence, according to equation (5), $\lambda(t) = \lambda(0) = \lambda_m$. When $t > 0$, first $\pi(t)$, $x(t)$ and $\lambda(t)$ should be calculated for $s < t$. Then, using $y(s,t)$ and equation (5), $x(t)$ is calculated, using $x(t)$ and equation (6), $\lambda(t)$ is calculated and, finally, using $\lambda(t)$ and equation (4), $\pi(t)$ is calculated.

In the following section, the model is simulated and the main results are presented.

4. Results

4.1. Predictions for the world economy

In order to understand the implications of the model, Figure 1 presents four possible paths or scenarios for the world economic rate of growth.

The first path (F-ER: full environmental restriction) shows the baseline model presented in Section 3, in which the environmental restriction fully affects the rate of growth of followers after 1970 according to what is stated in equation (3). For the calculations, the EF series was retrieved from the website of the Global Footprint Network (2019)[7]. In order to estimate EF after 2019, a constant rate of growth was assumed, driving EF to around 2.2 earths in 2050 and 3.2 in 2100.

The second path (I-ER: intermediate environmental restriction) shows the estimates for the world economy in the case that EF, which was 1.75 in 2019, remains in that level in the long term. Hence, no improvement is assumed, but at least deterioration would stop worsening.

[7] Retrieved from https://www.footprintnetwork.org/ in March 2020.

The third path (N-ER: no environmental restriction) shows the counterfactual case of a world economy in which no environmental restriction exists. In other words, this model is assuming that EF=1 for the whole period covered after 1970. In this scenario β=0.017 always and, hence, followers can always growth faster the later they start to grow.

In the last path, the fourth one, the estimates of Lucas (2000) are depicted.

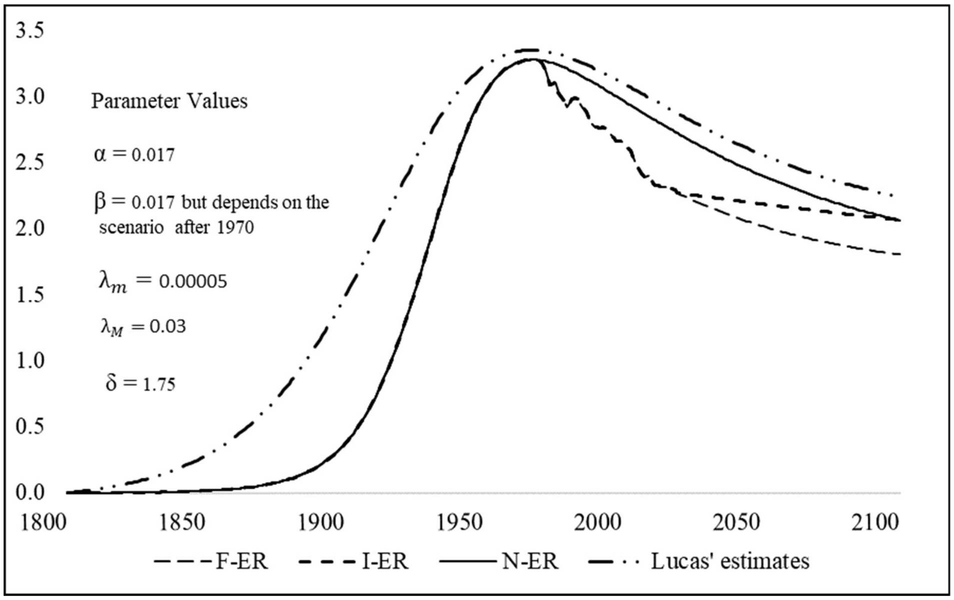

FIGURE 1: WORLD GROWTH SCENARIOS

Notes: F-ER stands for "Full Environmental Restriction", I-ER stands for "Intermediate Environmental Restriction", and N-ER stands for "No Environmental Restriction". F-ER assumes that the ecological footprint follows a constant rate of growth after 2019, reaching 2.2 earths in 2050 and 3.2 in 2100. I-ER assumes that the ecological footprint remains in 1.75 earths in the long term. N-ER assumes the counterintuitive case in which the ecological footprint is equal to 1.

It is possible to observe in Figure 1 that the model presented in Section 3 improves the performance of the original one in at least two key ways. Firstly, the model predicts a peak in world economic growth that is slightly below the one estimated in Lucas (2000). This constitutes an attempt to approach Lucas' appreciation that his model has actually overstated the peak. The overestimation is a fact in Lucas' model, according to which world income per capita should have been around $27,000 (in 1985 US dollars) in 2018. This value is extremely higher than the actual value for that year, even under the best-case scenario. Indeed, according to the series in 2011 international dollars of the World Bank, world income per capita would have reached $16,000 in 2018. It would have been lower according to the Maddison's project database.

Secondly, the model is able to predict a more realistic rate of growth until the end of the 21st century. According to Lucas' results, the growth rate of income per capita estimated for the next three decades (until 2050) would be, on average, 2.7%. This value overstates growth in a way that is far beyond reality. Indeed, income per capita growth has been over 2.7% in only four years during the last two decades, moving in general below the 2% during the last years. The problem is that small overestimations in the rate of growth produce large differences in the long term, creating a picture of the world economy by 2100 that is far away from the world possibilities of production.

In the F-ER scenario, the growth rate of income per capita should be around 2.27% nowadays (more in line with today's rate of growth), falling below 2% in the 2050s and converging to around 1.8% at the end of the century. The rate of growth at the end of the century is 0.43% less than that estimated in Lucas (2000) and around 0.25% less than in the cases of the N-ER and I-ER scenarios. The comparison between the F-ER and N-ER scenarios shows in a simple way the potential economic gains the world could experience if environmental goods were infinite.

Figure 2 shows GDP per capita paths in the F-ER scenario for selected economies that start growing in 1800, 1850, 1900, 1950 and 1990, and the actual path for the UK and US economies. It can be noted in Figure 2 that the slope of a follower starting in 1990 grows at a lower rate than that of those starting before. In addition, the model predicts that followers starting in the 19th century and in the beginning of the 20th should have converged by now, while those starting in the post war period should have more than 40% of the leader's income per capita.

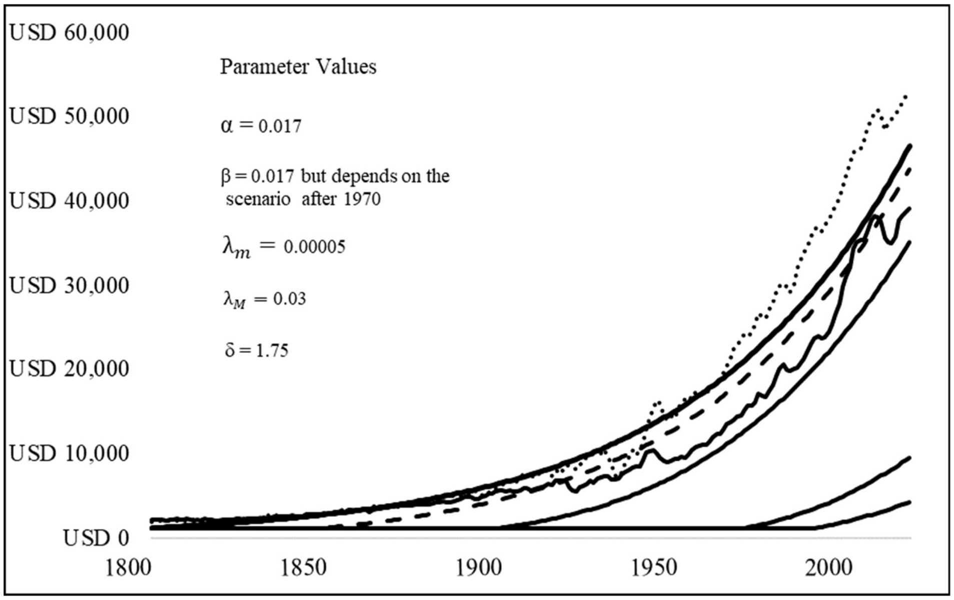

FIGURE 2: INCOME PATH, SELECTED ECONOMIES (IN 2011 INTERNATIONAL DOLLARS)

Figure 3 presents the support to understand why the peak took place around 1970. A long view analysis of the world economy shows that the Industrial Revolution started in England around 1750-1800, then it spread to a few countries around 1870 and finally it expanded to many economies after World War II. The main reason why the world economy experienced the peak in economic growth around 1970 is given by the large fraction of economies that started growing in the post war period.

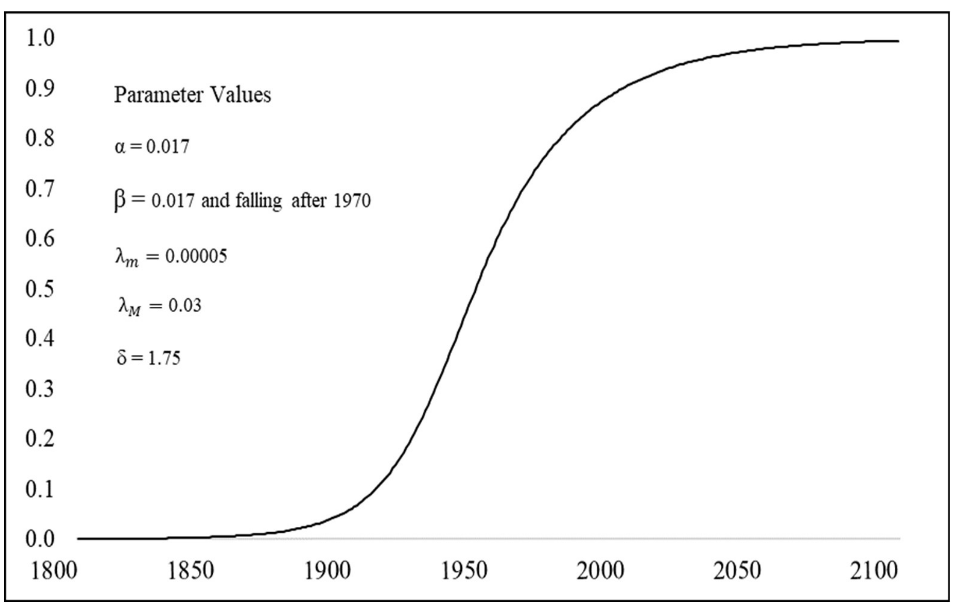

FIGURE 3: FRACTION OF ECONOMIES GROWING (F-ER SCENARIO)

As shown in Figure 3, the model predicts that, by now, around 95% of the world economies should have started growing and should have surpassed the threshold of $1,200. An overview of the available data from the World Bank dataset shows that in 2018 there were still six economies with a GDP per capita below the threshold, nine below $1,500 and twenty below $2000. All these economies, with the exceptions of Haiti and Afghanistan, were situated in Africa.

The main flaw of the model is that it understates economic growth in the 19th century. Indeed, following Maddison (2001), the world rate of growth of income per capita before 1820 is estimated to be nearly 0% (around 0.05%). However, between 1820 and 1870 income per capita growth should have accelerated to average 0.53%, speeding up even further after 1870. This model, clearly, understates this rate. Nevertheless, in a long view perspective, differences are corrected over time. Maddison reports a rate of growth of income per capita of 1.21% for the period between 1820 and 1998. This model is in line with these empirical results, estimating 1.29%. Instead, Lucas (2000) highly overstates growth, estimating a growth rate of 1.81%.

4.2. Predictions for followers starting after 1970

The model predicts that the reduction in world growth would be a consequence of the slowdown of followers, whose rate of growth would decrease after 1970 depending on the strength of the environmental constraint. Since followers at the beginning of the 20th century or before should have converged by the time EF surpasses 1, the reduction of growth affects economies more the later they start to grow. The recent dynamic followed by EF poses a challenge to the fraction of economies that, still, are not growing or are in their initial phases of development. The later an economy starts to growth, the more critical the environmental restriction becomes and the lower the initial rate of growth. If, as expected, EF reaches 2.2 by 2050, the value of β would collapse to around 0.005 and the initial rate of per capita GDP growth for an entrant in that year would be only 3.9%.

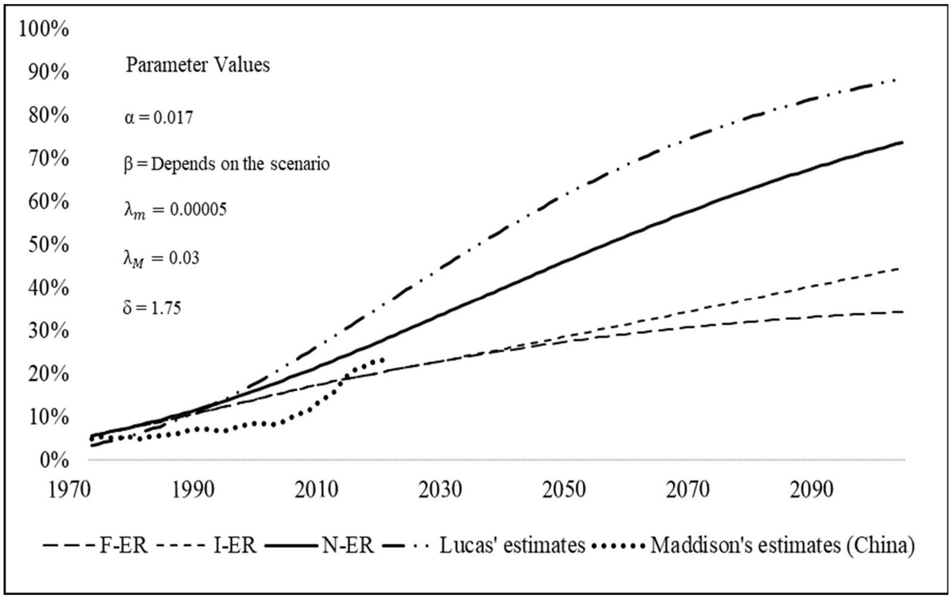

FIGURE 4: CONVERGENCE TO THE LEADER'S GDP PER CAPITA OF A FOLLOWER STARTING IN 1970

Notes: F-ER stands for "Full Environmental Restriction", I-ER stands for "Intermediate Environmental Restriction", and N-ER stands for "No Environmental Restriction". F-ER assumes that the ecological footprint follows a constant rate of growth after 2019, reaching 2.2 earths in 2050 and 3.2 in 2100. I-ER assumes that the ecological footprint remains in 1.75 earths in the long term. N-ER assumes the counterintuitive case in which the ecological footprint is equal to 1.

Figure 4 presents the convergence path for a hypothetical follower that starts growing in 1970 under the four scenarios and the real path followed by China with respect to the US economy according to the series retrieved from the Maddison Project Database (2018).

China, indeed, had in 1970 a GDP per capita of around $1,200 and, by 2020, should be moving around $13,000 to $14,000.[8] If the estimates of the model are accurate, China would not be able to close the gap with the leader economy during the 21st century and, due to the environmental restriction, the speed of convergence would fall. In the F-ER scenario, the Chinese GDP per capita would converge, by the end of the 21st century, to 34.6% of that of the leader from today's

[8] Note that China started its catching-up process after 1970. Maddison (2006) affirms that economic growth was fast in the communist period until the mid-1970s but, however, it was during the reform period, after 1978, that economic growth speeded up as the country progressively opened up to international trade and carried out pro-market reforms. The assumption of 1970 as the entrant year for China is supported by the fact that the threshold of $1,200 was surpassed that year. The same logic is used in the case of India, taking the year 1989 as the beginning of the catching-up.

23.2%[9]. In the I-ER and N-ER scenarios, China would reach 44.4% and 72.7% respectively. It seems that convergence would be possible only if the environmental restriction did not hold.

The Chinese example deserves a proper analysis but, *a* priori, the model appears to be useful. Indeed, the dilemma between economic growth and environment deterioration is present in nowadays China and, though in a simple manner, this model provides a tool for making predictions under different scenarios. Song and Woo (2008) argue that China, in the 21st century, will face the challenge to bring its growth path in line with environmental sustainability. Linster and Yang (2018), moreover, provide a good overview of the environmental problems high economic growth generated in China.

Additionally, in line with Barro (2016), the model predicts a slowdown in the Chinese rate of GDP per capita growth, to around 3% during this decade and to an average of 2.5% between 2030 and 2050. China, in consequence, would not be able to escape the "iron law of convergence".

The case of India, the second most relevant follower that entered the race to development in the 1990s, is similar to the Chinese. The model calibration allows roughly explaining the evolution of GDP per capita in India, an economy that reached an income per capita of $1,200 in 1988 and is now around $6,000. Its growth, however, having entered later than China, is lower, as predicted by the model and corroborated by the data. Figure 5 delineates the path for an entrant in 1989.

[9] The last ratio calculated, due to the availability of data from the Maddison Project Dataset, is for the year 2016.

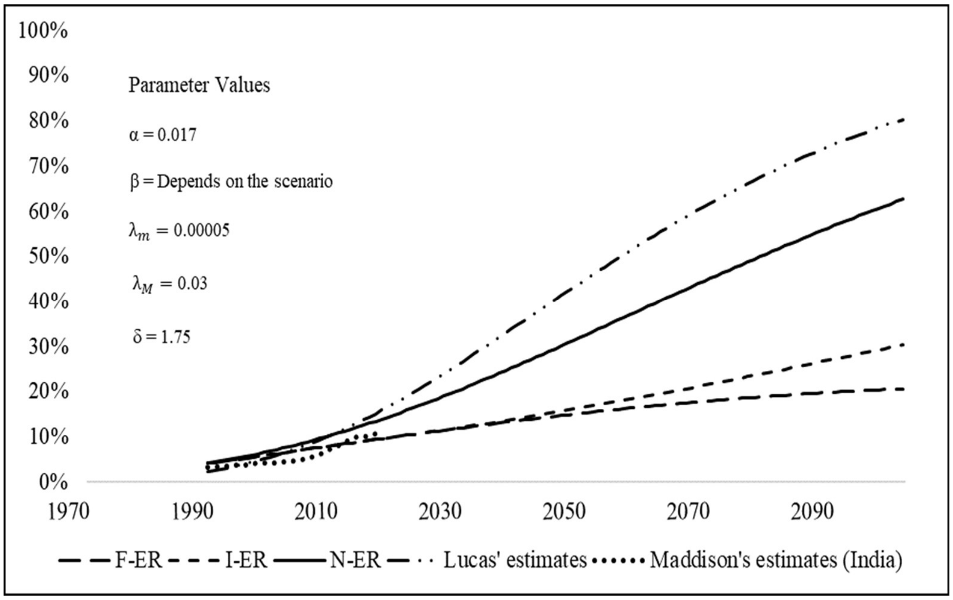

FIGURE 5: CONVERGENCE TO THE LEADER'S GDP PER CAPITA OF A FOLLOWER STARTING IN 1989

Notes: F-ER stands for "Full Environmental Restriction", I-ER stands for "Intermediate Environmental Restriction", and N-ER stands for "No Environmental Restriction". F-ER assumes that the ecological footprint follows a constant rate of growth after 2019, reaching 2.2 earths in 2050 and 3.2 in 2100. I-ER assumes that the ecological footprint remains in 1.75 earths in the long term. N-ER assumes the counterintuitive case in which the ecological footprint is equal to 1.

Lucas (2000) estimated a rapid convergence path for followers starting in 1970 and 1989. Lucas' results were extremely optimistic, expecting a follower like China to close the gap with leader economies by the end of the century (reaching 86.8% of the leaders' income per capita) and a follower like India to reach 80.5% of the leaders' income per capita. Instead, the model presented in Section 3 seems more realistic. The existence of different scenarios provides a range of possibilities to predict the convergence of followers starting after the 1970s. The N-ER scenario, probably, is optimistic too, and even when it could describe the path for some particular followers, it does not seem to be the general rule. The I-ER provides a possible convergence path for those who find the F-ER to be pessimistic. It should be noted that, being China and India outstanding performing economies in recent years, it may be possible that the model, focusing more on "average followers", slightly understate their convergence path in both the F-ER and I-ER scenarios.[10]

[10] Note that the real ratios for 2016 are calculated with respect to the US GDP per capita and not to the main three to five industrialize countries. Otherwise, the ratios would be slightly higher.

It should also be noted that the model does not aim at explaining the exact path of followers separately. Instead, it constitutes a general framework to understand economic growth from a long view perspective. Even when not the Chinese case nor the Indian one are the subjects of research of this paper, it is important to observe that the model could easily find its way into the recent debates relating economic growth and environmental sustainability in developing economies.

4.3. Estimates for across income inequality

The model is not only able to predict the GDP per capita growth peak around 1970, but also the peak in across income inequality in the end of the 1990s. Figure 6 depicts the patterns followed by income variability in the four scenarios. In the first three scenarios, the peak in across income inequality is found in the end of the 1990s. This result is different from that of Lucas (2000), in which the maximum income variability is reached at some point in the 1970s. However, Lucas' results are not in line with the empirical evidence.

Milanovic (2012) presents three different concepts of income inequality. The simplest concept among the three (Concept 1) consists of the calculation of a Gini coefficient for 150 countries worldwide without population weighting. In this concept, each country enters the calculation with its average GDP per capita. Milanovic estimates the peak in across income inequality for Concept 1 at the end of the 1990s, decreasing after.

As already mentioned, Lucas (2000) finds the peak in the 1970s. This would be correct if the model was estimated using population weighting. Indeed, according to Milanovic (2012), but also to Sala i Martin (2006), among many others, when properly measuring income inequality weighting by country population, the convergence in across income inequality is found to have started in the 1970s. However, Lucas' model does not apply population weighting and, hence, the peak in across income inequality should be found in the end of the 1990s instead of in the mid-1970s.

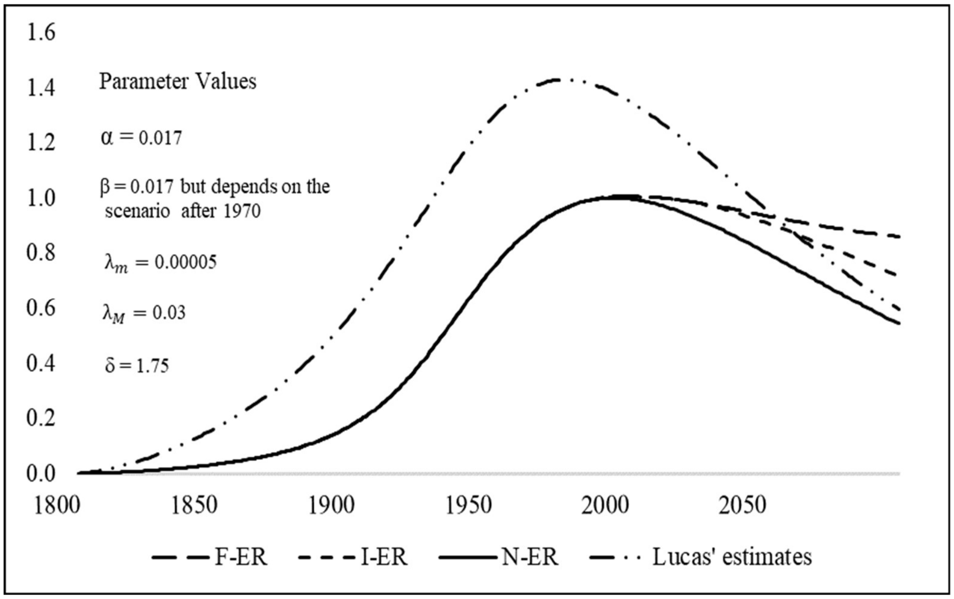

FIGURE 6: WORLD INCOME VARIABILITY

Notes: F-ER stands for "Full Environmental Restriction", I-ER stands for "Intermediate Environmental Restriction", and N-ER stands for "No Environmental Restriction". F-ER assumes that the ecological footprint follows a constant rate of growth after 2019, reaching 2.2 earths in 2050 and 3.2 in 2100. I-ER assumes that the ecological footprint remains in 1.75 earths in the long term. N-ER assumes the counterintuitive case in which the ecological footprint is equal to 1.

Figure 7 presents the ratio between world income per capita and the leader's income per capita since 1800, always in the four scenarios. The model correctly predicts the reduction in the ratio during the whole 19th century. It also accurately predicts that the ratio finds its minimum at the beginning of the 20th century, remaining more or less stable for some time. Lucas (2000) estimated convergence to start in the 1910s, while the model presented here estimated convergence to start in the 1940s.

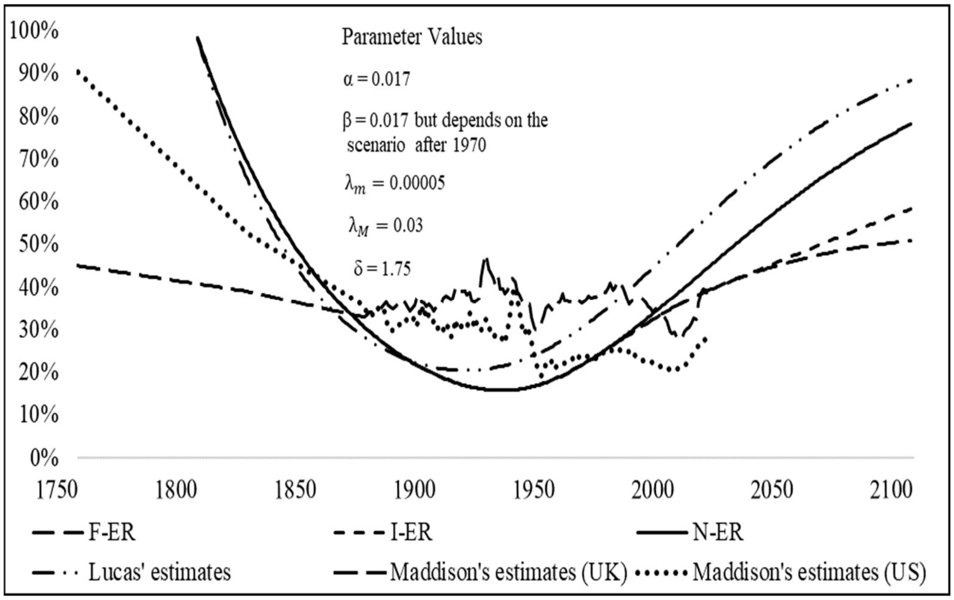

FIGURE 7: WORLD INCOME PER CAPITA AS A FRACTION OF THE LEADER'S

Notes: F-ER stands for "Full Environmental Restriction", I-ER stands for "Intermediate Environmental Restriction", and N-ER stands for "No Environmental Restriction". F-ER assumes that the ecological footprint follows a constant rate of growth after 2019, reaching 2.2 earths in 2050 and 3.2 in 2100. I-ER assumes that the ecological footprint remains in 1.75 earths in the long term. N-ER assumes the counterintuitive case in which the ecological footprint is equal to 1.

Figure 7 also presents the real evolution of the ratio between world income per capita and the income per capita of the UK and US economies since 1750. As it may be observed, the model decently fits the data, in which convergence also starts in 1940s. Here, it should be considered that estimates before 1870 were calculated using the Maddison's project series with base year 1990, while for those after 1870 the base is 2011. Moreover, before 1950 it is possible to count on data only for particular years and, hence, linear rates of economic growth were assumed in between years.

A quick view at Figure 7 reinforces the idea that the original model of Lucas (2000) has not only overstated GDP per capita growth but has also estimated an optimistic convergence pace of the world economy to the leader's GDP per capita. According to Lucas' estimates, world income per capita would reach around 90% of the leader's by the end of the 21^{st} century. This, however, does not seem plausible in the light of the difference found between Lucas' predictions for 2020 and the actual ratio today. In fact, according to Lucas' model the ratio by 2020 should be around 0.6, when it is barely moving between 0.3 and 0.4.

Instead, even when the F-ER scenario may seem pessimistic, it is forecasting world GDP per capita to reach 50.9% of that of the leader economy by the end of the century. Thus, convergence would continue in the remainder of the 21st century, but at a slower pace. If the environmental restriction is relaxed and the premium stops decreasing from now on, the I-ER scenario would predict a faster convergence to almost 58.5% of the leader's income per capita. The N-ER has the same flaws presented for the model of Lucas (2000) and does not seem plausible either.

5. Conclusions

This paper has tried to model the connection between economic growth and the environment, assuming that followers face an environmental constraint after 1970. This constraint was formalized by complementing the model of Lucas (2000) with a new equation that negatively affects the growth premium of follower countries after 1970. The choice of this year is founded on the fact that the Ecological Footprint (EF) reached the value of one earth that year, and then continued to increase. As a result, it is assumed that, from that year on, followers cannot use environmental goods with the same intensity that leader economies did it in the past. The model is estimated for three possible scenarios with different degrees of intensity for the environmental constraint.

As described in the previous section, the model generates accurate results in either of its scenarios. Firstly, it outlines a brief and powerful representation of the evolution of the world economy since the Industrial Revolution, with economic growth starting in a few countries during the 19th century and then spreading worldwide in the mid-20th century. Secondly, it estimates the peak of economic world growth around 1970, in line with the stylized facts in economics. Finally, it accurate finds the peak in across income inequality in the end of the 1990s.

In terms of forecasts, results vary considerably depending on the strength of the environmental constraint. However, in general, a slowdown is expected in terms of world economic growth. Lucas (2000) predicted that world income per capita would reach 88.6% of that of the leader by the end of the 21st century, while in the F-ER, I-ER and the N-ER scenarios of the model presented here it would reach around 50.9%, 58.5% and 78.4% respectively. It must be noted that convergence would be still fast in the N-ER scenario, in which the environmental constraint does not play a role.

The slowdown would affect more late followers, for which the environmental constraint becomes stronger. The model is able to show somehow the pace of convergence of late entrants to the development race, such as China in the 1970s, India around 1990 and today developing economies in general. In the case of China, for example, the model in the F-ER scenario supports the ideas of Barro (2016), predicting that China will not be able to escape the "iron law of convergence" and its income per capita growth will gradually fall to around 3% in the next decade, averaging 2.5% per year in the period between 2020 and 2050. Something similar would happen with India. Convergence would be faster in the I-ER and N-ER scenarios and, of course, much faster in Lucas (2000).

As it may be easily noted, the model has strong implications for the debate regarding the existence and shape of the environmental Kuznets curve (EKC) in developing countries. Indeed, the environmental constraint that late followers face forces them to reduce economic growth and pollution from the very initial phases of development. The environmental constraint implies less economic growth and allows for a flatter EKC to appear in developing countries than the one today developed economies faced when they starting catching up. Now, since followers cannot use environmental goods in the same intensive way these latter did in the past, then the EKC cannot have a pronounced inverted-U shape.

These results have two key policy implications: first, countries should make strong efforts to start growing before the restriction becomes stronger; second, countries that will be able to incorporate clean technologies before will relax the restriction and increase economic growth. The evidence in developing countries suggests that a strategy of "grow first, then clean up", derived from the existence of a pronounced EKC, is not necessarily valid. The model developed in here theoretically supports this evidence, suggesting a path of "clean up in order to grow", but growing less.

A priori, some leads for future research may be identified. For instance, expanding the time spam of analysis before 1800 and after 2100 with a different setup could improve the fit of the model, given that the path followed by the ratio between world GDP per capita and that of the UK and US is being smoother in practice than what the model predicted. Assuming that the constraint affects also the leader economy would be interesting too, such as it would be adding population weighting or making EF endogenous. Finally, developing more sophisticated functional forms to model the environmental constraint developing economies may face constitutes for sure a major challenge for future research.

The model, in general, fulfils the aim of presenting a formal analysis that allows estimating the limits that the environment may pose to economic growth in the near future, especially for developing economies. The fact that the setup and the assumptions of the environmental constraint are accurate in predicting the path of the world economy since the Industrial Revolution gives some confidence regarding the predictions for the remainder of the century.

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Chapter 2

Asymmetric responses of the markup to monetary shocks over the business cycle

Asymmetric responses of the markup to monetary shocks over the business cycle

Abstract

A rich literature has long studied the asymmetric effects of monetary policy over the business cycle, generally presenting mixed results. Most of the empirical work, however, focuses on the responses of output and prices. Given the key role it plays in the transmission of monetary policy and the relatively scarce studies on the subject, this paper centers the analysis on the dynamics of the markup. Recent empirical findings suggest that, even when the New Keynesian models are not able to reproduce such dynamic, the markup decreases in response to a monetary policy tightening shock. This paper, by putting forward a local projections approach and analyzing the response of the markup during the period 1990m2-2016m12, argues that the dynamic of the markup may depend on whether the monetary policy tightening shock takes place during a period of expansion or recession. In this latter case, for instance, the New Keynesian model seems to do a good job, suggesting that only tightening mistakes may be successfully addressed within the basic New Keynesian framework. Given that New Keynesian models constitute the main tool central banks use for policy analysis, these results have important policy implications, providing evidence that the mechanism of transmission of monetary policy through the markup would not be operative during booms.

JEL classification*:* E24, E31, E32

Keywords: Monetary shocks - business cycle - markup - asymmetric response - local projections.

1. Introduction

One of the key transmission mechanisms of monetary policy (MP) within the New Keynesian (NK) framework rests on the countercyclical behavior expected for the markup, conditional on a MP shock. As pointed out by Nekarda and Ramey (2020), the dependence of NK models on a countercyclical markup of price over the marginal cost was embraced by the literature in the early 1980s. Before the 1980s, instead, Keynesian models relied on sticky-wages for the transmission of shocks. However, arguing that these latter were at odds with the empirical evidence, most researchers shifted towards sticky-price models.

In the basic NK framework, the mechanism of transmission of monetary shocks through the markup is quite simple and appealing. Given that the price markup is defined as the inverse of the labor share, and since prices are sticky, when a contractionary monetary shock reduces aggregate demand price rigidity triggers an increase in the markup. This increase is equivalent to a reduction in unit labor costs, that pushes down inflation.

In the literature, the evidence regarding the markup's dynamics after a monetary shock does not seem to have reached definite results. Even more, empirical studies are not abundant and only some major pieces of evidence can be mentioned. In recent times, the markup is found to be procyclical in Nekarda and Ramey (2020) and in Cantore et al. (2021). These latter conclude that either the NK framework is not suitable to separate the dynamics of the markup and the labor share, or the markup is not countercyclical as expected in the NK models.

This paper aims to provide further evidence regarding the conditional response of the markup to a MP shock. In particular, it deepens the analysis by studying whether the phase of the business cycle, in which the MP innovation takes place, influences this response. An important line of the literature has focused on the asymmetric responses originated due to the fact that shocks take place at different phases of the business cycle. However, most studies center the attention on the dynamics of output, to determine whether monetary policy is more effective in booms than in recessions. Among these studies, that of Tenreyro and Twaites (2016) is one of the most influential in recent years. A detailed analysis of the literature on this topic suggests that this is the first study that focuses on the markup.

In this paper, following the identification strategy of Tenreyro and Twaites (2016), and resorting to the MP shock recently estimated by Jarociński and Karadi (2020) as external measure of the monetary innovation, the response of the markup is the focus. The empirical strategy implements a local projections (LP) approach à la Jordà (2005), and a smooth local projections approach (SLP) in the line of Barnichon and Brownlees (2019). The responses are estimated for the period 1990m2-2016m12, for which the shock is available, and controlling as well for the existence of the Federal Reserve (Fed) information shock, also estimated by Jarociński and Karadi. In order to count on monthly data, quarterly data is interpolated using the approach of Stock and Watson (2010), though it is shown that the estimations are robust to the use of quarterly data. Since the time span of estimation includes the Great Recession started in 2008 and the zero lower bound period, estimations are also carried out as a robustness check for a pre-crisis subsample.

The main result of this paper is that the response of the markup to a contractionary MP shock differs depending on whether the economy is expanding or in recession. A priori, a MP tightening that takes place in recessions reduces output but increases the markup (i.e., a countercyclical response). After a MP tightening in expansions, instead, both output and the markup display a negative response (i.e., a procyclical response), in agreement with the results of Nekarda and Ramey (2020) and Cantore et al. (2021). The findings are robust to the use of a set of alternative state of the art measures of the markup, for all the specifications proposed: in level and in first differences; for different data frequencies (i.e., monthly and quarterly observations); various control variables; and across time spans (i.e., both the full sample and pre-crisis sample).

The fact that contractionary MP shocks should not be the norm in recessions - though it is possible to find several contractionary shocks along the period under analysis - seems to suggest that the NK model cannot reconcile theory with the empirical evidence, at least not in normal times. Such findings are consistent with the findings of Cantore et al. (2021) and have important policy implications, since the role of the NK models and its transmission mechanism should be reconsidered in times of booms. Do interest rate hikes reduce inflation in times of expansion? If so, what are the operative mechanism of transmission?

How the rest of this paper is organized, is subsequently described. In Section 2, the literature review provides coverage of the two strands of existing research from which this work departs: (i) the cyclical dynamics of the markup and (ii) testing the asymmetric responses of macroeconomics variables to MP shocks over the business cycle. Then, Section 3 describes the data. Next, Section 4 details the empirical strategy and LP modelling specification to evaluate the response functions of the markup to MP shocks over the business cycle. Thereafter, the main results are presented in Section 5. Penultimately, Section 6 enumerates the extensive robustness checks performed. Lastly, Section 7 ventures some theoretical and policy implications and concludes the paper.

2. Literature review

This paper builds on two strands of literature. On the one hand, this paper is inscribed in the line of the literature focused on the analysis of the cyclicality of the markup. On the other hand, it builds on the literature testing for asymmetric responses of macroeconomics variables to MP shocks over the business cycle.

The first strand is quite large when focusing on the unconditional cyclicality of the variable, with a clearly open debate and remains without any irrefutable evidence. Countercyclicality is reported, in general resorting to definitions of the markup based on the inverse of the labor share, in Bils (1987), Rotemberg and Woodford (1991), Rotemberg and Woodford (1999), Oliveira et al. (2002), Galí et al. (2007) and Mazzoli and Lombardini (2021), among others. Acyclicality or procyclicality, instead, is found in Domowitz et al. (1986), Morrison (1994), Chirinko and Fazzari (1994), Gomme and Greenwood (1995), Haskel et al. (1995), Galeotti and Schianterelli (1998), Marchetti (2002), and Rios-Rull and Santaeulalia-Llopis (2010). More recently, Bils et al. (2018) estimate countercyclical markups again by examining self-employed and intermediate inputs, since they argue that wages may be smoothed versions of the true cyclical price of labor. The countercyclicality estimated would be compatible with high price stickiness in recessions and/or firms choosing a higher markup in recessions, as found in Gilchrist et al. (2017).

Nekarda and Ramey (2020) provide a wide range of measures for the markup, finding that, in general, estimates relying on Cobb-Douglas production functions are slightly procyclical or acyclical. Instead, those estimated through constant elasticity of substitution (CES) production functions, based on output-capital ratio and with capital utilization estimated from the workweek of capital, are moderately countercyclical.

Empirical applications analyzing the conditional cyclicality of the markup to a MP shock are, instead, scarce. Nekarda and Ramey (2020), for instance, find a procyclical response of the markup conditional on a MP shock. Cantore et al. (2021) center the analysis on the response of the labor share to a MP tightening shock and find that a MP tightening increases the labor share, concluding that either NK models are unable to separate the dynamics of the labor share from the markup or the markup does not respond in the way NK models predict. The approach of Cantore et al. is based on the use of a Vector Autoregressive (VAR) approach and estimates are presented for the United States, the Euro Area (EA), the United Kingdom, Australia, and Canada until the year 2007.

The scope of this paper, working with a set of measures of the markup, is similar to that of Nekarda and Ramey (2020) and Cantore et al. (2021), though a different empirical strategy is set forth. The use of LP provides a level of flexibility that is not present in a VAR approach. Moreover, in this paper the analysis is pushed further: do the responses of the markup depend on the phase of the business cycle the economy is going through? Consequently, as aforementioned, this paper builds on a second important line of the literature focused on the study of the asymmetric responses of macroeconomic variables originated in certain features of the monetary shocks that hit the economy.

Specifically, this literature has focused on the asymmetric effects triggered by shocks taken place at different phases of the business cycle (recession or expansion), shocks of different size (large or small) and shocks with different direction (accommodative or contractionary). Among these papers, it is possible to find Cover (1992), Morgan (1993), Thoma (1994), Kandil (1995), Karras (1996), Peersman and Smets (2001), Garcia and Schaller (2002), Kaufmann (2002), Tenreyro and Thwaites (2016) and Angrist et al. (2018). A few other pieces of work have also studied the effects of some of these dimensions simultaneously, such as Weise (1999), Ravn and Sola (2004), and Lo and Piger (2005).

The paper of Tenreyro and Thwaites (2016) is a key reference for this research. The question addressed in there, by employing a LP approach, is whether monetary policy is less effective under recessions, focusing the analysis on the US economy and using the monetary shock of Romer and Romer (2004) as the exogenous measure of the MP shock. The methodology followed in this paper closely relates to that of Tenreyro and Thwaites. Nevertheless, the focus is not put on the response of output, but on the dynamics of the markup conditional on a MP shock, and the exogenous measure of the MP shock is given by the measure estimated by Jarociński and Karadi (2020), which allows controlling for the information shock estimated by these latter as well and extend the estimation period until 2016.

Applications seeking to understand the asymmetric dynamics of the markup conditional on a MP shock that takes place at different phases of the business cycle are, to the best of the authors' knowledge, non-existent. Consequently, the empirical contribution of this paper is relevant, since it aims to provide evidence to understand how the mechanisms of transmission of monetary policy may vary across the phases of the business cycle.

3. The data

In order to apply a LP approach, it is necessary to define the dependent variables for which the impulse response functions (IRFs) will be calculated and the measure of the MP shock previously identified. This section focuses first on the dependent variables, with special focus on the different estimates for the markup used in this paper, and then turns into the analysis of the MP shock of Jarociński and Karadi (2020).

3.a. The dependent variables

In principle –beyond the robustness checks- this paper resorts to four time series for the US economy. First, real gross domestic product (RGDP). Second, a baseline measure for the markup estimated as the inverse of the labor share in the nonfarm business sector -Mu (CD)-. As stated in Nekarda and Ramey (2020), this measure of the markup is consistent with the ones measured in the NK framework and derives from the assumption of Cobb-Douglas technology and the absence of overhead labor. Third, an estimate for the markup coming from a CES production function, measured by the output-capital ratio with variable capital utilization based on the workweek of capital -Mu (CES-KVU). Fourth, a similar measure to Mu (CES-KVU) but allowing in this case for overhead labor -Mu (CES-KVU-OH).

The macroeconomic series used cover the period 1990Q1-2016Q4 and come from three different sources. The series for RGDP is retrieved from the database of the Federal Reserve Bank of St. Louis.[1] The labor share in the nonfarm business sector comes from the Bureau of Labor Statistics (BLS) and is used to calculate the baseline measure of the markup[2]. Finally, the two measures of the markup based on CES production functions are the preferred measures calculated by Nekarda and Ramey (2020).

To control for the independent effect of the season on macroeconomic variables, just like in Olivei and Tenreyro (2010), the analysis is based on seasonally adjusted data. Indeed, given the fact that MP shocks are distributed along the year, it is important to control for the different effects the timing of the shocks may carry.

Since the aim of the paper is to estimate the IRFs for these variables to the MP shock of Jarociński and Karadi (2020), using data for the period 1990m2-2016m12 for which the shock is available, the immediate implication of this objective is that limited observations are available at quarterly frequency. In consequence, resorting to the methodology implemented by Jarociński and Karadi, which is founded on Stock and Watson (2010) and Bernanke et al. (1997), the data is transformed from quarterly into monthly frequency through a direct approach that employs the Kalman filter. Basically, using series available at monthly frequency, quarterly series are interpolated for each month of the quarter. As presented in Appendix A, the series of industrial production and unemployment serve as input for the transformation of the series of real GDP, and then, the measures for the markup are interpolated using the data on real GDP estimated in the first place. In Table 1, it is possible to find the correlation coefficients of the cyclical components of the quarterly series and those of the monthly series, after being transformed -extracted through a Hodrick-Prescott filter. It may be observed that these latter

[1] Retrieved from https://fred.stlouisfed.org/series/gdpc1.
[2] Retrieved from https://www.bls.gov/.

keep the correlation properties of the original series, without any change in signs and only minor changes in the coefficients.

A first inspection of the data, as presented in Table 1, gives some preliminary hints on the relationship between the markup and real GDP. Interestingly, for the period under analysis and an unconditional approach, all the estimates for the markup appear to be procyclical, with the baseline measure based on the Cobb-Douglas production function -Mu (CD)- displaying the highest procyclical behavior. The estimates based on CES production functions are both slightly procyclical, with the one not allowing for overhead labor -Mu (CES-KVU)- displaying the lowest coefficient.

TABLE 1. CORRELATION COEFFICIENTS BETWEEN THE MARKUP AND REAL GDP GROWTH

	Mu (CD)	Mu (CES-KVU)	Mu (CES-KVU-OH)
RGDP growth (quarterly)	0.46	0.25	0.30
RGDP growth (monthly)	0.29	0.19	0.22

Notes: The table presents the correlation coefficients for the quarterly and interpolated (monthly) data for the period 1990-2016. Mu (CD) stands for the baseline measure of the markup, calculated as the inverse of the labor share in the nonfarm business sector derived from the standard assumptions of Cobb-Douglas technology and the absence of overhead labor. Mu (CES-KVU) stands for the estimate of the markup assuming a Constant Elasticity of Substitution (CES) production function, measured by the output-capital ratio and variable capital utilization based on the workweek of capital. Finally, Mu (CES-KVU-OH) constitutes a similar measure of the markup as Mu (CES-KVU) but it also allows for overhead labor.

Source: authors' calculations based on data retrieved from the Federal Reserve Bank of St. Louis, BLS and Nekarda and Ramey (2020).

The dynamics of the baseline measure of the markup and real GDP growth are presented in Figure 1. A simple inspection of the series shows that, after falling during the recession of the beginning of the 1990s, the markup increases until around 1997. Then, it decreases and reaches its minimum around 2001, continuously growing after until 2006. It drops just before the start of the Great Recession and starts an increasing path in the middle of the crisis, stabilizing over 1.75 after 2012. As accounted in Mazzoli and Lombardini (2021), the markup seems to revert its trend before real GDP does, falling before recessions start and increasing in the middle of the contractions, just before the recovery. According to Nekarda and Ramey (2020), the markup seems to peak around the middle of expansions, to decline going into recessions and, finally, to rise when coming out of a recession. This suggests that overcoming a recessionary phase carries along a reduction in the labor share, and the intensity of the reduction seems to be associated to the intensity of the recession.

A long-term analysis of the markup shows an increasing trend, which became more acute in the beginning of the 2000s. This increase in the markup is consistent with the steady decline in the labor share detailed in Karabarbounis and Neiman (2014), which would have drove the labor share below its socially optimal level, as accounted in Growiec et al. (2021).

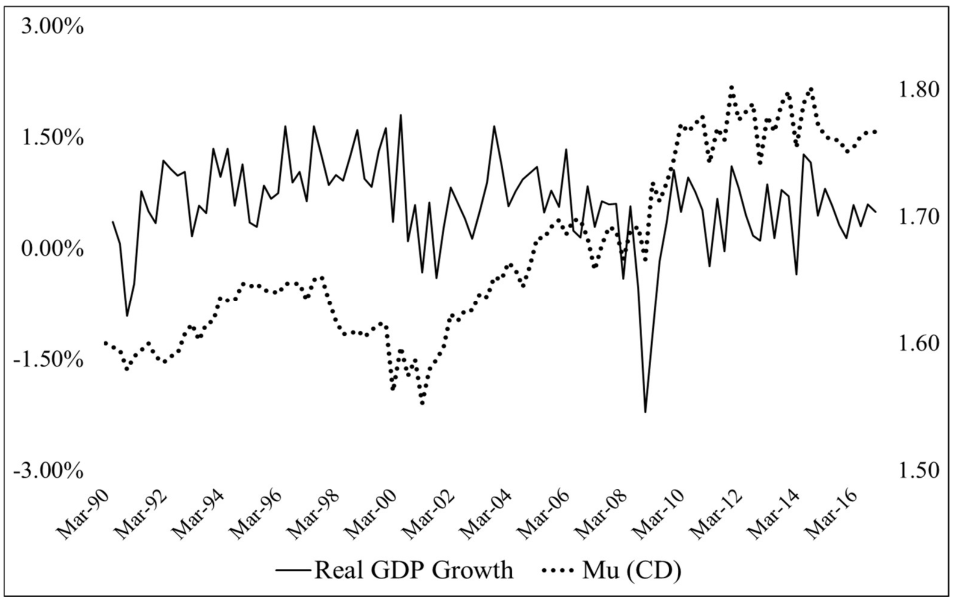

FIGURE 1: EVOLUTION OF REAL GDP GROWTH (LEFT AXIS) AND THE MARKUP (RIGHT AXIS).

Notes: Mu (CD) stands for the baseline measure of the markup, calculated as the inverse of the labor share in the nonfarm business sector derived from the standard assumptions of a Cobb-Douglas production function and the absence of overhead labor.

Source: authors' calculations based on data retrieved from the BLS and the Federal Reserve Bank of St. Louis.

Figure 2 presents two alternative measures for the markup along with the baseline estimate. Interestingly, both measures based on CES production functions share a similar behavior. An important difference with the baseline measure is given by the earlier decreasing path started around 1994, when in the case of the baseline measure this started in 1998. In addition, these new two estimates started falling after 2010, when the baseline measure remained quite stable.

These differences are important, since they suggest different dynamics for the evolution of the labor share.

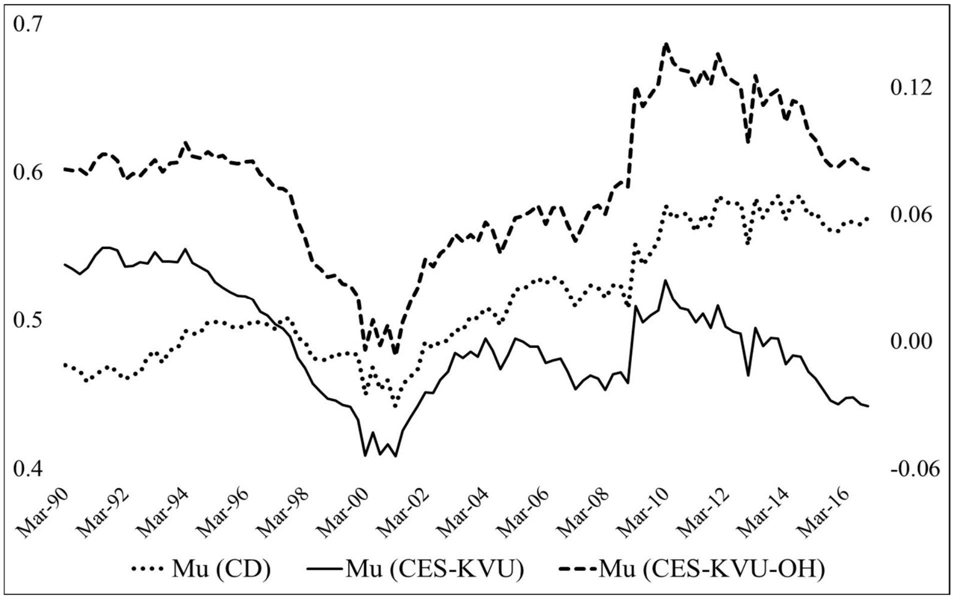

FIGURE 2: ESTIMATES OF THE MARKUP (IN LOG).

Notes: Mu (CD) stands for the baseline measure of the markup, calculated as the inverse of the labor share in the nonfarm business sector derived from the standard assumptions of Cobb-Douglas technology and the absence of overhead labor. Mu (CES-KVU) stands for the estimate of the markup assuming a Constant Elasticity of Substitution (CES) production function, measured by the output-capital ratio and variable capital utilization based on the workweek of capital. Finally, Mu (CES-KVU-OH) constitutes a similar measure of the markup as Mu (CES-KVU) but it also allows for overhead labor.

Source: authors' calculations based on data retrieved from the BLS and from Nekarda and Ramey (2020)

3.b. The monetary shock of Jarociński and Karadi (2020)

The work of Jarociński and Karadi (2020) attempts to deconstruct monetary policy surprises and the role played by information shocks in the US and the European Union (EA). Indeed, a key contribution of the paper is to disentangle monetary policy shocks from contemporaneous information shocks by analyzing the high-frequency co-movement of interest rates and stock prices in a narrow window around policy announcements. Through a Bayesian Structural VAR (BVAR) approach, the response of macroeconomic variables to both shocks is then evaluated.

Figure 3 presents the monetary shock estimated in the paper, where it is possible to tell between shocks taking place in recessions and expansions. As affirmed by Jarociński and Karadi (2020), shocks occur throughout the sample, without particular periods in which they present a particular high concentration or different magnitude. Of course, it is imperative to point out the important magnitude of shocks taking place around September 2001 -after the terrorist attack on the US-, and around the period of the Great Recession.

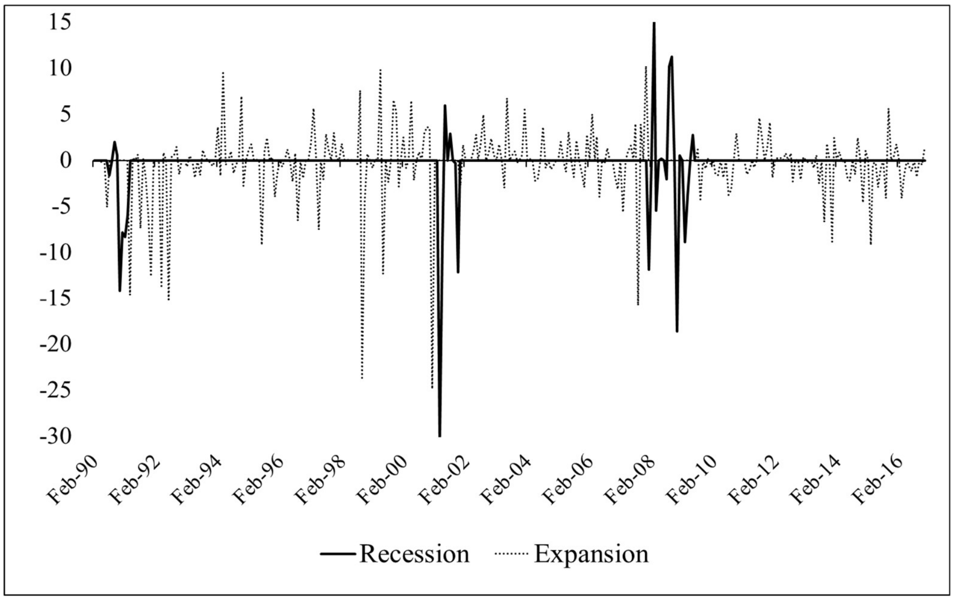

FIGURE 3: MONETARY SHOCK OF JAROCIŃSKI AND KARADI (2020) (IN BASIS POINTS).

A quick look at the MP shock reveals an interesting fact: shocks do not always go in the expected direction. Actually, MP tightening shocks have sometimes taken place during recessions, while easing shocks have also taken place in the middle of expansions. This is better understood by looking at Table 2.

As it can be easily comprehended, at least 10 tightening shocks took place during a recession between 1990 and 2016, averaging each of those shocks around five basis points (bps). The tightening shocks that take place in recessions are only a few, but their order of magnitude is more than twice the average of tightening shocks taking place in expansions. This fact is the motivation behind the empirical exercise proposed in this paper, since there might be a chance that even when the direction of the shocks is the same, always tightening, they might still trigger different dynamics on the main relevant macroeconomic variables depending on the phase of the business cycle in which they occur.

TABLE 2: AVERAGE MONETARY SHOCK OF JAROCIŃSKI AND KARADI (2020)

	Avg. tightening MP shock	Avg. easing MP shock
Recession	5.1	-9.4
Occurrences	10	15
Expansion	2.2	-3.3
Occurrences	96	101

Notes: The table presents the average monetary shock in recessions and expansions (in basis points).

4. The model

The LP approach has become a widely used methodology to estimate IRFs, and is proven to have some advantages over Structural VAR specifications (see Jordá 2005). For instance, LP provide a simpler and more flexible alternative to capture non-linear specifications in multivariate contexts. In addition, they constitute a perfect tool to make inferences, estimating a simple OLS regression at each horizon instead of relying on the extrapolation of IRFs at distant horizons.

The basic LP approach implies estimating an equation of the following type:

$$y_{t+h} = c + \beta_h \epsilon_t^{mp} + \gamma_h' x_t + \varepsilon_{t+h} \qquad (1)$$

$$h = 0, \ldots H$$

where y_{t+h} is the dependent variable h periods ahead, c is a constant, ϵ_t^{mp} is a monetary policy shock, x_t is a vector of control variables, and ε_{t+h} is the residual.

Given that the LP approach needs to count on an exogenous measure of the monetary shock, ϵ_t^{mp} will be given by the shock calculated by Jarociński and Karadi (2020). The estimated coefficients β_h, for h = 0, ..., H, represent the IRFs of the variable of interest at time t + h to the monetary policy shock at time t.

Since the idea is to test whether the MP shocks display a different effect depending on the phase of the business cycle the economy is going through, the baseline specification becomes:

$$y_t = F_{t-h}\left(\beta_{t-h}^{R}\epsilon_{t-h}^{mp} + \gamma_h^{R\prime}x_{t-h}\right) + (1 - F_{t-h})\left(\beta_{t-h}^{E}\epsilon_{t-h}^{mp} + \gamma_h^{E\prime}x_{t-h}\right) + \varepsilon_t \qquad (2)$$

where y_t is the dependent variable at time t, F_{t-h} takes the value one if the economy is facing a recession or zero if it is in expansion at time $t-h$, ϵ_t^{mp} is always the monetary policy shock, x_{t-h} is the vector of control variables at time $t-h$, and finally, β_{t-h}^{R} and β_{t-h}^{E} are the responses of the dependent variable at time $t-h$ to MP innovations in recessions and expansions, respectively.

This specification is similar to the one of Tenreyro and Twaites (2016), but instead of using only output as dependent variable and resorting to a smooth transition approach, responses will be estimated for each dependent variable (output and the three measures of the markup) using a threshold LP model in which F_{t-h} will be given by the National Bureau of Economic Research (NBER) recession indicator[1].

A further refinement to the LP methodology is the smooth local projections (SLP) approach put forward in Barnichon and Brownlees (2019). Their technique addresses the shortcoming that the nonparametric nature of LP comes at an efficiency cost, producing excessive variability in the estimator. This may be especially severe when working with monthly data (Funashima, 2022). Consequently, when working with monthly data, estimations will be performed using

[1] Retrieved from https://fred.stlouisfed.org/series/USREC.

the SLP, which preserves the flexibility of standard LP, but increases precision based on B-spline smoothing of the standard IRFs.

Moreover, given the evidence regarding the existence of a unit root in the time series under analysis –see Appendix A-, robustness checks will make Eq. (3) turn into a first difference of logs specification of the following form:

$$\Delta y_t = F_{t-h}\left(\beta_{t-h}^{R,D}\epsilon_{t-h}^{mp} + \gamma_h^{R\prime}x_{t-h}\right) + (1 - F_{t-h})\left(\beta_{t-h}^{E,D}\epsilon_{t-h}^{mp} + \gamma_h^{E\prime}x_{t-h}\right) + \epsilon_t^D \qquad (3)$$

The analysis of the asymmetric effects of monetary policy may depend on the specification chosen, suggesting the use of first differences when unit roots are present. As stated in Kilian and Kim (2011), running a specification in levels when there is presence of a unit root is still consistent, though it may carry along a biased estimator. In this sense, the risk of over-differencing the data, as debated in Gosponidov et al. (2013), disappears when working with non-stationary series, in which case working with first differences should be more efficient. It is a generalized practice, however, as it may be observed in recent and influential papers, such as those of Tenreyro and Thwaites (2016) and Ramey and Zubairy (2018), to run the models in log levels, adding a time trend to the specification. Hence, in order to provide robust results, this paper estimates two specifications: a log level specification augmented with a linear time trend and a first difference of logs specification.

The IRFs are calculated running Eq. (2) -log level specification- and Eq. (3) -first difference of logs specification- and smoothed through the SLP approach of Barnichon and Brownlees (2019). Following Tenreyro and Twaites (2016), the control vector contains lags of the dependent variable and the Fed Funds rate (six lags of each, so two quarters are covered). In addition, lags of the MP shock are also included, following the order of autocorrelation suggested by the autocorrelation function. Even if working with a monetary shock should rule out autocorrelation by definition, when focusing on tightening shocks only in recessions or in expansions, the data suggests the existence autocorrelation (seven lags in both business cycle phases when working with monthly data and the full sample). Other controls include the series of the information shock of Jarociński and Karadi, a dummy for the Great Recession period in the full sample estimation, and the aforementioned linear time trend in the log level specification.

5. Results[2]

The estimations of Eq. (2) and Eq. (3) are reported in Figure 4 and Figure 5, in which it is possible to observe the responses of the three measures of the markup along with the response of real GDP to the MP shock of Jarociński and Karadi (2020). The responses are calculated to a one-standard deviation MP tightening shock, both in recessions and in expansions, for the period 1990m2-2016m12. In addition, also the non-business cycle dependent response (baseline) is reported. An analysis of Figures 4 and 5 allows us to identify some important dynamics.

First, it should be noted that in recessions the markup displays a strong increase after a MP tightening shock, just as expected in the NK framework. Indeed, given that output experiences a sharp decrease, this implies that the markup responds countercyclically. In the log level specification, the responses are similar for the three measures of the markup, although the baseline measure -Mu (CD)- shows a more erratic path and peaks at around 10 bps, while both measures based on CES production functions peak at around 20 bps. Statistical significance does not seem to constitute an issue in this specification, with significant responses taking place in several or most horizons along the first three years after the shock. In the first difference of logs specification, on its part, all the measures for the markup display a longer and stronger

[2] The full dataset and Matlab replication files can be retrieved from the following repository: https://github.com/nicolasblampied/Replication-Files---Essays-on-Contemporary-Issues-in-Macroeconomics.-Ch.-2.

increase in recessions, with the baseline measure peaking at around 15 bps, and those based on CES technology, at around 30 bps.

Second, it may be observed that in expansions the behavior of the markup is clearly procyclical conditional on the MP tightening shock. In the log level specification, all the measures show a decreasing and significant path for 15-22 months, with the baseline measure showing significance for the longest period. In the first difference of logs specification, interestingly, the markup seems to revert its decreasing behavior before compared to the log level specification, coming back to its original value and even increasing after around 18-25 months. This latter increase, however, is often insignificant.

It seems important to devote a moment to analyze the IRFs when the responses to the tightening shock are not business cycle dependent. In this case, with the exception of the measure based on a CES production function and allowing for overhead labor in the log level specification, all the other measures in both specifications displayed a negative response for at least the first year, turning positive (and insignificant in general) afterwards. In general terms, the negative response of the markup lives longer when focusing on the baseline measure and in the log level specification. This suggests that the responses identified by Nekarda and Ramey (2020) and Cantore et al. (2021) might also depend highly on the specification chosen, even when qualitatively speaking these results are similar to theirs.

When it comes to the behavior of the real GDP, it may be noted that the responses are, as expected, negative, but stronger and showing more significance in the first difference of logs specification. A relevant implication of the log level specification is that tightening shocks would not display a significant response in expansions, a key finding when thinking of the effectiveness of monetary policy as a countercyclical tool.

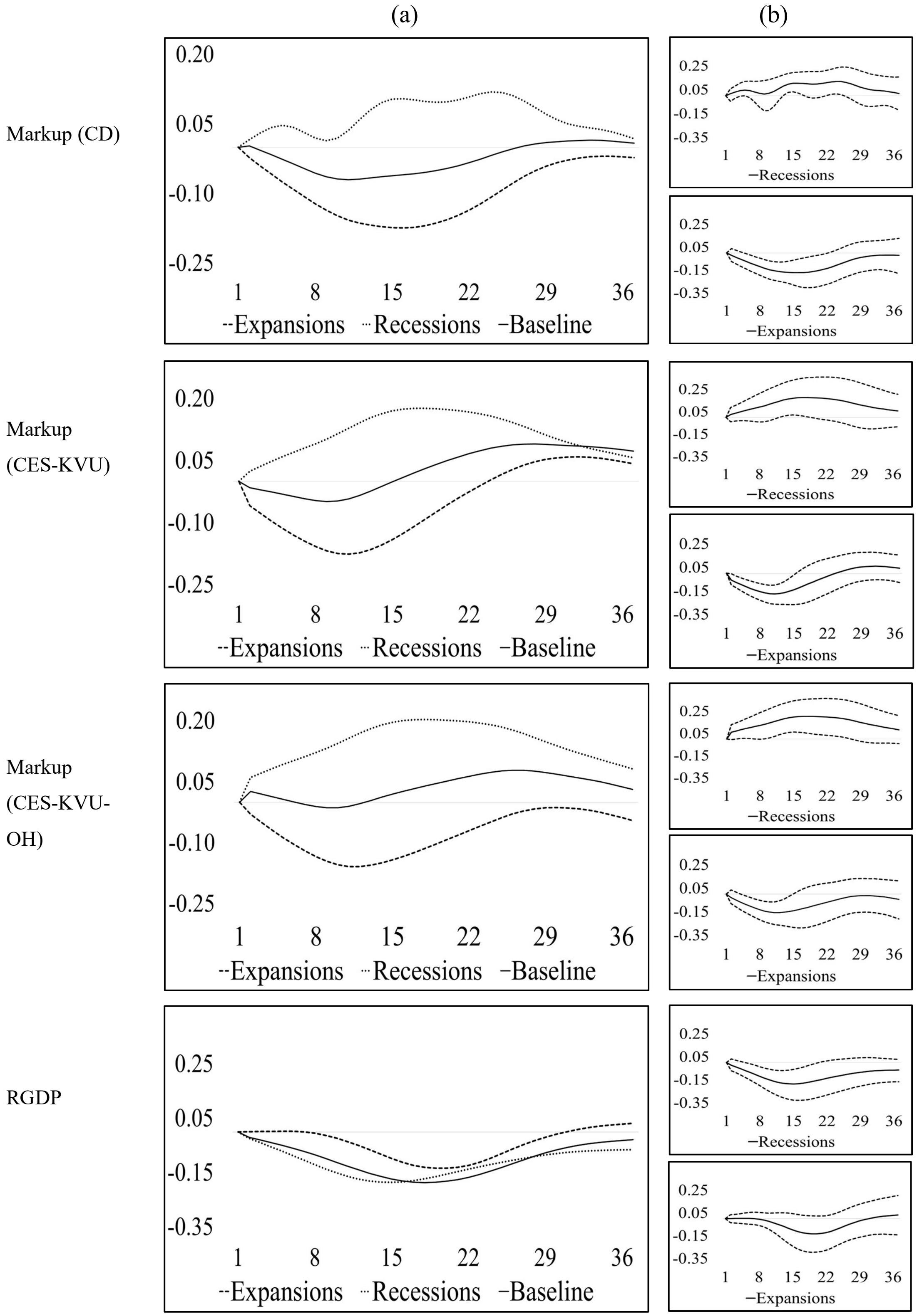

FIGURE 4. IRFs TO A ONE-STANDARD-DEVIATION MP TIGHTENING SHOCK IN RECESSIONS AND EXPANSIONS.

Notes: Panel (a) reports the cumulated response for the first 36 months for the log level specification (the response multiplied by 100 gives the basis points). Panel (b) reports the IRFs in recessions and expansions along with the 10% confidence intervals. The sample covers the period 1990m2-2016m12.

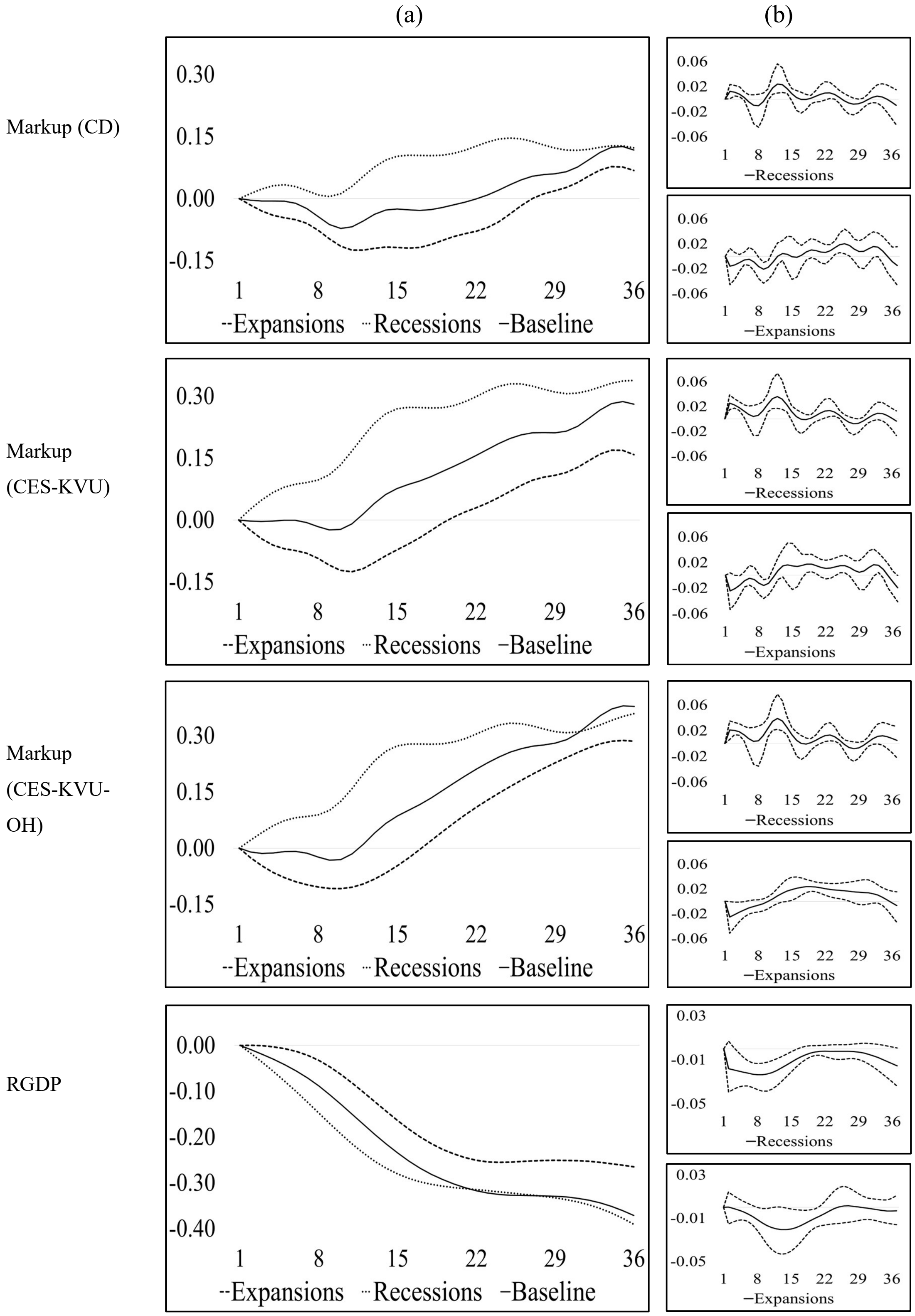

FIGURE 5. IRFs TO A ONE-STANDARD-DEVIATION MP TIGHTENING SHOCK IN RECESSIONS AND EXPANSIONS.

Notes: Panel (a) reports the cumulated response for the first 36 months for the first difference of logs specification (the response multiplied by 100 gives the basis points). Panel (b) reports the point estimates in recessions and expansions along with the 10% confidence intervals. The sample covers the period 1990m2-2016m12.

The most prominent result is that the dynamics followed by the markup after the MP tightening shock are very different, both in magnitudes and in directions, depending on the phase of the business cycle at which the shock takes place. A plausible way to check these results could be given by the comparison with the results of Cantore et al. (2021), where they also focus on tightening shocks, but bearing in mind that this latter paper focuses on the IRFs of the labor share and does not take into account business cycle asymmetries. That said, the responses of the markup in expansions are surprisingly similar in magnitude and sign to the responses found in this latter paper for the non-business cycle dependent responses, ranging between 10 and 20 bps. Instead, the non-business cycle dependent responses reported in this paper are somehow smaller than those of Cantore et al.

In addition, in the case of output, it is possible to observe that the maximum fall that suffers in the non-dependent case, of around 20 bps and 30 bps in the log level specification and in the first difference of logs specification, respectively, is somehow similar to the one reported by Cantore et al. (2021), of around 20 bps. Of course, another issue to consider in these comparisons is that the sample of this latter study stops before the Great Recession, something that could naturally lead to a different magnitude of responses. However, the standard deviation of the monetary policy tightening shock for the full sample in this paper is around 27 bps, similar to the tightening shock of 25 bps tested in Cantore et al.

6. Robustness checks

In order to be able to assure that the response of the markup to a MP tightening shock is robust, displaying a negative dynamic in times of expansion and a positive one in times of recession, a set of robustness checks has been carried out. The most important of these checks are included in Appendix B. In particular, the response of the markup is robust to all the checks listed below:

a) Data span: since the data span, covering the period 1990m2-2016m12, included the Great Recession and the zero lower bound period, a subsample stopping in 2007m12 has also been estimated. It is important to mention that, since the estimations resort to the MP shock of Jarociński and Karadi (2020), they are not subject to the critique of Basu and House (2016) and Ramey (2016). In these papers, they point out that when using samples with more recent data the IRFs radically change in comparison to those estimated in Christiano et al. (2005), for which they count on older data. A possible reason for this would be that the quantitative easing program in response to the Great Recession has made it more difficult to properly identify the MP shocks.

b) Data frequency: the estimations performed with monthly data –interpolated- were complemented with the use of quarterly data. When using quarterly data -see Appendix B-, it is possible to observe that the responses in recessions take around four quarters to become positive, after what they display a sharp upward dynamic. Instead, in expansions the responses are negative for around six or seven quarters, with a longer negative response in the case of the baseline measure of the markup. It is important to note that when using quarterly data, the estimations were performed following the LP approach of Jordà (2005), since quarterly data does not suffer from the volatility monthly data does, as accounted in Funashima (2022). In addition, the LP confident intervals are built using Newey-West standard errors.

c) Stochastic trends: since the evidence suggests the existence of unit roots in all the series under analysis –see Appendix A-, the estimation in log levels has been complemented, as analyzed before, with an estimation in first differences.

d) Controls: several sets of control variables have been tested. In particular, lags of the MP shock were added following the order of autocorrelation suggested by the autocorrelation function. In addition, the information shock of Jarociński and Karadi (2020) has been included in all the estimations, though by removing it only minor changes were experienced. Moreover, following Tenreyro and Twaites (2016), lags of the dependent variable and the Fed Funds rate were also included as controls (two quarters -six lags-). Finally, a dummy for the Great Recession period was included in the full sample estimation and a linear time trend in the log level specification.

e) Dependent variables: although the focus is put on the markup, it is key to note that the response of output is robust to the use of other measures available at monthly frequency (IRFs for industrial production are presented in Appendix B).

7. Conclusions

This paper aimed to understand whether the response of the markup conditional on a monetary policy (MP) shock depends on the phase of the business cycle in which the shock occurs. The markup constitutes a key variable in the framework of the New Keynesian (NK) model, and its expected countercyclical behavior conditional on a MP shock is an essential channel through which these models operate. Indeed, they count on this transmission mechanism in order to reduce inflation pressures after a policy tightening.

Though still scarce, the analysis of the dynamics of the markup conditional on a MP shock has made some important progress in recent years, with Nekarda and Ramey (2020) and Cantore et al. (2021) being the most prominent references in the literature, and ruling in favor of a procyclical behavior. However, these papers do not pay attention to the possible asymmetric responses triggered by the fact that shocks take place at different phases of the business cycle. The aim of this research was to bridge this gap, and do it by putting forward a different empirical strategy, resorting to a LP approach à la Jordà (2005), a SLP approach in the terms of Barnichon and Brownlees (2019), and the empirical approach developed in Tenreyro and Twaites (2016).

The main finding of this paper is that the response of the markup to a MP tightening shock during the period 1990m2-2016m12 has been asymmetric, decreasing in expansions and increasing in recessions. Since the real GDP falls after the shock, the empirical analysis carried out in this study suggests that the response of the markup is procyclical in expansions, as expected in Nekarda and Ramey (2020) and Cantore et al. (2021), and the opposite to that expected in the NK framework. The response in recessions is as expected in the NK model, countercyclical. These results have important policy implications, since tightening shocks should not be the norm in contractionary phases. In particular, the results imply that only tightening mistakes may be successfully addressed within the basic NK framework. This seems to suggest that the NK model cannot reconcile theory with the empirical evidence, at least not in normal times. Moreover, the increase of interest rates in periods of booms would not reduce inflation, at least not through the transmission mechanism of the markup.

The responses are robust to all the measures of the markup tested, all model specifications and the subsample stopping before the Great Recession. The subsample estimations may be of interest, since they allow positing some ideas for future work regarding how including the Great Recession and the zero lower bound period may affect the results.

Much work is still needed to enrich this strand of literature, constituting the contributions of this paper to be a step in such a direction. Future research may aim at trying different empirical identification strategies to estimate the response of the markup, different measures of the shock, different asymmetries, different periods or countries, among many other leads of work.

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Appendix A: the data

Appendix A presents relevant information regarding the treatment of the data, in particular the transformation of series from quarterly into monthly frequency and the unit root tests performed.

a. Interpolation of monthly data from quarterly data

To derive monthly data, this paper follows Jarociński and Karadi (2020) and interpolates quarterly to obtain monthly frequency. Figure 1A reports the series available at quarterly frequency and the ones at monthly frequency that served as input to interpolate quarterly data into monthly frequency.

TABLE 1A: QUARTERLY SERIES INTERPOLATED AND MONTHLY SERIES USED AS INPUT FOR THE INTERPOLATION.

Quarterly	Monthly Input
Real GDP	Industrial production index Unemployment rate
Mu (CD)	Real GDP
Mu (CES-KVU)	Real GDP
Mu (CES-KVU-OH)	Real GDP

It may be noted that, as a robustness check, other monthly series were also used as input, resulting in similar results. In order to replicate this interpolation, Matlab codes are available as supplementary data.

b. Unit root test results

TABLE 2A: AUGMENTED DICKEY-FULLER TEST AND KPSS TEST

	ADF Test Statistic	Probability	KPSS Test Statistic	Probability
Real GDP	-1.91	0.65	0.38	< 0.01
Mu (CD)	-1.84	0.69	0.31	< 0.01
Mu (CES-KVU)	-2.19	0.49	0.36	< 0.01
Mu (CES-KVU-OH)	-2.41	0.37	0.32	< 0.01

Notes: The table displays the results for the tests performed on quarterly data for the period 1990Q1-2016Q4. The specification included an intercept, a trend and up to twelve lags.

The ADF test and the KPSS tests in Table 2A suggest that all the series have a unit root. These results are robust to a specification without trend and to the use of interpolated monthly data.

Appendix B: robustness exercises

Appendix B details the robustness checks performed, including subsample estimations, treatment of stochastic trends and robustness of the response of output.

a. Robustness check 1: IRFs for the markup in the log level specification for the full sample 1990Q1-2016-Q4 (quarterly data)

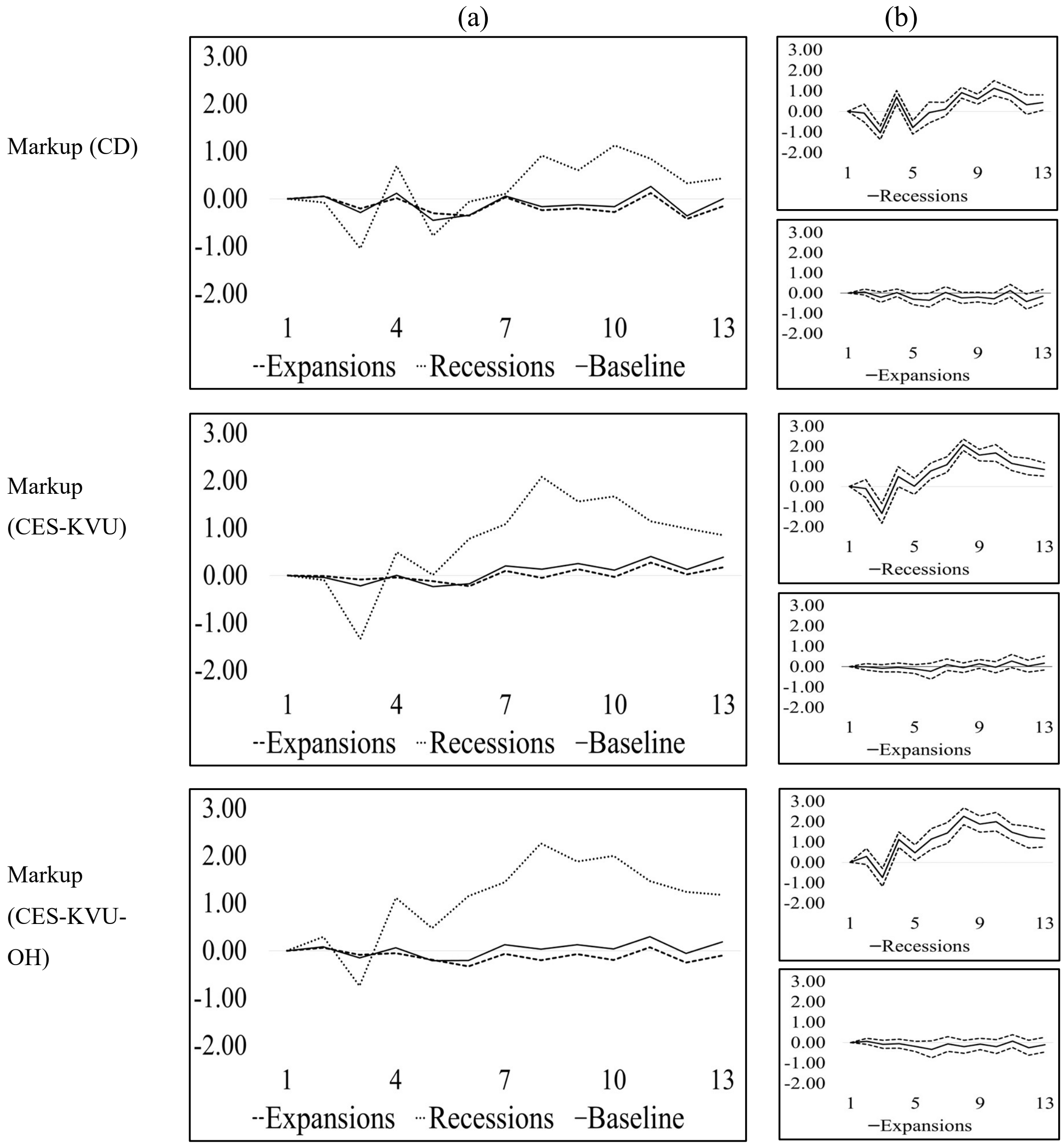

FIGURE B1. IRFs TO A ONE-STANDARD-DEVIATION MP TIGHTENING SHOCK IN RECESSIONS AND EXPANSIONS.

Notes: Panel (a) reports the cumulated response for the first 12 quarters (three years) for the log level specification (the response multiplied by 100 gives the basis points). Panel (b) reports the IRFs in recessions and expansions along with the 10% confidence intervals. Please note that in order to perform the quarterly estimation, the monetary shock was built by aggregating monthly data. This is consistent with the basic approach used in Ottonello and Winberry (2020).

b. Robustness check 2: IRFs for the markup in the log level specification for the subsample 1990m2-2007-m12

(a) (b)

Markup (CD)

Markup (CES-KVU)

Markup (CES-KVU-OH)

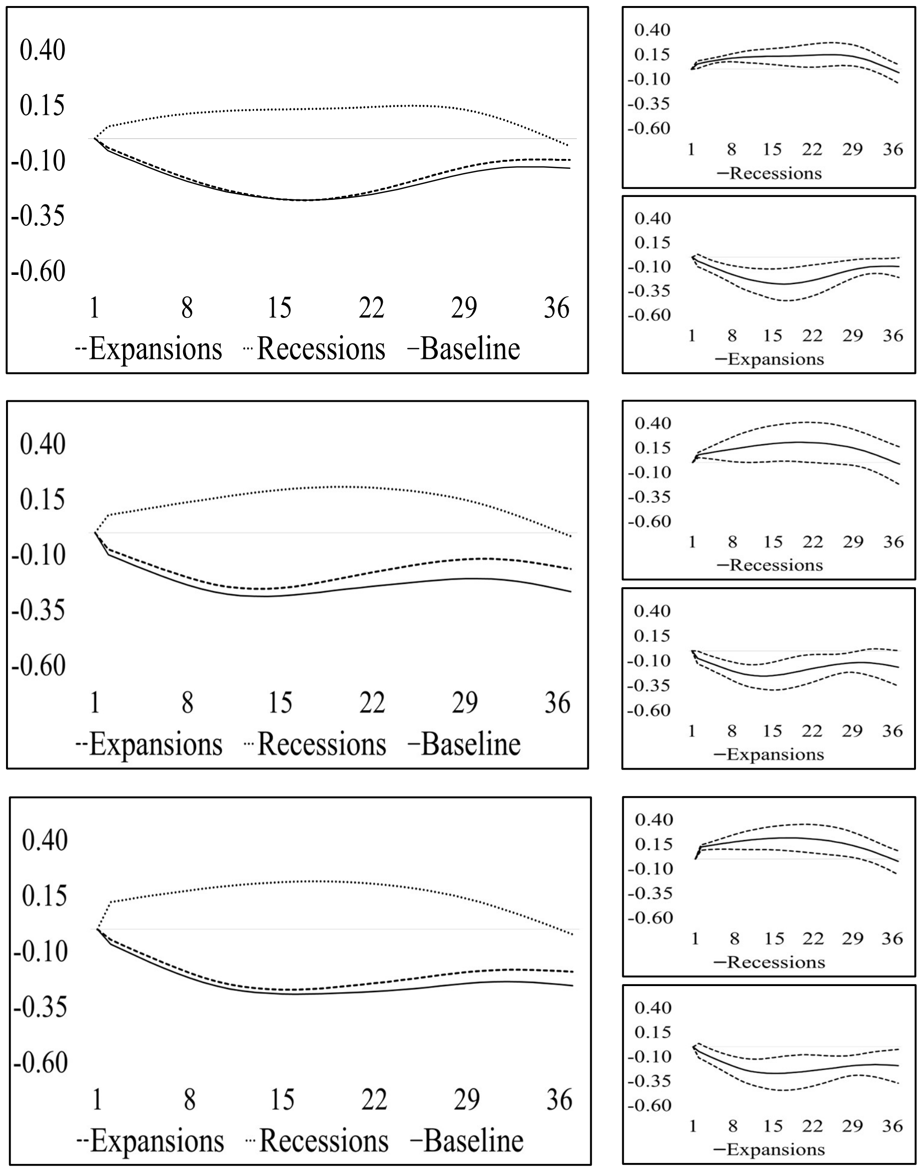

FIGURE B2. IRFS TO A ONE-STANDARD-DEVIATION MP TIGHTENING SHOCK IN RECESSIONS AND EXPANSIONS.

Notes: Panel (a) reports the cumulated response for the first 36 months for the log level specification (the response multiplied by 100 gives the basis points). Panel (b) reports the IRFs in recessions and expansions along with the 10% confidence intervals.

c. Robustness check 3: IRFs for industrial production in the log level specification, for both the full sample and the subsample covering 1990m2-2007-m12, and for the first differences of logs specification for the full sample

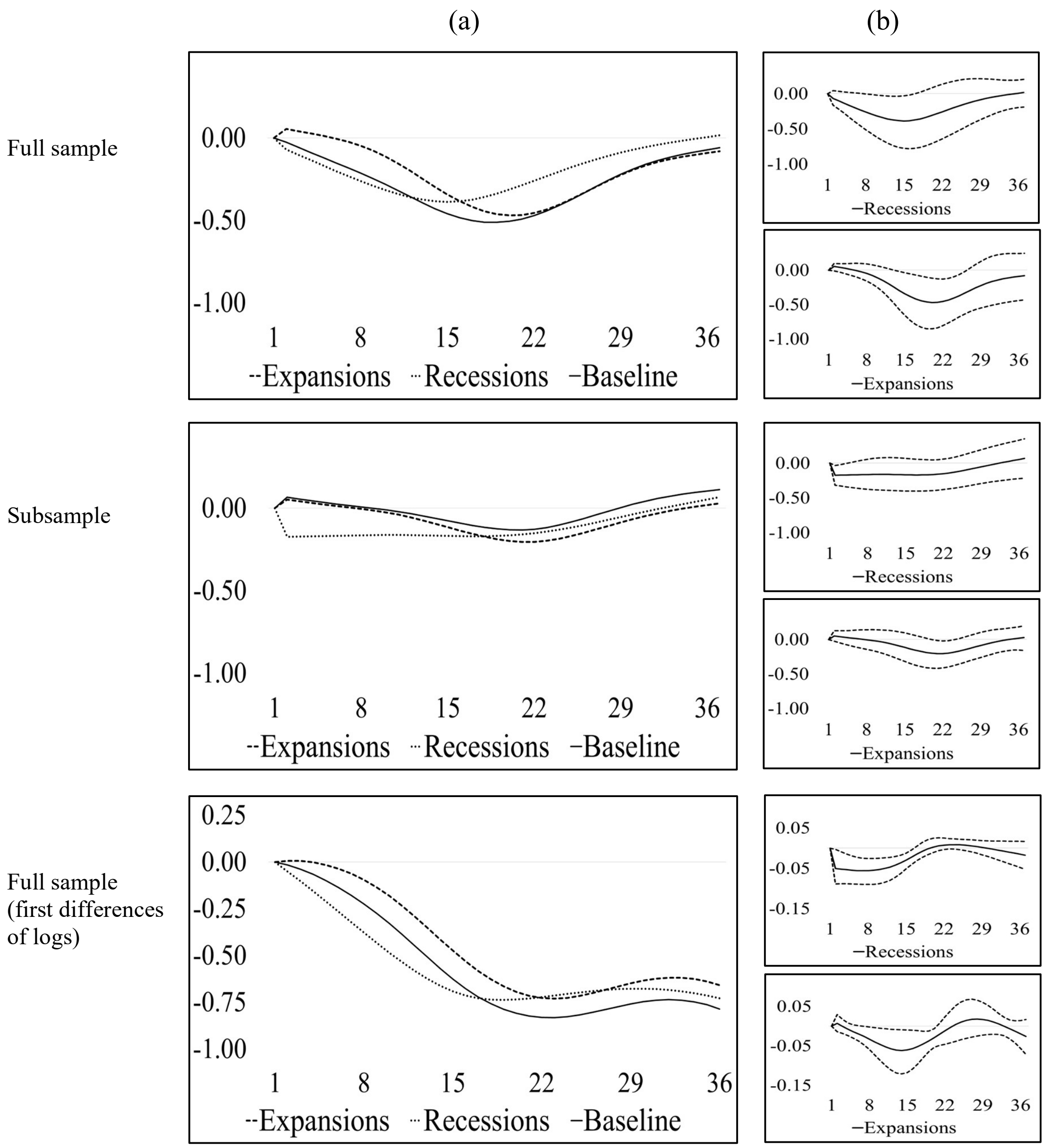

FIGURE B3. IRFs FOR INDUSTRIAL PRODUCTION TO A ONE-STANDARD-DEVIATION MP TIGHTENING SHOCK IN RECESSIONS AND EXPANSIONS.

Notes: Panel (a) reports the cumulated response for the first 36 months for the log level specification (the response multiplied by 100 gives the basis points). Panel (b) reports the IRFs in recessions and expansions along with the 10% confidence intervals.

Chapter 3

Uncertainties under monetary tightening and easing shocks and different market states

Uncertainties under monetary tightening and easing shocks and different market states

Abstract

This paper examines the impact of monetary shocks on monetary policy and stock market uncertainties. In this context, this work also seeks to determine which types of shocks and market states elevate uncertainties. Therefore, monetary actions are disentangled into tightening and easing shocks, so to explore whether business cycle phases and stock market volatility regimes matter. To identify monetary shocks, a theoretical vector autoregressive model of the US economy that accounts for the interconnectedness between monetary policy and the stock market is put forward. This model is augmented in order to accommodate for unconventional monetary policy actions at the zero lower bound. Then, with local projections, the responses of monetary policy and stock market uncertainties to such shocks are estimated. The main results suggest that monetary tightening shocks reduce uncertainties, while easing shocks either increase uncertainties or are negligible. In addition, when checking volatility regimes and business cycle phases, results suggest that tightening shocks reduce uncertainty under the tranquil volatility regime and business cycle expansions, while the responses in turbulent volatility and recessions are not robust across empirical specifications. Easing shocks, on its part, increase uncertainty in tranquil volatility and expansions, reducing it in recessions after a year, and display non-robust responses during turbulent volatility. These results are helpful in appraising the role of monetary actions on uncertainties, in alternative states of the market.

JEL classification: E32; E44; E52

Keywords: monetary policy; shocks; stock market; uncertainty

1. Introduction

What are the effects of monetary shocks on monetary policy and stock market uncertainties? Do tightening and easing shocks incite asymmetric uncertainties responses? Are monetary shocks consistent across all real sector and financial market states? Given the strong linkages between monetary actions and uncertainties related to monetary policy and the stock market, these questions are of particular importance to central bankers for policy appraisal purposes and for investors to gauge the impact of policy related news on uncertainty levels. This is because uncertainty can affect the injections made by economic agents into the circular flow of income, which has implications for the growth of both the economy and the stock market. Several studies relate uncertainty in its different forms and macroeconomic and financial performance. Recently, Husted et al. (2020) emphasize the negative link between monetary policy uncertainty and investment, Ko and Lee (2015) point out the negative relationship between economic policy uncertainty and stock prices, and Mao and Huang (2022) find that climate policy uncertainty reduces green innovation by increasing credit constraints.

Yet, there are discrepancies around precisely how monetary policy movements affect uncertainties. For instance, Bekaert et al. (2013) show that monetary easing decreases risk aversion and uncertainty in the stock market. However, Funashima (2022) finds such expansionary monetary shocks increase monetary policy uncertainty (MPU), while contractionary monetary shocks yield negligible effects, and argue that unanticipated monetary easing can counter-intuitively depress stock prices through an elevated environment of uncertainty. This paper contributes to this line of existing research by explicitly analyzing the link between monetary actions (including tightening and easing shocks) and the stock market, in terms of both MPU and stock market uncertainty (SMU).

Another contribution of this work is that it considers whether such relationships change over the business cycle and volatility regimes in the stock market. Predicting the performance of macroeconomic and financial variables, during different phases in the economy and financial markets, remain revolving empirical research issues. In particular, the potency of monetary policy in recessions compared to expansions is uncertain (Tenreyro and Thwaites, 2016). Moreover, since changes in macroeconomic activity are a key determinant of stock returns, the latter becomes more complex to predict when the economy is in recession because macroeconomic indicators themselves become harder to forecast in such times (Hamilton and Lin, 1996). Furthermore, although stock market volatility is important for predicting macroeconomic volatility, the converse has historically been less convincing and given rise to the so-called *volatility puzzle* (Schwert, 1989). Hence, further investigation is warranted into how monetary and stock market uncertainties react to monetary shocks, not only over the phases of the business cycle but also over volatility regimes.

As a third contribution, given the problem of appropriately identifying monetary shocks at the zero lower bound (see, e.g., Basu and House, 2016; Ramey 2016), this paper provides a solution to capture quantitative easing injections within policy rate innovations. This way, it is possible overcome the endpoint sample constraint faced in numerous empirical studies, including Funashima (2022), and extend the sample beyond the pre-Great Recession era to include more recent data. To do this, the structural vector autoregression (SVAR) suggested in Bjørnland and Leitemo (2009) is augmented, which facilities the identification of conventional monetary policy shocks in a model that permits the interaction between policy rates and the stock market (Gambacorta *et al.*, 2014), by replacing the federal funds rate series with shadow short rates (SSR). Krippner (2020) explains that SSR estimates are generated regressors to proxy policy interest rates that reflect unconventional monetary policy actions.

From impulse response functions (IRFs), based on local projections (LP), the main findings ofthis paper indicate that MP tightening shocks reduce MPU and SMU, while easing shocks would either increase them or play a negligible effect. The analysis across stock market volatility regimes and business cycle phases suggests that tightening shocks reduce uncertainty in tranquil times and in expansions, while the responses in turbulent times and in recessions are not robust across empirical specifications. Easing shocks, instead, increase uncertainty in tranquil times and in expansions, reduce it in recessions after a year or so, and display non-robust responses in turbulent periods.

2. Methods and data[1]

The empirical procedures put forward in this work consist of two steps. In the first step, the SVAR suggested in Bjørnland and Leitemo (2009) is estimated in order to obtain monetary shocks in a model that embraces the interconnectivity between the stock market and the policy rate. Their SVAR consists of a combination of short and long run restrictions. The short run restrictions are indicated by the positioning of the zeros imposed on the contemporaneous 5x5 matrix, as illustrated in Eq. (1):

$$\begin{bmatrix} q_t \\ p_t \\ c_t \\ s_t \\ r_t \end{bmatrix} = B(L) \begin{bmatrix} S_{11} & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & S_{45} \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} \end{bmatrix} \begin{bmatrix} \varepsilon_t^q \\ \varepsilon_t^p \\ \varepsilon_t^c \\ \varepsilon_t^s \\ \varepsilon_t^r \end{bmatrix} \quad \text{Eq. (1)}$$

where the left-hand-side of the equation is a vector of macroeconomic variables - Z_t in Eq. (2) below. Here, q_t is the log of the US industrial production (IP) index[2], detrended using a two year (24 month) seasonal differencing filter, which is considered a robust measure for removing unit roots and isolating the cyclical component of most time series of interest in economic and finance (Hamilton, 2021). p_t is the annual percent change in the consumer price index (CPI) (2015 = 100)[3]. c_t is the annual change in the log of the S&P GSCI commodity index[4]. s_t is the

[1] Replication files available at https://github.com/nicolasblampied/Replication-Files---Essays-on-Contemporary-Issues-in-Macroeconomics---Ch.-3.
[2] Retrieved from https://fred.stlouisfed.org/series/INDPRO in June 2022.
[3] Retrieved from https://fred.stlouisfed.org/series/CPALTT01USM661S#0 in June 2022.
[4] Retrieved from the Bloomberg Terminal in June 2022.

returns on the real S&P 500 index[5], where returns are computed as the logarithmic-difference of the real stock price index times 100, and where deflation is done using the CPI (2015 = 100). r_t is the detrended SSR[6], where the cyclical component of interest is decomposed in a similar manner to IP to induce stationarity. By using the SSR in place of the federal funds rate, we can accommodate unconventional monetary policy activity within this macroeconomy framework.

On the right-hand-side of Eq. (1), $B(L)$ is a (5x5) convergent matrix polynomial in L, where L is the lag operator, such that $B(L) = \sum_{j=0}^{\infty} B_j L^j$ in the moving average representation of the VAR model (ignoring deterministic terms) in Eq. (2):

$$Z_t = B(L)v_t \quad \text{Eq. (2)}$$

where v_t is a (5x1) vector of reduced-form iid residuals, with a positive-definite covariance matrix. Writing the underlying orthogonal structural disturbances (ε_t) as linear combinations of the innovations (v_t), such that $v_t = S\varepsilon_t$, where S is the contemporaneous 5x5 matrix specified in Eq. (1), Eq. (2) can be expressed as structural shocks in Eq. (3):

$$Z_t = C(L)\varepsilon_t \quad \text{Eq. (3)}$$

where $C(L) = B(L)S$. It can be seen that the stock market and monetary policy variables are able to immediately react to all variables in the system but can affect macroeconomic variables, such as output and prices, with a delay as implied by the zeros positioned in the short run matrix in Eq. (1). However, an additional long run restriction to reflect the neutrality of monetary policy on the stock market is imposed, which is achieved by setting the infinite number of relevant lag coefficients in $\sum_{j=0}^{\infty} C_{45,j}$, suggested by Eq. (3), equal to zero. Hence, for the subsequent modelling that will be done in the second step, ε_t^r is the identified monetary shock of interest[7].

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[5] Retrieved from https://uk.finance.yahoo.com/ in June 2022.
[6] Retrieved from https://www.ljkmfa.com/visitors/ in June 2022. See Krippner (2013) for more information on the SSR framework.
[7] ε_t^s is a stock market shock, while the other uncorrelated structural shocks in the ε_t vector on the right-hand-side

The period of analysis is based on monthly data from 1997m3 to 2021m12[8]. For this sample, data is required from 1995m1, which is the earliest start date based on the availability of the SSR series. Then, 24 months are required to apply the detrending filter on the IP and SSR series and a further 2 months are lost to prime the SVAR model. Following Bjørnland and Leitemo (2009), we ensure the five variables admitted into the VAR are stationary. Based on the KPSS tests (see Kwiatkowski *et al.*, 1992), with intercept and intercept and trend variants, we fail to reject the null hypothesis of stationarity at the 5% level of significance, for all the series described in the vector on the left-hand-side of Eq. (1) ($\equiv Z_t$ in Eq. 2). Moreover, an optimal lag length of two months is determined for the VAR based on the Schwarz information criterion and this model satisfies the stability condition, such that no inverse roots of the AR characteristics polynomial lie outside the unit disc.

In Figure 1 and Figure 2, the monetary shock is plotted and business cycle phases and volatility regimes are emphasized. Periods of recession for the US business cycle are identified using the recession indicator from the National Bureau of Economic Research[9]. For financial turmoil in the US stock market, the approach of Mahadeo et al. (2022) is followed and the so-called practitioner's rule is adopted. According to this approach, VIX values that exceed 20 are characterized as being in the turbulent volatility regime. The VIX series[10] is especially appropriate for this analysis, as the stock market variable from SVAR model in the first step is the real S&P 500 returns and the VIX measures near term implied volatility from price inputs of the S&P 500 index options.

A quick look at these figures further reveals the motivation of our empirical exercise, since it is possible to observe the fact that easing and tightening shocks do not always go in the expected

of Eq. (1) remain uninterpreted.

[8] For this sample, we require data 1995m1, which is the earliest start date based on the availability of the SSR series. Then, 24 months are required to apply the detrending filter on the IP and SSR series and a further 2 months are lost to prime the SVAR model.

[9] Retrieved from https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions in July 2022.

[10] Retrieved from https://fred.stlouisfed.org/series/VIXCLS in July 2022.

direction, with easings (tightenings) taking place in periods of expansion (recession). It is also straightforward to see that easings and tightenings are evenly distributed across stock market regimes.

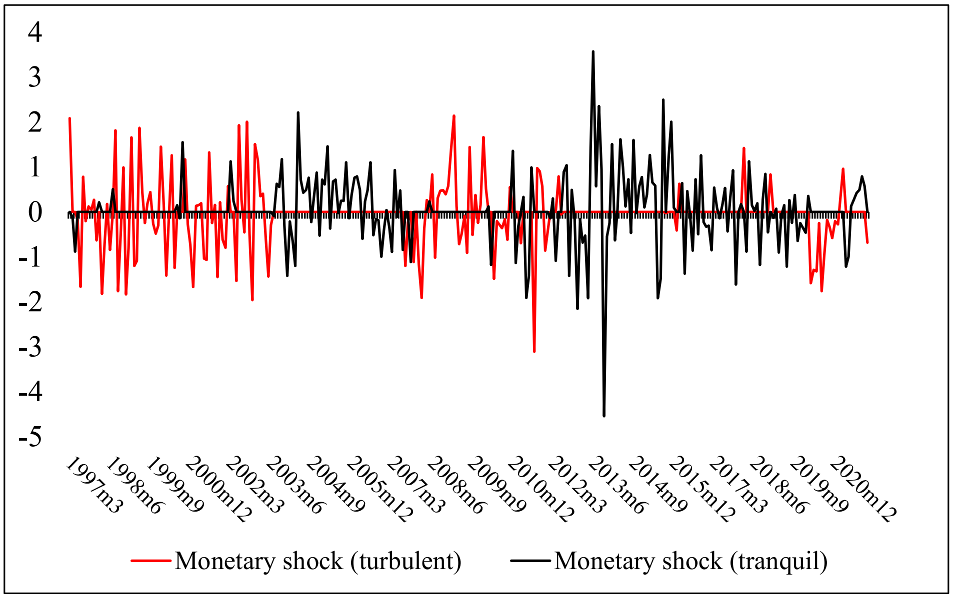

FIGURE 1. MONETARY POLICY SHOCK ACROSS STOCK MARKET VOLATILITY REGIMES

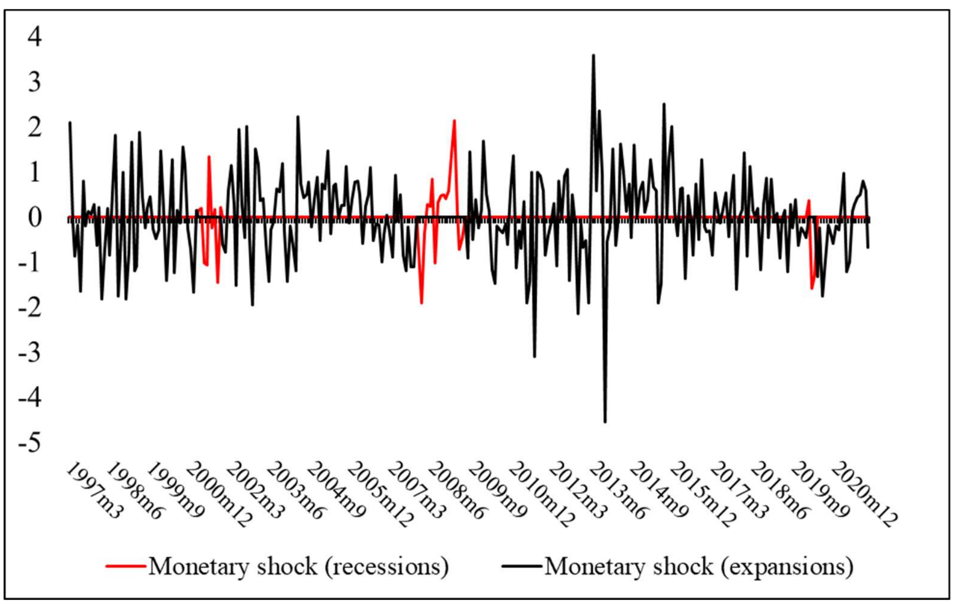

FIGURE 2. MONETARY POLICY SHOCK ACROSS BUSINESS CYCLE PHASES.

In the second step, using newspaper-based MPU and SMU indices, which are measured following the approach of Baker *et al*. (2016)[11], the IRFs of these uncertainties to the monetary shock estimated in the first step are estimated. To do so, the LP approach of Jordá (2005) is applied and IRFs are then smoothed following the smooth local projections approach (SLP) of Barnichon and Brownlees (2019). The basic LP approach implies estimating an equation of the following type:

$$y_{t+h} = c + \beta_h \epsilon_t^{mp} + \gamma_h' x_t + \varepsilon_{t+h} \quad \text{Eq. (4)}$$

$$h = 0, \ldots H$$

where y_{t+h} is a given uncertainty variable (MPU or SMU) h periods ahead, c is a constant, ϵ_t^{mp} is the monetary policy shock, x_t is a vector of control variables, ε_{t+h} is the residual, and β_h, for h = 0, ..., H, represents the IRFs of the variable of interest at time $t + h$ to the monetary policy shock at time t.

To test business cycle and stock market asymmetries, the baseline specification, following Funashima (2022), which is consistent also with the specification of Tenreyro and Twaites (2016), becomes:

$$y_t = c + \beta_{t-h}^R \, \epsilon_{t-h}^R + \beta_{t-h}^E \, \epsilon_{t-h}^E + \gamma_h' x_{t-h} + \varepsilon_t \quad \text{Eq. (5)}$$

where ϵ_{t-h}^R (ϵ_{t-h}^{Turb}) represents the shocks in recessions (or in a turbulent stock market volatility regime), ϵ_{t-h}^E (ϵ_{t-h}^{Tran}) represents the shock in expansions (or in a tranquil stock market volatility regime), $\epsilon_t^{mp} = \epsilon_{t-h}^R \left(\epsilon_{t-h}^{Turb} \right) + \epsilon_{t-h}^E \left(\epsilon_{t-h}^{Tran} \right)$, and x_{t-h} represents the control vector.

[11] MPU and SMU data are retrieved from https://www.policyuncertainty.com/monetary.html and https://www.policyuncertainty.com/equity_uncert.html, respectively, in July 2022.

3. Results and discussion[12]

In Figure 3, it is possible to find the IRFs of MPU and SMU to a one-standard deviation MP shock, and to both tightening and easing shocks. Since the shape and magnitude of the IRFs for both variables are similar, all along this section MPU and SMU are referred, simply, as *uncertainty*. The clearest result is the decreasing response of uncertainty after an MP tightening, which peaks around a year subsequent to the shock. This short-run reduction in uncertainty is consistent with the findings of Bekaert et al. (2013). The main difference is that in this latter paper, uncertainty increases in the long-term, while the results presented in Figure 1 suggest an initial reduction followed by a non-significant behavior. Easing shocks display a non-significant response in the level specification, but uncertainty increases in the first differences of logs specification -see appendix B-. This increase, instead, would be consistent with the results of Funashima (2022).

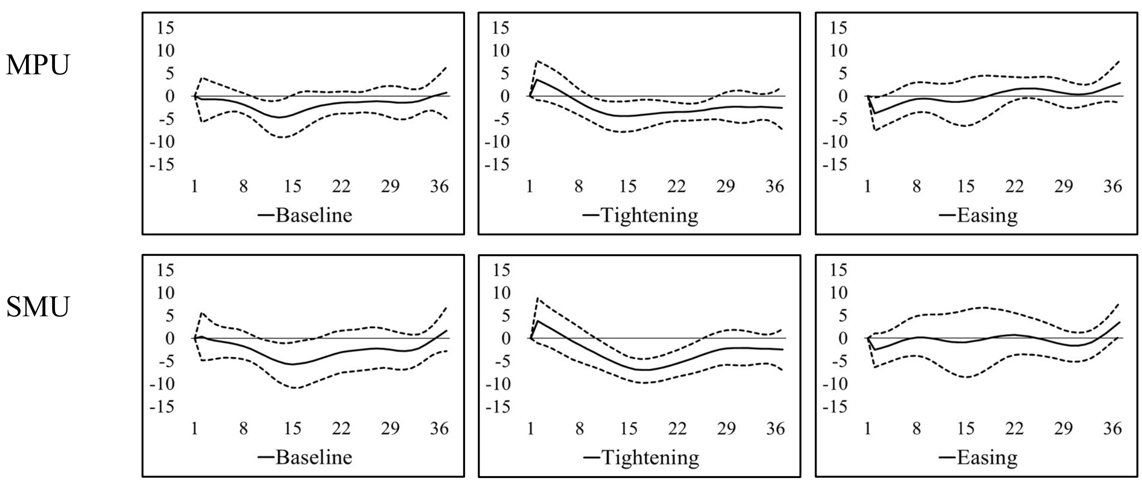

Figure 3. IRFs to a one-standard-deviation MP shock. The solid black line reports the cumulated response for the first 36 months for the log level specification augmented with a linear trend. The dotted lines reports the 10% level of significance.

In Figure 4, the responses across business cycle phases and stock market regimes are reported without focusing on tightening or easing shocks at the moment. Stock market asymmetries do

[12] The full dataset and Matlab replication files can be retrieved from the following repository: https://github.com/nicolasblampied/Replication-Files---Essays-on-Contemporary-Issues-in-Macroeconomics---Ch.-3.

not seem to play a significant role, with MP shocks reducing uncertainty in tranquil times and increasing it in turbulent periods. However, responses are not robust to the specification in first differences. The analysis of business cycle asymmetries suggests that MP shocks reduce uncertainty in recessions, while triggering a non-significant or erratic response in expansions.

MPU

SMU

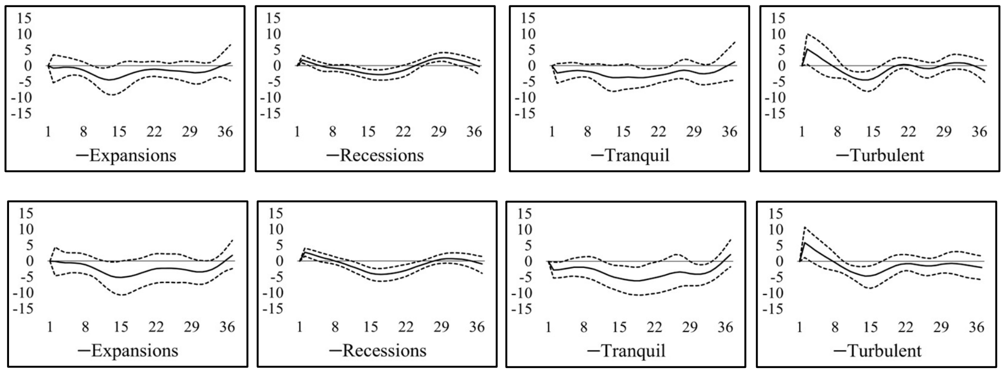

Figure 4. IRFs to a one-standard-deviation MP shock. The solid black line reports the cumulated response for the first 36 months for the log level specification augmented with a linear trend. The dotted lines reports the 10% level of significance.

The most interesting results appear when running the IRFs of Figure 3 considering tightening and monetary shocks separately. Figures 5 and 6 summarize the results in each of these scenarios. A significant and robust result across specifications is that tightening shocks reduce uncertainty in tranquil regimes and expansions. This is clearly indicative of the high effectiveness of contractionary monetary policy shocks in times of expansion, as pointed out by Tenreyro and Twaites (2016). Indeed, given recent findings on the negative link between uncertainty and real macroeconomic variables (Husted et al., 2020), these results provide a hint on the effects of monetary policy shocks through the previous impact on uncertainty.

Easing shocks, instead, seem to increase uncertainty in tranquil times and expansions, displaying some weak significant IRFs. Additionally, when analyzing easing shocks in recessions and turbulent times, the most unambiguous result is that easing shocks reduce uncertainty in recessions, but only around one year after the shock and thereafter giving rise to an erratic movement. The lagged and erratic response indicates that monetary policy is less straightforward in recessions, showing consistency again with Tenreyro and Twaites (2016).

Interestingly, Eickmeier et al. (2016) analyze the effects of monetary shocks in tranquil and turbulent times, finding them to be more effective in the former than in the latter due to the fact that changes in the interest rate in a low volatility environment is more effective at changing credit conditions. Our results are consistent with tightening monetary policy being more effective in tranquil times, but not with easing shocks further pushing the economy in times of low volatility, not at least through the reduction of uncertainty.

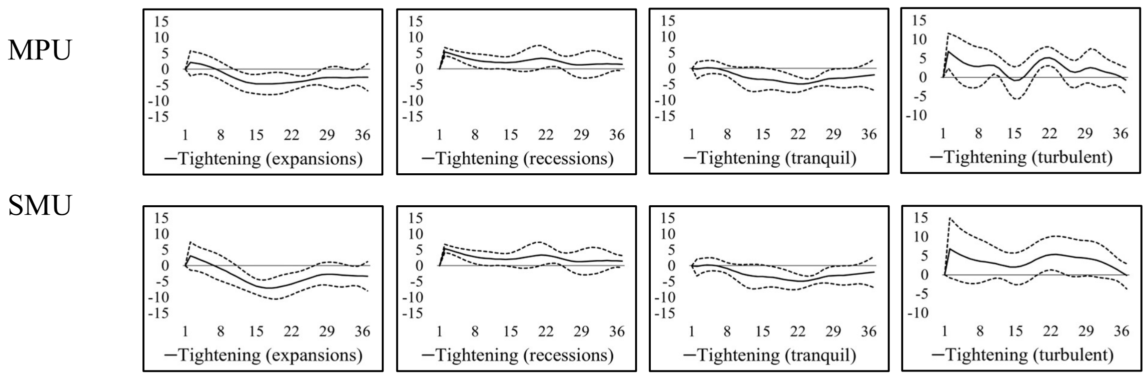

Figure 5. IRFs to a one-standard-deviation MP shock. The solid black line reports the cumulated response for the first 36 months for the log level specification augmented with a linear trend. The dotted lines report the 10% level of significance.

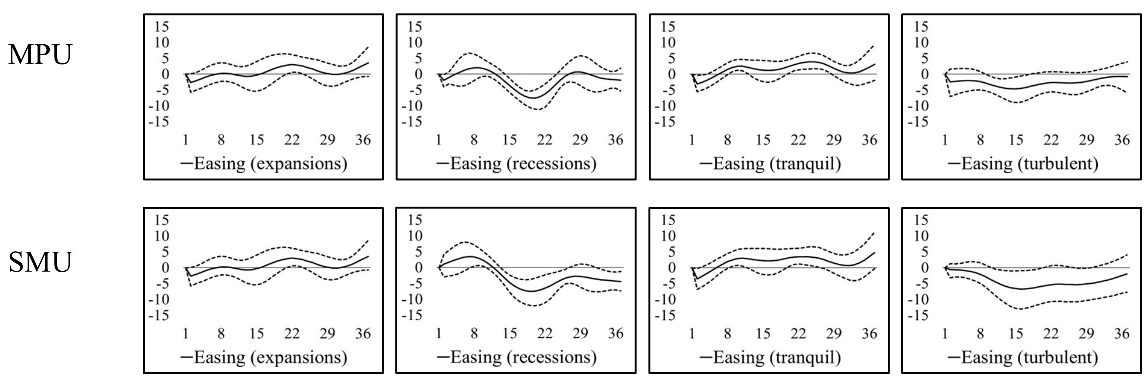

Figure 6. IRFs to a one-standard-deviation MP shock. The solid black line reports the cumulated response for the first 36 months for the log level specification augmented with a linear trend. The dotted lines report the 10% level of significance.

4. Robustness checks

Robustness checks are included in Appendix B. The response of MPU and SMU are robust to all the checks listed below:

a) Stochastic trends: in order to treat potential unit roots properly, the estimation in log levels has been complemented with an estimation in first differences. An estimation in levels without trend and assuming stationary data has also been estimated.

b) Controls: several sets of control variables have been tested. In particular, lags of the MP shock were added following the order of autocorrelation suggested by the autocorrelation function, along with lags of the dependent variable following Tenreyro and Twaites (2016) -three months-, a dummy for the Great Recession period, and a linear time trend in the log level specification.

5. Conclusion

This paper examines whether monetary policy (MP) shocks propagate greater monetary policy and stock market uncertainties. From a theoretical vector autoregressive model of the US economy, monetary shocks are identified and, then, using local projections the impulse responses of monetary policy uncertainty (MPU) and stock market uncertainty (SMU) are estimated to such MP shocks. A key contribution of this work is that it also considers whether there exist any asymmetries in the response of uncertainties to tightening and easing shocks, as well as whether responses change over the business cycle and volatility regimes in the stock market.

The main findings indicate that MP tightening shocks reduce MPU and SMU, while easing shocks would either increase them or play a negligible effect. Across stock market volatility regimes and business cycle phases, the results suggests that tightening shocks reduce uncertainty in tranquil times and in expansions, while the responses in turbulent times and in recessions are not robust across empirical specifications. Easing shocks, instead, increase uncertainty in tranquil times and in expansions, reduce it in recessions after a year or so, and display non-robust responses in turbulent periods.

Moving towards a more intuitive interpretation, it seems that uncertainty falls when the central bank operates as expected by the market. When in expansions the monetary authority increases the interest rate so to avoid an overheating of the economy, uncertainty falls. In the same line, an expansionary monetary shock that takes place in recessions, when the market expects the central bank to ease monetary policy to foster a recovery, also reduces uncertainty.

Taken together, these results broaden the research of Funashima (2022) by studying stock market volatility regimes and business cycle asymmetries. In particular, the impulse response functions imply that easing shocks increase volatility especially in tranquil times and in expansions, while the response is less clear when it is not business cycle or volatility regime dependent. In addition, it could be the case that easing shocks reduce uncertainty in recessionary phases. Tightening shocks, which Funashima found to be non-significant (or to only marginally reduce uncertainty), would reduce uncertainty, but particularly so in tranquil and expansionary periods. These results suggest that monetary policy holds promising potential as an effective countercyclical tool to reduce economic and stock market uncertainty, through easing polices in recessions and tightening policies in expansions or tranquil stock market volatility regimes.

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Appendix A: robustness checks

Appendix A presents relevant information regarding the treatment of the data, in particular the unit root tests performed on the data.

a. Unit root test results

	ADF Test Statistic	Probability	KPSS Test Statistic	Probability
MPU	-8.33	0.00	0.64	0.02
SMU	-2.58	0.10	1.42	< 0.01

TABLE 2A: AUGMENTED DICKEY-FULLER TEST AND KPSS TEST

Notes: The table displays the results for the tests performed on monthly data for the period 1997m3- 2019m12. The specification included an intercept, up to fifteen lags in the ADF test and the default five lags in the KPSS test. The specification did not include a trend, since a visual inspection of both series does not suggest the existence of a trend. MPU stands for "Monetary policy uncertainty" and SMU stands for "Stock market uncertainty".

The ADF test and the KPSS tests in Table 1A are contradictory and cannot rule out completely the existence of a unit root. This is the reason why in Appendix B robustness checks are performed in log level without a trend and in first difference of logs.

Appendix B: robustness checks

Appendix B details the robustness checks performed, in particular those refer to the treatment of stochastic trends.

a. Robustness check 1: IRFs for the markup in the first difference of logs specification

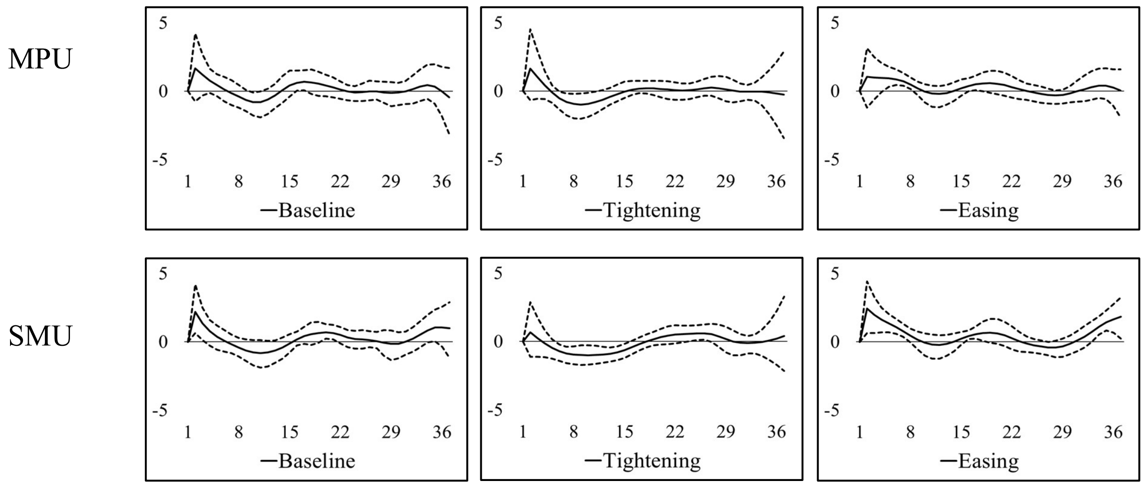

Figure B1. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

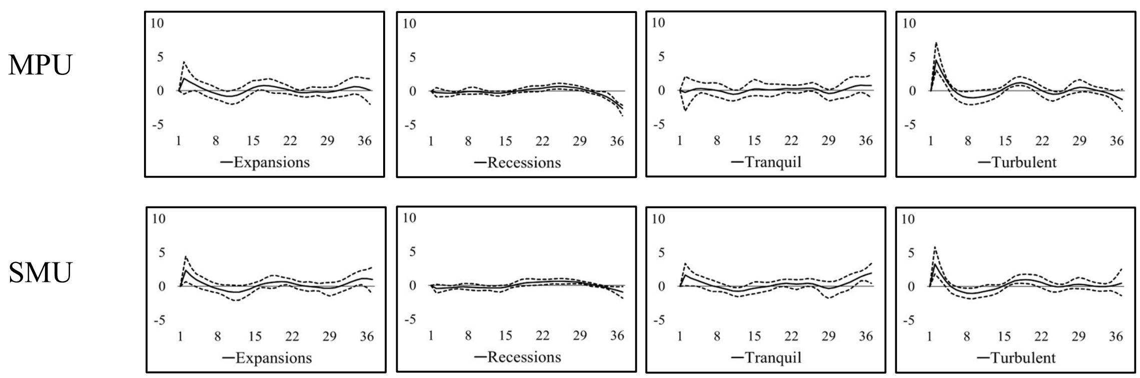

Figure B2. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

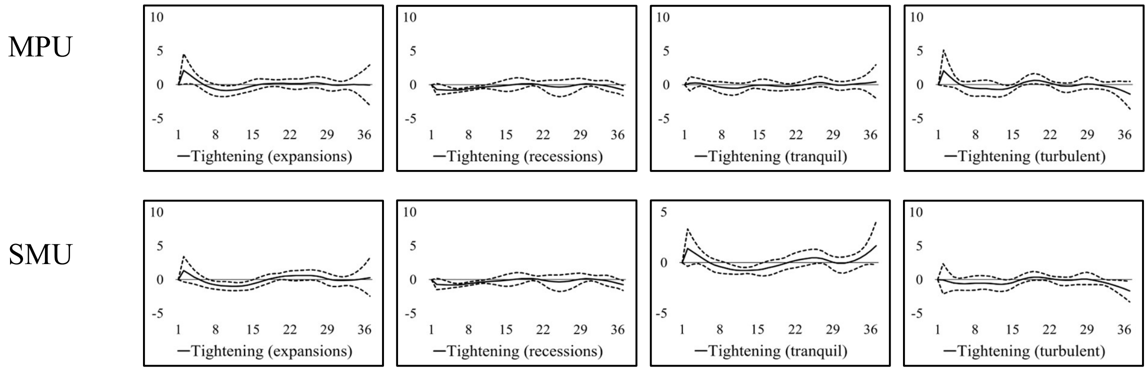

Figure B3. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

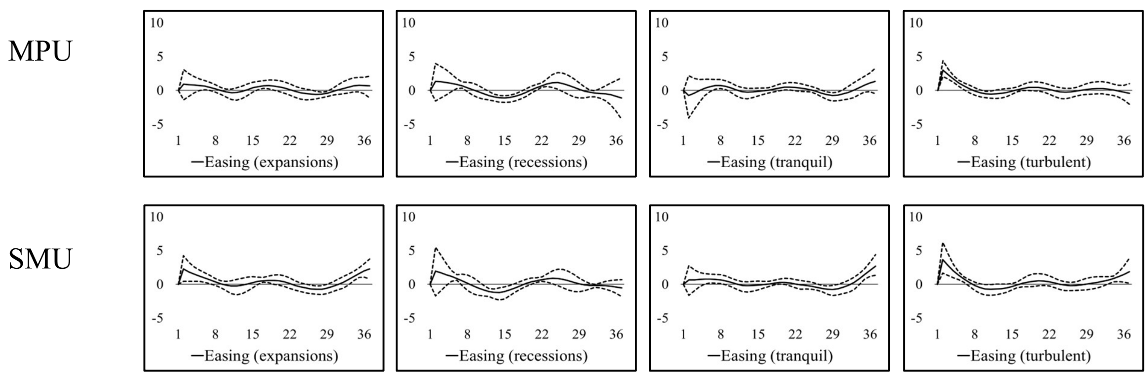

Figure B4. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

b. Robustness check 2: IRFs for the markup in the log level specification without linear time trend

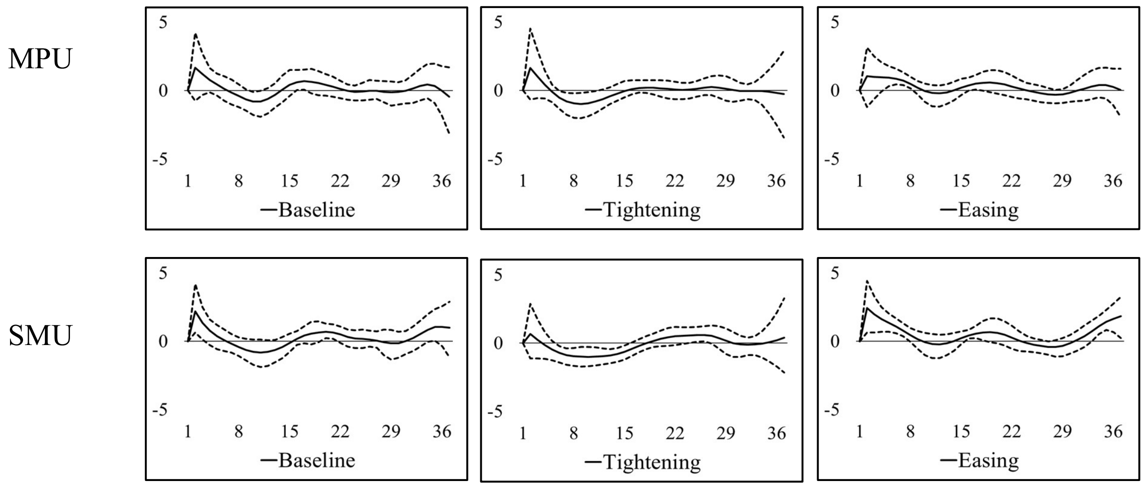

Figure B1. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

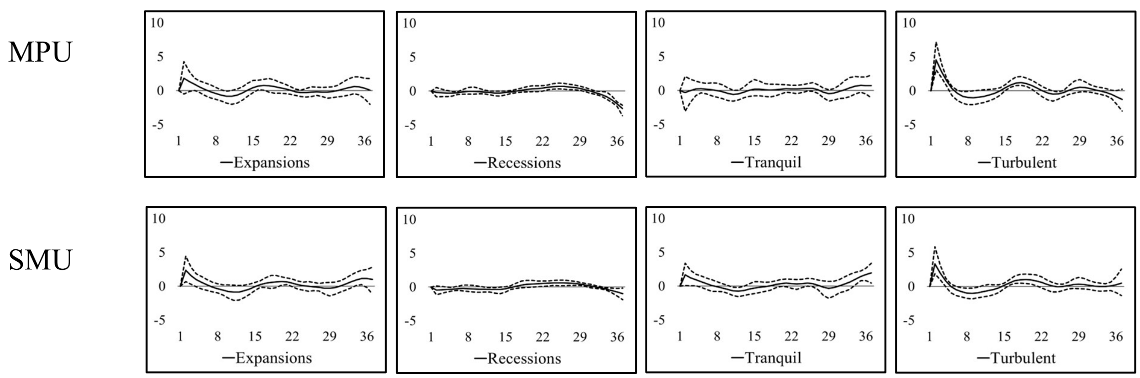

Figure B2. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

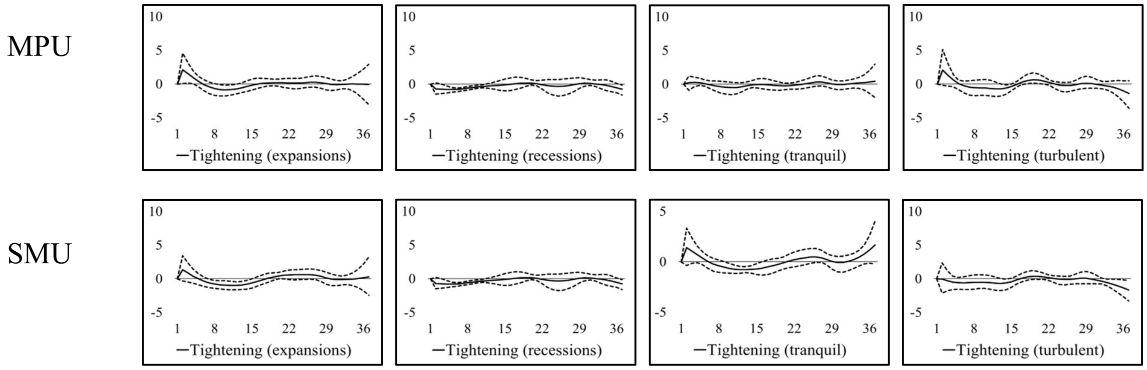

Figure B3. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

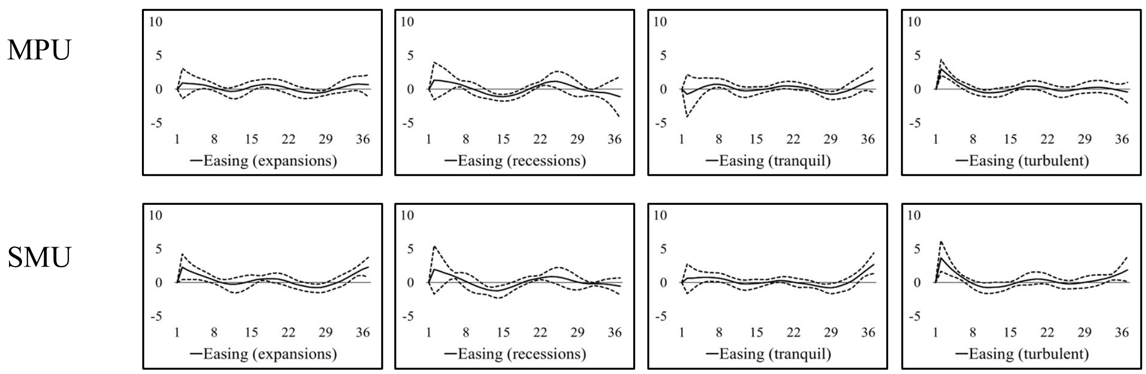

Figure B4. IRFs to a one-standard-deviation MP shock. The solid black line reports the point response for the first 36 months for the first difference of logs specification. The dotted lines report the 10% level of significance. The sample covers the period 1997m3-2019m12.

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My memory may be weak sometimes, I must admit. To those I forgot, I am deeply sorry.

Nicolás Blampied