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**The effects of Monetary Policy on Total Factor Productivity in  
the Euro Area**

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# The effects of Monetary Policy on Total Factor Productivity in the Euro Area

## Abstract

This paper analyses the impact that Monetary Policy has on Total Factor Productivity (TFP) in the Euro Area, by computing a utilization corrected TFP measure and obtaining impulse response functions by using Local Projections with a high frequency identification external instrument. It finds evidence of a negative relationship between tightening monetary policy and aggregate TFP, being part of this effect explained by a fall in capital utilization. A sample split shows that the response of TFP to a monetary shock is twice as large during the pre crisis period, suggesting that the financial crisis aftermath had a considerable impact on this linkage.

**JEL Classification:** C33, D24, E44, E52 and E58

**Keywords:** Monetary Policy, Total Factor Productivity, High Frequency Identification, Local Projections

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# 1 Introduction

Total Factor Productivity (henceforth TFP) constitutes a key determinant of long run growth and it plays an important role in Real Business Cycle theory and classical DSGE models. Productivity shocks were long been believed to be exogenous, as solid macroeconomic models and theories were built around this paradigm. [Evans \(1992\)](#) cast doubt of the exogeneity of these fluctuations, proving that TFP variations are highly sensitive to changes in aggregate demand and granger caused by monetary and fiscal aggregates. This hypothesis was widely accepted in the literature, as several studies focusing on the cause of TFP fluctuations emerged, with the role of business innovation and monetary policy being subject to special attention. Being monetary policy a key tool for the economic growth and stability of the Euro Area, it is crucial to understand how it can impact the productivity standards of the euro countries.

This study proposes to analyze the link between Monetary Policy and TFP in the Euro Area. A utilization adjusted TFP measure is computed for a panel dataset containing the eleven founding countries of the Eurozone and Greece, from the period of 2001 to 2018, at the quarterly frequency. To identify monetary policy shocks, an external instrument constructed using high frequency changes in market prices around ECB policy announcements is used, provided by [Kerssenfischer \(2019\)](#). Sign restrictions were used to clean up informational effects of the shocks series, as pure monetary innovations are considered. The local projection methodology, introduced by [Jordà \(2005\)](#), is applied with the external instrument (the LP-IV method) to obtain the effect of policy surprises on different productivity measures and capacity utilization. Lastly, a sample split is conducted to examine whether the crisis period, mainly characterized by financial frictions and the zero lower bound constraint, had an impact on the transmission of monetary policy to productivity.

Several relevant findings are obtained. First, the LP-IV approach seems to properly capture the economic dynamics in the sample, as no puzzling effects (notably in prices) were

detected in the response of standard macroeconomic aggregates to a monetary shock. Second, a monetary policy contraction decreases overall TFP. Part of this fall is explained by a reduction of capacity utilization, which explains a substantial difference in the responses of raw and adjusted TFP. Official and derived utilization series have a similar reaction to a policy shock. Lastly, results highly differ when considering distinct time frames. The response of TFP is more than twice as larger when the pre crisis period is considered, suggesting that credit constraints played an important role on what regards the link between the two variables, as suggested in the literature.

This paper contributes to a growing literature that attempts to explain how TFP might be affected by monetary policy, and whether the latter can be a cause of the overall productivity slowdown (Moran and Queralto, 2018). Firstly, by the construction of a utilization adjusted TFP measure for the Euro countries, using the Imbs (1999) correction. Most studies involving this scheme are highly restricted to the U.S due to data availability, mainly regarding the application of the Fernald (2014) and Basu et al. (2006) methods. Secondly, it innovates in the implied methodology both by obtaining impulse responses by the means of local projections and identifying monetary shocks through a high frequency identification scheme, a recent growing method to identify the dynamic causal effects of monetary policy shocks. Lastly, this study relates to a wide literature that seeks to measure the effects of monetary policy, with the distinctiveness that it focuses on an understudied measure that has a key impact on business cycles and economic growth.

The remainder of this paper is structured as follows. Section 2 covers the main literature on the topic. Section 3 provides an explanation of the dataset as well as an overview of the Imbs (1999) factor utilization correction. Section 4 develops on the adopted methodology, detailing the local projections procedure and the construction of the external instrument. Section 5 and 6 present the results and several robustness tests to ensure their credibility. Section 7 concludes with a brief discussion.

## 2 Literature Review

Literature on the effects of monetary policy on TFP is scarce when compared to other aggregate macro variables. This is surprising mainly when considered the importance of TFP impulses on business cycle models (Kydland and Prescott, 1982), New Keynesian extensions (Moran and Queralto, 2018) and mainstream DSGE models. As previously noted, the first groundbreaking analysis in the topic heads back to Evans (1992) who cast doubt on the long lived paradigm of the exogeneity of productivity shocks. He finds that treasury bills, government spending and money stock granger-caused those fluctuations. Given the countercyclical nature of monetary policy, conventional economic reasoning would point to a TFP expansion after a rate cut and vice versa. This association is in line with Evans and dos Santos (2002) verdicts, who use structural VARs to find a positive linkage between accommodative monetary policy and productivity growth. Likewise, Jorda et al. (2019) finds a similar relation amidst both variables, proving the existence of long run effects of monetary policy on output, partly caused by a continuous and persistent decline of TFP in face of a positive monetary shock.

A broad share of the literature attempts to explore the channels through which monetary policy affects TFP. Innovation and business dynamism are often seen as the main drivers of productivity (Anzoategui et al., 2019) usually proxied by R&D investment or patent counts, as they are included in several DSGE models<sup>1</sup>. For instance, Comin and Gertler (2006) develop a DSGE model with endogenous TFP where firms choose R&D investment. The link between monetary policy and innovation is deeply documented by Moran and Queralto (2018). The authors build a New Keynesian framework based on Comin and Gertler (2006) and reinforce their results empirically by using structural VARs, proving that a monetary expansion constitutes an incentive for firms and innovators to invest in productivity enhancing projects, increasing aggregate TFP. They suggest harsh productivity losses due to the zero

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<sup>1</sup>See Basu and Fernald (2002) for a wider discussion on the determinants of productivity.

lower bound constraint.

There are, in fact, other offsetting channels. [Obstfeld \(2018\)](#); even supporting the innovation channel between monetary policy and productivity; warns that in the presence of financial frictions and market imperfections, only the non credit constrained firms can respond positively to a rate decrease. This adds to a wide literature that attempts to study misallocation as a source of cross country differences in aggregate TFP ([Midrigan and Xu, 2014](#)). Mainly during crisis periods, a monetary expansion will make profitable firms invest more and increase their capital stock; while weak firms, lacking credibility on credit markets, will not respond in such manner. As a consequence, the dispersion of the marginal product of capital across firms increases, as it was observed in several Southern European economies, in line with the sharp decline in interest rates and binding credit constraints during and after the crisis period ([Gopinath et al., 2017](#)). As pointed by [Obstfeld \(2018\)](#), a related cause of TFP losses caused by easing monetary policy during the post crisis period is the rise of zombie firms. The author argues that this type of non sustainable firms maintain their activity due to easy credit conditions and low interest rates, in spite of making no profits whatsoever, as they constitute a barrier to the entry of new competitive firms in the market and an impediment to productivity growth.

A related concern in the literature involves TFP measurement, more specifically, as argued by [Meier and Reinelt \(2019\)](#), issues relating capacity utilization and the existence of aggregate markups. If monetary policy has an impact on capacity utilization, TFP measures that do not account for this issue might induce spurious conclusions. The authors suggest that part of the productivity decline caused by a contractionary policy shock is due to a decrease in capacity utilization, using the well known adjusted TFP series of [Fernald \(2014\)](#). In the same line, as most productivity measures are on the base of labor income shares as factor weights ([Solow, 1957](#)), TFP is mismeasured with the existence of aggregate markups ([Hall et al., 1986](#)). [De Loecker and Warzynski \(2012\)](#) develop a method to estimate firm-level markups.

## 3 Data

### 3.1 Dataset

The panel dataset consists of quarterly observations from 2001Q1 to 2018Q4 on several economic measures such as output, prices, GDP components and other relevant indicators for the purpose of this study. All the included variables are relevant even not being subject to careful analysis in section 5, being necessary for the TFP computation in section 3.2. The adopters of the euro (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain) and Greece were the chosen countries for the analysis, as they are expected to properly capture the dynamics on the Euro Area and provide a reasonable time range, which ends up being compensated with the cross-sectional dimension. Table 2 in the appendix contains a detailed description of the variables as well as their sources. All variables except rates were transformed into their natural logarithmic form (x100).

### 3.2 Productivity Data

As stated in section 2, a big concern regarding TFP measurement involves capacity utilization. Other issues, such as the ones related to the correct measurement of output in the presence of quality improvements, are extensively addressed in the literature as crucial for long run TFP growth, but less relevant for short term productivity changes (Comin et al., 2018). Ideally, lacking a cross-country dataset of utilization adjusted TFP, one would use the Basu et al. (2006) methodology to account for this issue <sup>2</sup>. This method is, however, highly restricted to the U.S due to data availability. As such, following the approach of Jorda et al. (2019) and Levchenko and Pandalai-Nayar (2017), the Imbs (1999) correction was performed

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<sup>2</sup>The authors build a factor correction model accounting for non-constant returns to scale and heterogeneity at the industry level.



instead.

The author builds a partial equilibrium model following [Burnside et al. \(1996\)](#), where firms operate in perfect competitive factor, input and output markets, producing according to the following production function:

$$Y_t = A_t(K_t u_t)^\alpha (L_t e_t)^{1-\alpha} \quad (1)$$

where  $Y_t$  is output,  $K_t$  the capital stock,  $L_t$  the number of employees,  $u_t$  and  $e_t$  denote the factor utilization correction and  $A_t$  corresponds to the adjusted TFP. Depreciation is a function of capital utilization according to the expression  $\delta_t = \delta u_t^\phi$  (henceforth depreciation equation) as firms choose optimally their level of  $u_t$ . Households choose consumption and labor supply, being the latter determined by a trade off between effort  $e_t$  and wages  $w_t$ , which are adjusted every period, depending on the time frequency. As such, firm's maximization problem is:

$$\max : A_t(K_t u_t)^\alpha (L_t e_t)^{1-\alpha} - w(e_t)L_t - (r_t + \delta_t)K_t \quad (2)$$

while households solve:

$$\max : E \sum_{j=0}^{\infty} \beta^j \left\{ \ln C_t - \frac{L_t^{1+\theta}}{1+\theta} - \frac{e_t^{1+\psi}}{1+\psi} \right\} \quad (3)$$

subject to a budget constraint. After normalizing  $E(u_t^\phi) = 1$ , both solutions correspond to:

$$u_t = \left( \frac{Y_t/K_t}{\bar{Y}/\bar{K}} \right)^{\frac{\delta}{\bar{r}+\delta}} \quad e_t = \left( \alpha \frac{Y_t}{C_t} \right)^{\frac{1}{1+\psi}} \quad (4)$$

An initial capital series is constructed using the perpetual inventory method and a constant depreciation rate, from where a first utilization series is constructed. Variate values for  $\delta$  are then obtained using the depreciation equation, from which a new capital series

can be constructed using investment data and the standard capital accumulation equation:  $K_{t+1} = (1 - \delta_t)K_t + I_t$ . This procedure is repeated until the depreciation rate converges.<sup>3</sup> Note that capital utilization is high whenever the output-capital ratio is above its average value. This is precisely how some central banks compute their official utilization series (Paquet et al., 1997). While the correct measurement of capital utilization has been a highly debated topic in TFP studies, labor hoarding does not have the same share of the literature. Also, as the model imposes some strict assumptions on households' labor supply, it was decided not to include labor effort  $e_t$  in the final adjusted TFP computations. Final utilization adjusted TFP series are then computed using:

$$A_t = \frac{Y_t}{(K_t u_t)^\alpha (L_t)^{1-\alpha}} \quad (5)$$

Standard (raw) TFP series were also computed without accounting for the adjustment factors. A deeper explanation of the model can be found in Imbs (1999).

## 4 Methodology

### 4.1 Local Projections: The LP-IV methodology

Common macroeconomic literature focuses on analyzing the behavior of economic indicators over time when faced with an unexpected change in other variables. Multivariate time series models; more specifically, VARs (Vector autoregressions); dominate this approach mainly due to their easiness in computing impulse response functions (IRFs). In the present scenario, instead, the method proposed by Jordà (2005) is implemented and IRFs are esti-

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<sup>3</sup>Initial values of  $\delta = 2\%$  and  $r = 1\%$  were considered. As for the capital stock, the initial value corresponds to the real data value for 2000, the year just before the start of the sample. Section 6 shows there are no differences when these values vary

mated using local projections (LP). In short, local projections consist of several sequential regressions, estimated at each horizon of the response. Taking a monetary policy shock as a benchmark, the following equation is estimated:

$$y_{i,t+h} = \alpha_{i,h} + \Delta r_{i,t} \beta_h + X_{i,t} \gamma_h + \xi_{i,t+h} \quad h = 0, 1, \dots, H; \quad (6)$$

where  $y_{i,t+h}$  is the outcome variable for country  $i$  observed  $h$  periods ahead,  $\alpha_{i,h}$  are country fixed effects,  $\Delta r_{i,t}$  corresponds to a change in the policy rate, and  $X_{i,t}$  refers to a vector of control variables, correlated with  $\Delta r_{i,t}$  and explanatory of  $y_{i,t}$ . Contrary to VAR models, local projections IRFs do not depend on the model specification, as a different equation is estimated for each horizon  $h$ . This constitutes one of the biggest advantages of the LP method over VARs (Jordà, 2005). If a certain data generating process is not well approximated by a VAR(p) process, IRFs will be biased and misleading, as the model does not reflect the reality of the data.<sup>4</sup> The response at each period corresponds to the coefficient  $\beta_h$ , which should be as accurate as possible. This can be achieved by, for instance, the usage of control variables to tackle endogeneity. In the present study, the instrumental variable (IV) approach is used to reach an unbiased and precise prediction of the impulse response to a monetary policy shock. The idea is to use a variable that is highly correlated with  $\Delta r_{i,t}$  and uncorrelated with the remainder macro shocks hitting the economy. This approach relates to recent literature that attempts to get external sources of variation on interest rates to identify the causal effects of monetary shocks, instead of imposing internal restrictions on the model such as SVARs ordering and sign restrictions (this constitutes another advantage of the LP method, as it does not require internal restrictions to identification). For instance, Gertler and Karadi (2015) apply the external instrument approach on a VAR (the VAR-IV method), while Jordà et al. (2019) uses the same technique with local projections (the LP-IV approach). Equation 6 is thus estimated using Instrumental Variable standard methods.

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<sup>4</sup>Local projections provide several other advantages, such as not suffering from the curse of dimensionality, efficient in accommodating with non-linearities and being estimated with simple OLS regressions. See Jordà (2005) for a full description of the method.

## 4.2 The Instrument: High Frequency Identification

As argued by [Stock and Watson \(2018\)](#), and based on their notation, an instrument is valid to estimate a dynamic causal effect if it fulfills the three following conditions (hereafter the LP-IV conditions):

- (i)  $E(\varepsilon_{1,t}Z'_t) = \alpha' \neq 0$  (relevance);
- (ii)  $E(\varepsilon_{2:n,t}Z'_t) = 0$  (contemporaneous exogeneity);
- (iii)  $E(\varepsilon_{t+j}Z'_t) = 0$  for  $j \neq 0$  (lead-lag exogeneity).

where  $\varepsilon_{1,t}$  corresponds to the shock of interest (monetary shock in this case) and  $\varepsilon_{2:n,t}$  correspond to all other shocks. The two first LP-IV conditions are the classical relevance and exogeneity conditions of the instrumental variable literature, while the third one imposes that the instrument ought to be uncorrelated with all shocks at all leads and lags. As explained in the next section, this can be achieved with the inclusion of control variables.<sup>5</sup>

To obtain an instrument that accomplishes these requirements, this study relies on high frequency surprises data around ECB policy announcements, an approach that has been previously used by [Gertler and Karadi \(2015\)](#) for the US and [Corsetti et al. \(2018\)](#) for the Euro Zone. By choosing a narrow time window around the announcements, it is reasonable to assume that any surprises occurring within this time frame are related to the monetary policy shock and not by other structural shock hitting the economy. Such assumption is plausible when considered the short time range chosen around the announcements. More specifically, the instrument used was built by [Kerksenfischer \(2019\)](#) in his recent research on central banks information effects.<sup>6</sup> The author computes the change in 2 year German government bond

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<sup>5</sup>This assumption is necessary to identify the effects of the shock of interest alone, as variables usually depend on the entire history of all shocks. See [Stock and Watson \(2018\)](#) for a deeper explanation on the LP-IV conditions.

<sup>6</sup>Shock series are available in the author's personal web page: <https://sites.google.com/site/markkerssenfischer>

yields <sup>7</sup> and the EURO STOXX 50 index around all 186 ECB Governing Council meetings from March 2002 to December 2018. The considered time range goes from 10 minutes prior to the ECB's press release to 20 minutes after the end of the press conference. ECB policy announcements start at 13:45 CET via press release, but part of the information is only filtered to the market during the press conference and Q&A with the president<sup>8</sup>, which starts at 14:30 CET. Thus, the change of German bond yields during this short period of time corresponds uniquely to a Monetary Policy Shock.

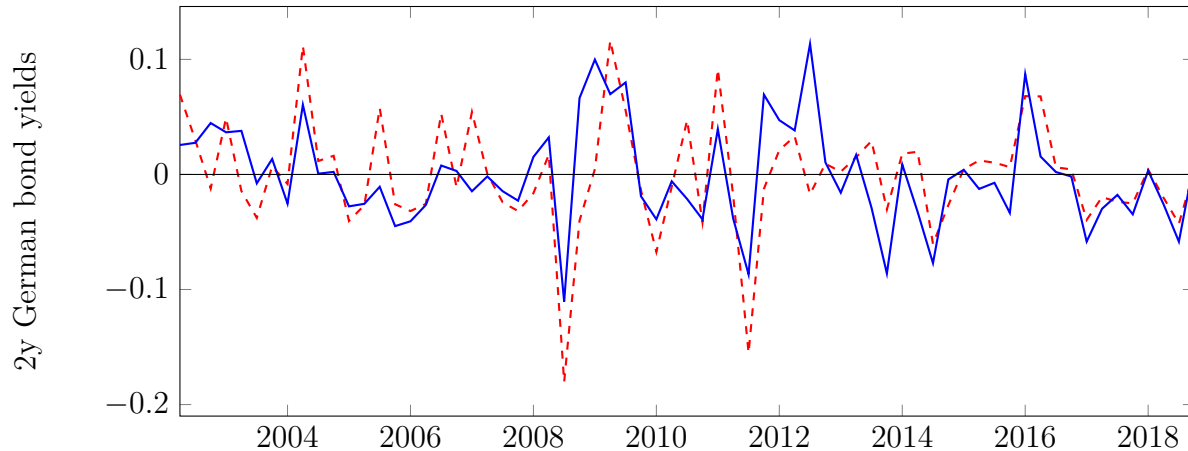
Despite all the advantages, this approach is often misleading due to central banks' information effects (Romer and Romer, 2000). Policy announcements convey not only information about monetary policy but also regarding the central bank's economic outlook and expectations. For instance, an interest rate increase, which corresponds to a contractionary policy move, might indicate a favorable economic outlook by the central bank and have puzzling effects on economic and financial indicators. Kersefischer (2019) detects contradictory effects on the behavior of stock prices around some of the ECB announcements. More precisely, council meetings where expansionary policies were announced were followed by a decline on both bond yields and the STOXX 50 index, as the behavior of the latter goes against standard economic theory.<sup>9</sup> Despite being expansionary announcements, during the conference the president transmitted pessimist signals on the current economic outlook, as the markets reacted oppositely to what would be expected. Kersefischer (2019) imposes sign restrictions on the behavior of German bond yields and stock prices in order to disentangle both effects, separating the surprises obtained by the high frequency identification scheme into pure monetary policy shocks and information shocks. Figure 1 plots both types of surprises: the standard high frequency changes and the ones obtained with sign restrictions. The ob-

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<sup>7</sup>As argued in Hanson and Stein (2015), government bonds are seen as a good Monetary Policy instrument proxy.

<sup>8</sup>During the press conference, the president elaborates on the decisions made and answers journalists questions, providing important signals on current and future economic situation, which are immediately reflected on financial market prices.

<sup>9</sup>Usually, a rate decrease should raise stock prices, due to both a decrease in the discount rate and lower expected dividends.



**Figure 1:** External instrument. The dashed line corresponds to the high frequency change around policy announcements. The solid line correspond to pure monetary surprises, obtained by imposing sign restrictions on the high frequency comovement of bond yields

served difference between series strengthens the importance of taking information effects into account. In this study, the purpose is to analyze the impact of pure policy news and not informative effects, as the latter are neglected. As shown further, disregarding information shocks leads to considerable puzzling effects.

As the type of data used is at quarterly frequency, daily shocks need to be aggregated to obtain quarterly surprises. Similarly as [Meier and Reinelt \(2019\)](#), the following averaging procedure is applied:

$$\varepsilon_t = \sum_{\tau \in D(t)} \phi(\tau)\varepsilon_t + \sum_{\tau \in D(t-1)} (1 - \phi(\tau))\varepsilon_t \quad (7)$$

where  $D(t)$  corresponds to the set of days in quarter  $t$  and  $\phi(\tau)$  is the number of the remaining days in quarter  $t$  after the announcement divided by the total number of days in quarter  $t$ . This averaging procedure enables to incorporate the fact that some meetings occur earlier in a quarter than others. Thus, if a meeting happens on the first day of the quarter, it will influence only that quarter, whereas a meeting occurring at the end of the quarter will have a higher impact in the next quarter.

As the instrument is only available from 2002q2 onwards, the considered sample is reduced by 5 observations.

## 5 Results

In this section, the LP-IV method is applied to get the impulse response function of several economic indicators to a monetary policy shock, identified with the instrument referred in section 4.2. All variables are represented in its natural logarithmic form (x100) except for interest rates. Equation 6 is estimated using a lag of the identified shock as a control variable, due to the serial correlation induced on the shock variable by the time aggregation in equation 7. The inclusion of control variables is highly recommended in the literature, as an instrument might only satisfy the LP-IV conditions after the addition of controls to the regression. Although in the present case the instrument is exogenous by itself, including control variables reduces the sampling variance of the  $\beta_h$  coefficient as they decrease the variance of the error term (Stock and Watson, 2018). To preserve degrees of freedom, the only control included is a lag of the shock. Finally, standard errors are estimated through a clustered robust covariance matrix scheme. According to Jordà et al. (2019), this method conveniently corrects for the serial correlation in the residuals imposed by the local projections method.

### 5.1 Standard macro variables

To begin with, this section aims to test the validity and behavior of the instrument by evaluating the response of standard macroeconomic variables to a contractionary policy shock. Figure 2 plots the impulse response functions to a one standard deviation increase in the policy rate, instrumented by Kerstenfischer (2019) policy shock. All the variables respond to the shock as suggested by classical economic theory and with similar shapes as other high frequency identification studies (Miranda-Agrippino and Ricco, 2018). Output and its components (consumption, investment and exports) suffer a considerable contraction over the time span of twenty quarters, in line with the empirical literature. In the same line, the unemployment rate suffers a familiar increase, returning to zero in the long run. As

foreseeable, credit falls by a significant amount; as well as stock prices which decrease substantially in the short run, as predicted by [Kerssenfischer \(2019\)](#). Remarkably, the results do not appear to suffer from the price puzzle<sup>10</sup>, as both consumer and producer prices behave as predicted in textbooks, suffering a reduction after a policy rate increase. Given the presence of such paradox in several empirical models, this particular result demonstrates the validity of the model and its ability to properly capture economic dynamics, both due to the local projections methodology and the appropriate identification of monetary shocks, via high frequency strategy. Moreover, [Figure 7](#) in the appendix demonstrates the existence of puzzling effects on output, consumption, stock prices and unemployment to the same policy shock, when using [Kerssenfischer \(2019\)](#) instrument that does not account for information effects. Such results intensify the idea presented in [section 4.2](#) and deeply detailed in [Jarocinski and Karadi \(2018\)](#) that central banks announcements convey information about the state of the economy that is capable to influence the behavior of economic and financial indicators. Thus, clearing those effects is fundamental to predict the reaction to a pure monetary policy shock.

## 5.2 Total factor productivity

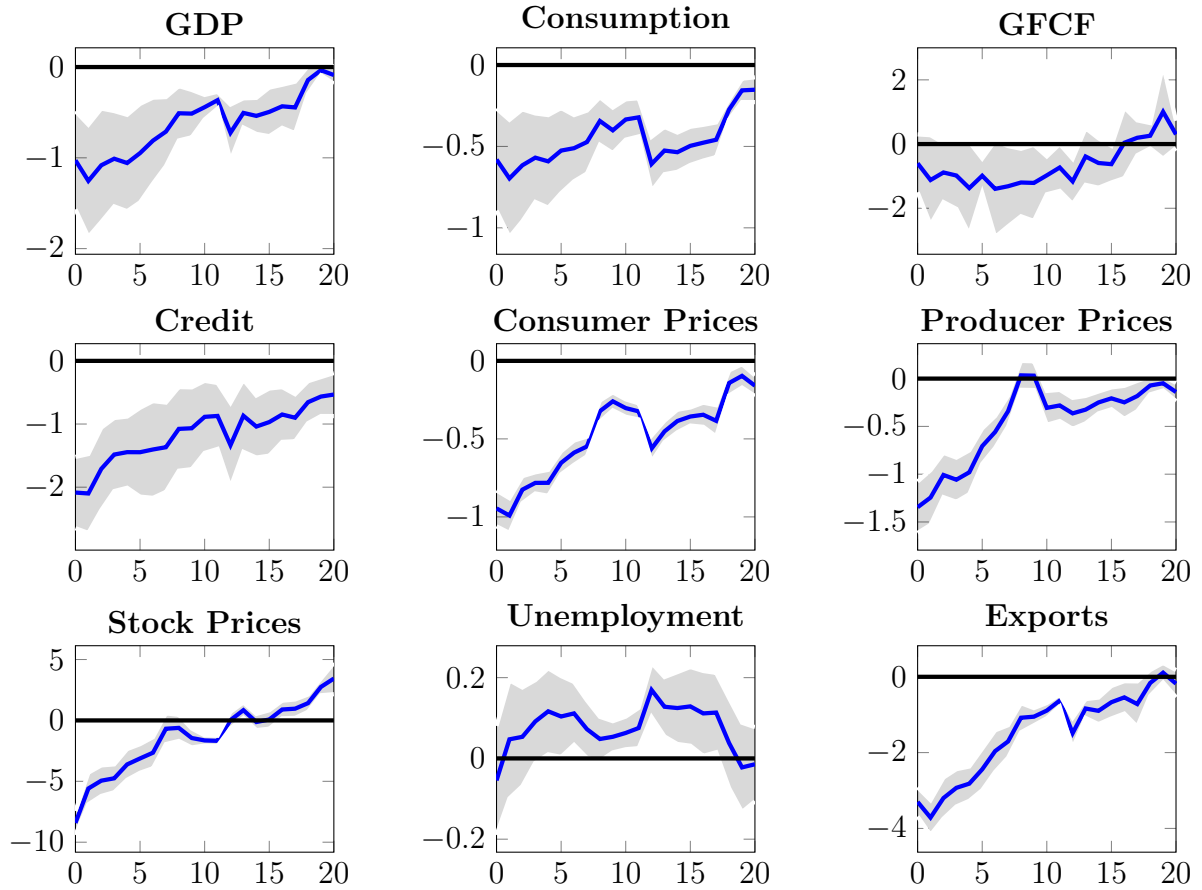
Having proven the robustness and credibility of both the model and identification strategy, the behavior of TFP is now analyzed. [Figure 3](#) illustrates the impulse responses of utilization adjusted TFP (computed using the [Imbs \(1999\)](#) correction), standard raw TFP (without factor adjustment), the capital utilization rate derived in the model and official capacity utilization series extracted from Eurostat.

The results go in line with most of the literature, which proposes productivity loses after a monetary contraction. Adjusted TFP suffers an immediate decline, which is particularly harsh in the first eight quarters, converging to zero over time. Similar dynamics are observed in other productivity measures. The response of raw TFP exhibits the same pattern as the

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<sup>10</sup>The price puzzle corresponds to a rise in prices following a contractionary monetary policy shock, typically found in VAR studies.





**Figure 2:** Response of several macroeconomic aggregates to a one standard deviation policy shock. The shaded area corresponds to 95% confidence intervals bands, obtained using cluster robust standard errors.

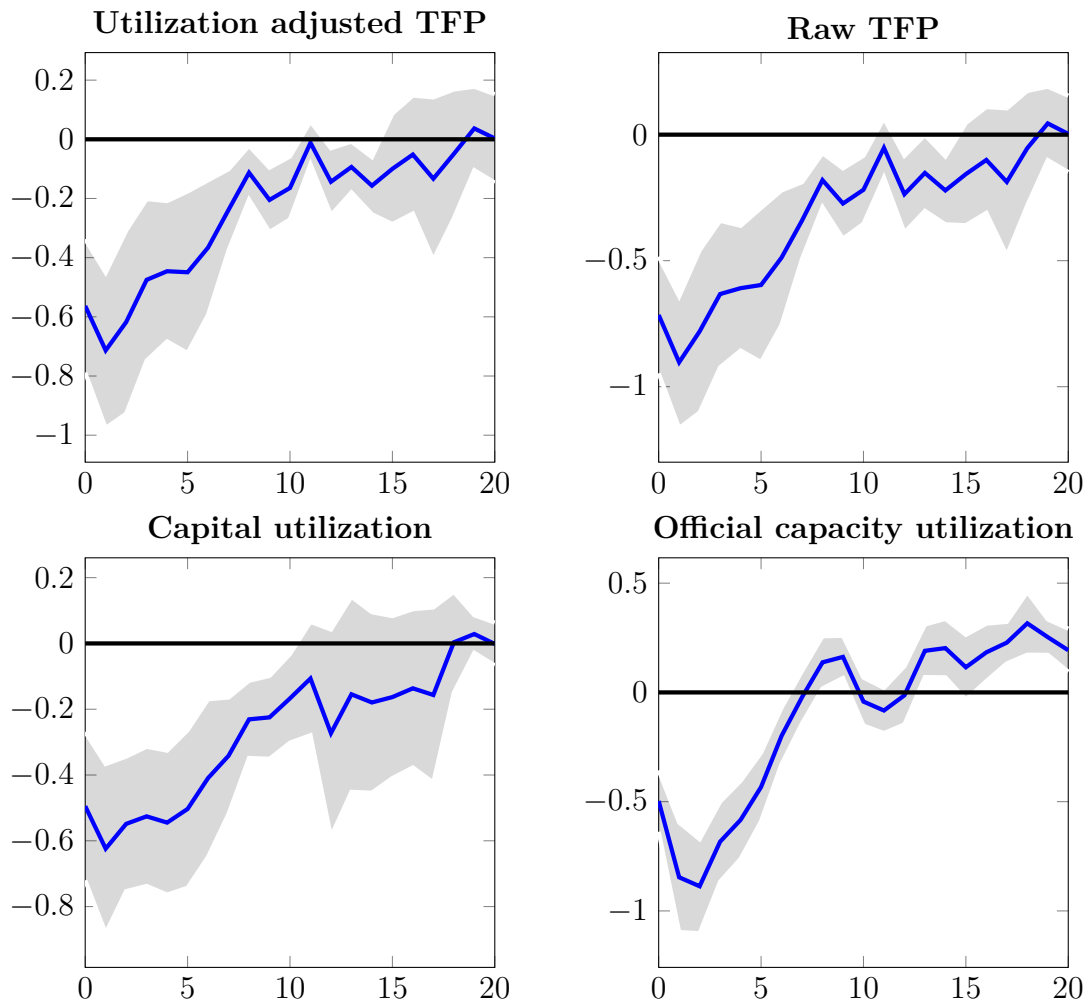
adjusted one, but more accentuated than the latter in the short run, in line with [Jorda et al. \(2019\)](#) findings and coherent with the extensive literature that highlights the importance of capital utilization to TFP measurement. This result is compatible with the behavior of the response of capital utilization, which also suffers a significant decline, converging over time. For a detailed analysis of this result, table 1 in the appendix reports the coefficient estimates of the impulse response function of both TFP measures. As visible, the response of the utilization adjusted TFP series is considerably smaller than the raw TFP one as this difference becomes smaller over time, consistent with the response of capital utilization, which is notably large in the first quarters of the analysis.

Moreover, the response of the official utilization series emphasizes the obtained results. Despite returning to zero earlier in time when compared to the computed series, official utilization suffers a considerable decline before convergence, identically as found by [Miranda-Agrippino and Ricco \(2018\)](#), as the response of both series depicts identical shapes. This result reinforces the validity of the derived utilization factor, as well as the importance it has on productivity quantification.

Given all these conclusions, the main result one can take is that tightening monetary policy decreases aggregate TFP, being part of such fall caused by a reduction in capital utilization. Such relationship is not surprising given all the literature arguing in favor of it and in line with standard economic reasoning. As a rate increase truncates firms' capacity to borrow and invest, it is reasonable to assume that; in the absence of financial frictions and market imperfections; it is accompanied by a productivity decline.

### 5.3 Sample split and R&D

As detailed in section 2, several literature argues that credit constraints and financial stability play a big role in the link between monetary policy and productivity. The post crisis period is said to have contributed to the misallocation of capital across firms (due



**Figure 3:** Response of productivity measures and capacity utilization to a one standard deviation policy shock. The shaded area corresponds to 95% confidence intervals bands, obtained using cluster robust standard errors.

to binding credit constraints) as well as promoting the appearance of zombie firms; both phenomena highly restricting TFP growth. Furthermore, a broad literature points towards R&D investment as the main source of productivity growth, with several DSGE models already incorporating such relation (Comin and Gertler, 2006). This section serves precisely to test these conclusions undertaken in the literature.

Being the sample nonuniform on what regards the economic stability of the Euro Area, the impulse responses of adjusted TFP are estimated for both the pre and post crisis periods. As such, the sample is divided into two different time spans: from 2002Q2 to 2008Q2 (the start of the financial crisis) and from 2009Q3 to 2018Q4.<sup>11</sup> This way, two different analyses are performed; the first based on a period of time where the European economy can be considered as well functioning, and the second based on a time length marked by the sovereign debt crisis and the zero lower bound constraint.

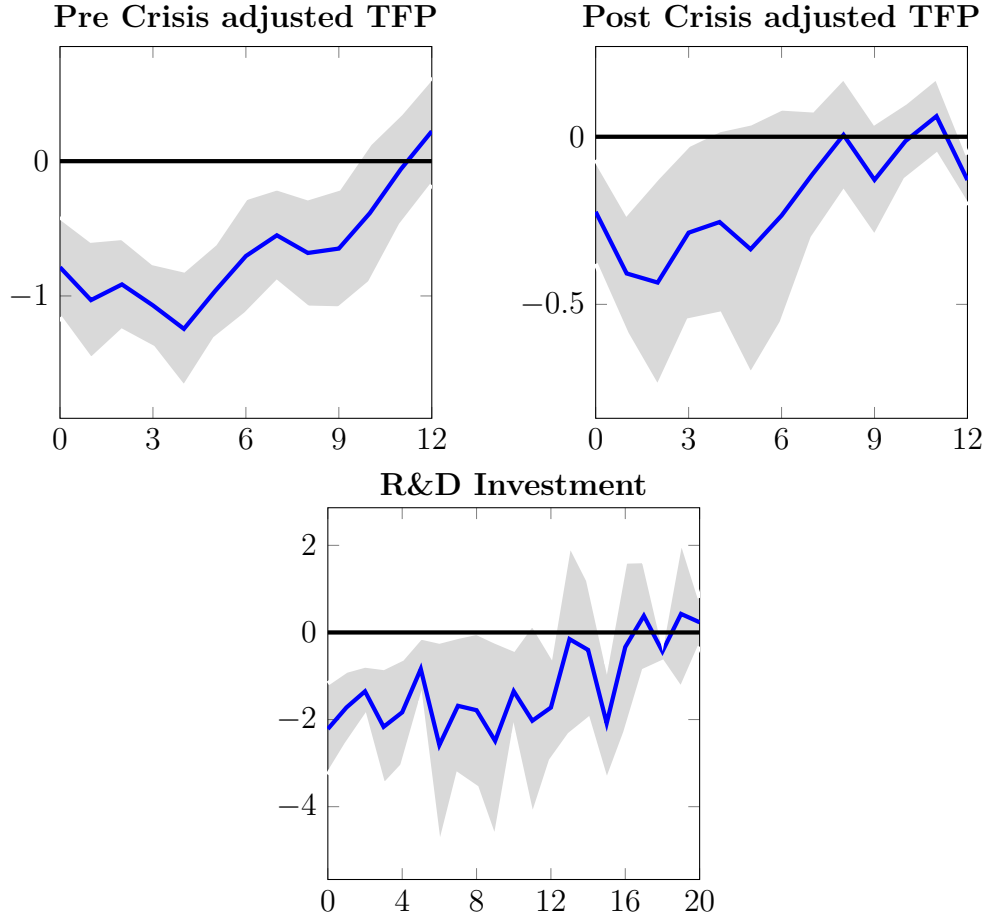
Figure 4 depicts both impulse responses to a contractionary policy shock <sup>12</sup>. The results appear to match a priori expectations. During the pre crisis period, the response of adjusted TFP is more than twice as larger when compared to the full sample case, suggesting that in the absence of financial frictions the impact of a policy innovation on productivity is larger. In contrast, results change significantly when considering the post crisis sample. As it is visible, the response of TFP is smaller and non statistically significant from the third period onwards. Both these results are favorable to the referred hypothesis and coherent with Moran and Queralto (2018) findings, who suggest harsh productivity loses due to the zero lower bound. In fact, as this constrain highly impacted the transmission channels of monetary policy to the real economy, it was only predictable that it would reduce productivity gains obtained by expansionary monetary policy moves.

Finally, the response of R&D investment to a monetary shock is considered. This result is somewhat ambiguous among the literature. Moran and Queralto (2018) find a persistent

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<sup>11</sup>Because each subsample has a short time range, the period of the financial crisis was disregarded as it is expected to highly influence the results.

<sup>12</sup>As a short time span is now considered, the impulse response function is only derived for twelve quarters



**Figure 4:** Response of pre and post crisis adjusted TFP and R&D Investment to a one standard deviation policy shock. The shaded area corresponds to 95% confidence intervals bands, obtained using cluster robust standard errors.

effect on R&D, similar to the response of aggregate TFP, while [Meier and Reinelt \(2019\)](#) find no significant response. As visible in figure 4 a contractionary policy movement has indeed negative significant effects on R&D investment. The response however does not seem to follow a similar pattern as the one of TFP. As a deeper analysis would be needed to conclude that R&D investment is the main channel through which monetary policy affects productivity, this relation is considered as ambiguous, as no ultimate conclusions are taken.

## 6 Robustness Checks

Several robustness checks were performed to ensure the validity and credibility of the results. Regarding the estimation of utilization adjusted TFP, the [Imbs \(1999\)](#) method was estimated with different parameter values. Namely, considering a real interest rate of 0.5% per period does not affect the results (figure 5 in the appendix). The results are, in fact, considerably sensitive to the initial value of the depreciation rate,  $\delta_t$ , which was set to 2% per quarter, i.e 8% per year. Figure 6 shows that increasing the initial value of  $\delta_t$  to 2.5% per quarter (10% per year) significantly expands the response of the capital utilization rate and, consequently, the difference between the response of raw and adjusted TFP. The main conclusions are not affected but intensified by a larger response. Nevertheless, a depreciation rate of 2% per quarter is said to be more appropriate, as buildings and equipment are often considered to depreciate at a yearly rate of 2.5% and 10%, respectively; as it is the case in the Long Term Productivity Database, developed by [Bergeaud et al. \(2016\)](#).

[Fernald \(2014\)](#) argued that there are structural breaks in the U.S TFP. As it is plausible to assume that the same might happen with other economies, the same model is estimated accounting for structural breaks, which in the present case correspond to the crisis period. Time dummies between 2008Q3 and 2009Q2 were included and, as visible in figure 8 results remained similar. Also, extra lags of the shock variable were included and again, results were kept unchanged (figure 9 in the appendix).

## 7 Conclusion and Discussion

Using local projections à la [Jordà \(2005\)](#) with an external instrument to identify monetary surprises, this study proposes to investigate how monetary policy impacts TFP in the Euro Area. In doing so, it contributes to the monetary policy literature, by exploring the effects of the latter on an understudied variable that is usually analyzed for a single economy, rather

than for a group of countries as in the present case. Using the [Imbs \(1999\)](#) factor correction, a utilization adjusted TFP measure is defined for the eleven Euro founders and Greece. A tightening monetary policy shock decreases aggregate TFP and capacity utilization. This result was foreseeable given the countercyclical nature of monetary policy. Results point to a substantial difference between adjusted and raw TFP, stressing the importance of utilization adjustment in productivity measurement. A sample split enabled to conclude that the aftermath of the financial crisis highly influenced the transmission channel between monetary policy and productivity, as argued in the literature. The response of TFP to a shock during the post crisis is half as large when compared to the pre crisis period.

A key policy question is whether monetary policymakers should take the pattern of productivity into consideration when making policy decisions. The role of unconventional monetary policy is being at stake after the massive drag on productivity growth after the global financial crisis. In fact, the outcome of the crisis has displayed remarkable signals of productivity hysteresis, mostly caused by stagnation on aggregate demand (for almost a decade) and tight credit conditions along with a wide wind of uncertainty tilting investment in risky but high return projects ([Obstfeld, 2018](#)). On top of this, in line with the Japanese case in the 90's, the zombie firm phenomenon is said to have highly contributed to the productivity slowdown after the crisis and imposed a massive constraint on economic growth and on the efficiency of the financial system. These firms, who buy their way of staying alive through loans from weak banks, not only impose a barrier to other companies to enter the market but also impede credit to flow to more productive sectors, contributing to a misallocation of capital and an increase of the productivity gap across firms ([Andrews and Petroulakis, 2019](#)).

Even considering all the side effects of unconventional monetary policy and knowing that, during the post crisis period, it implied little productivity gains (as suggested in section 5), having altered the course of monetary policy to improve TFP growth would not have necessarily brought more benefits to the economy. As convincingly argued by [Obstfeld \(2018\)](#),

any market failure, such as capital misallocation and the appearance of zombie firms, ought to be tackled directly through specific measures for the purpose (for instance, a more robust banking supervision), instead of changing the conduct of monetary policy. Moreover, productivity gains would not compensate all the downgrades associated with tighter policy actions, in terms of unemployment, output losses and inflation far from its target. There are several actions policymakers should perform in order to boost productivity, from innovation enhancing measures to structural reforms, which are certainly more effective than relying on monetary policy for that purpose.

This study points to a wide fruitful line of future research. Firstly, once data availability enables so, considering an improved utilization adjusted TFP measure for the Euro Area countries would be highly relevant. For instance, incorporating the existence of non constant returns to scale and firm heterogeneity as in [Basu et al. \(2006\)](#) would be warmly desirable. Secondly, as deeply argued in [Meier and Reinelt \(2019\)](#), the existence aggregate markups play an important role in TFP measurement when factor shares are used as weights. Accounting for this issue and many others that might contribute to a more precise TFP quantification would only enrich the analysis. Lastly, for a more in depth breakthrough of the Euro Area dynamics, a cross country analysis that permits to study the heterogeneous effects among the Euro economies would be highly relevant, as well as the elaboration on possible spillover effects existing between countries.

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## Appendix

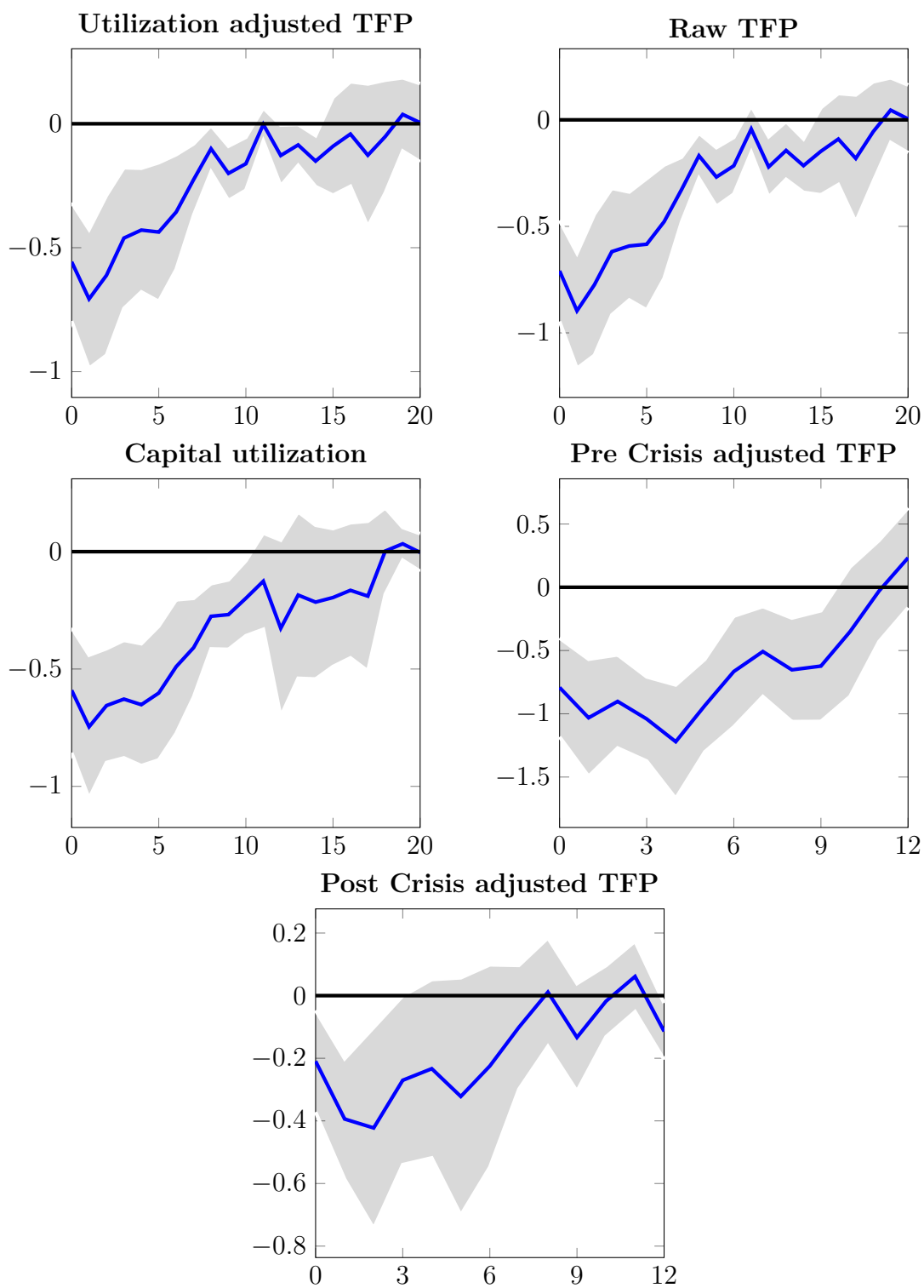
**Table 1:** Responses of adjusted TFP, raw TFP and utilization at quarters 0 to 20

	Adjusted TFP	Raw TFP	Capital utilization
h=0	-12.80*** (2.613)	-16.25*** (2.681)	-11.23*** (2.601)
h=1	-16.21*** (3.045)	-20.52*** (3.025)	-14.17*** (2.967)
h=2	-14.04*** (3.589)	-17.74*** (3.733)	-12.46*** (2.362)
h=3	-10.79*** (3.166)	-14.37*** (3.370)	-11.94*** (2.444)
h=4	-10.13*** (2.750)	-13.84*** (2.868)	-12.37*** (2.526)
h=5	-10.21*** (3.167)	-13.55*** (3.544)	-11.43*** (2.769)
h=6	-8.315*** (2.637)	-11.09*** (3.092)	-9.293*** (2.770)
h=7	-5.416*** (1.590)	-7.740*** (1.762)	-7.753*** (2.044)
h=8	-2.563** (1.053)	-4.096*** (1.239)	-5.242*** (1.358)
h=9	-4.655*** (1.262)	-6.208*** (1.616)	-5.106*** (1.457)
h=10	-3.734*** (1.231)	-4.970*** (1.564)	-3.793** (1.560)
h=11	-0.269 (0.837)	-1.189 (1.361)	-2.422 (1.996)
h=12	-3.258** (1.311)	-5.363*** (1.763)	-6.191* (3.643)
h=13	-2.127** (0.993)	-3.447** (1.742)	-3.507 (3.431)
h=14	-3.563*** (1.119)	-5.026*** (1.559)	-4.071 (3.174)
h=15	-2.268 (2.165)	-3.554 (2.350)	-3.699 (2.848)
h=16	-1.171 (2.311)	-2.276 (2.434)	-3.093 (2.782)
h=17	-3.026 (3.187)	-4.256 (3.385)	-3.550 (3.077)
h=18	-1.123 (2.526)	-1.213 (2.632)	0.0830 (1.771)
h=19	0.834 (1.635)	1.015 (1.688)	0.652 (0.661)
h=20	0.0682 (1.733)	0.0709 (1.759)	-0.0332 (0.750)
Observations	552	552	552

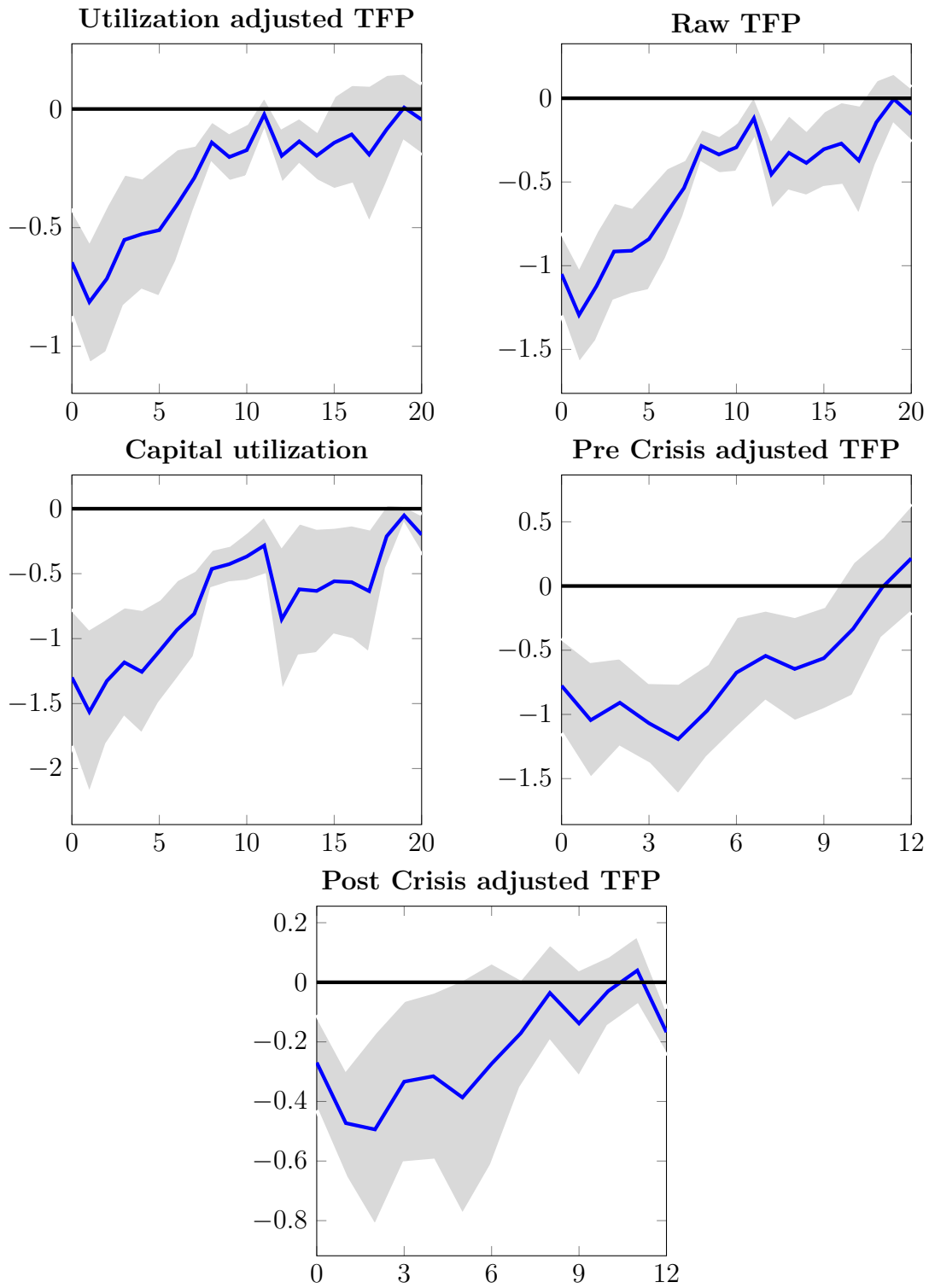
Standard errors in parentheses

Source: Own computations

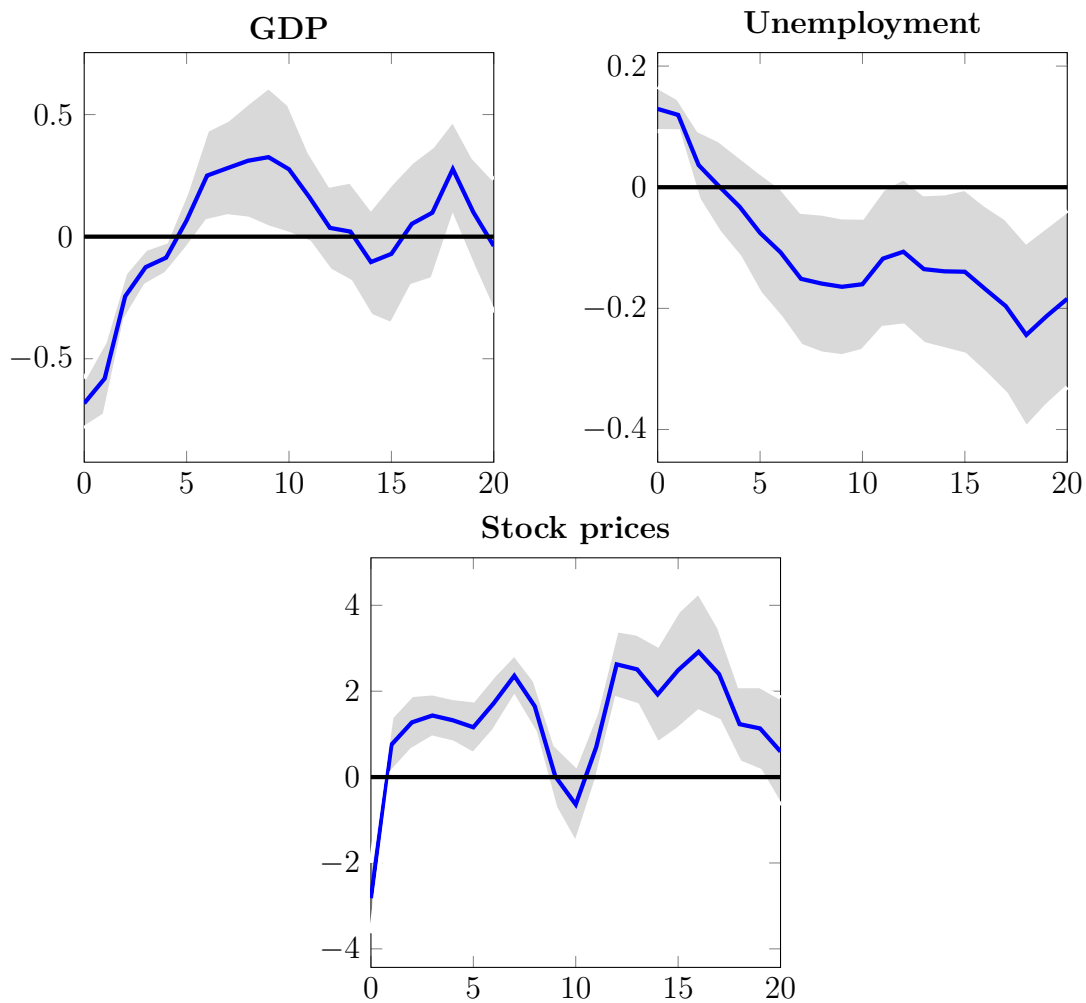
\*  $p < .1$ , \*\*  $p < .05$ , \*\*\*  $p < .01$



**Figure 5:** Responses of the variables analysed in sections 5.2 and 5.3 considering a real interest rate  $r=0.5\%$  in the factor correction TFP adjustment detailed in section 3.2

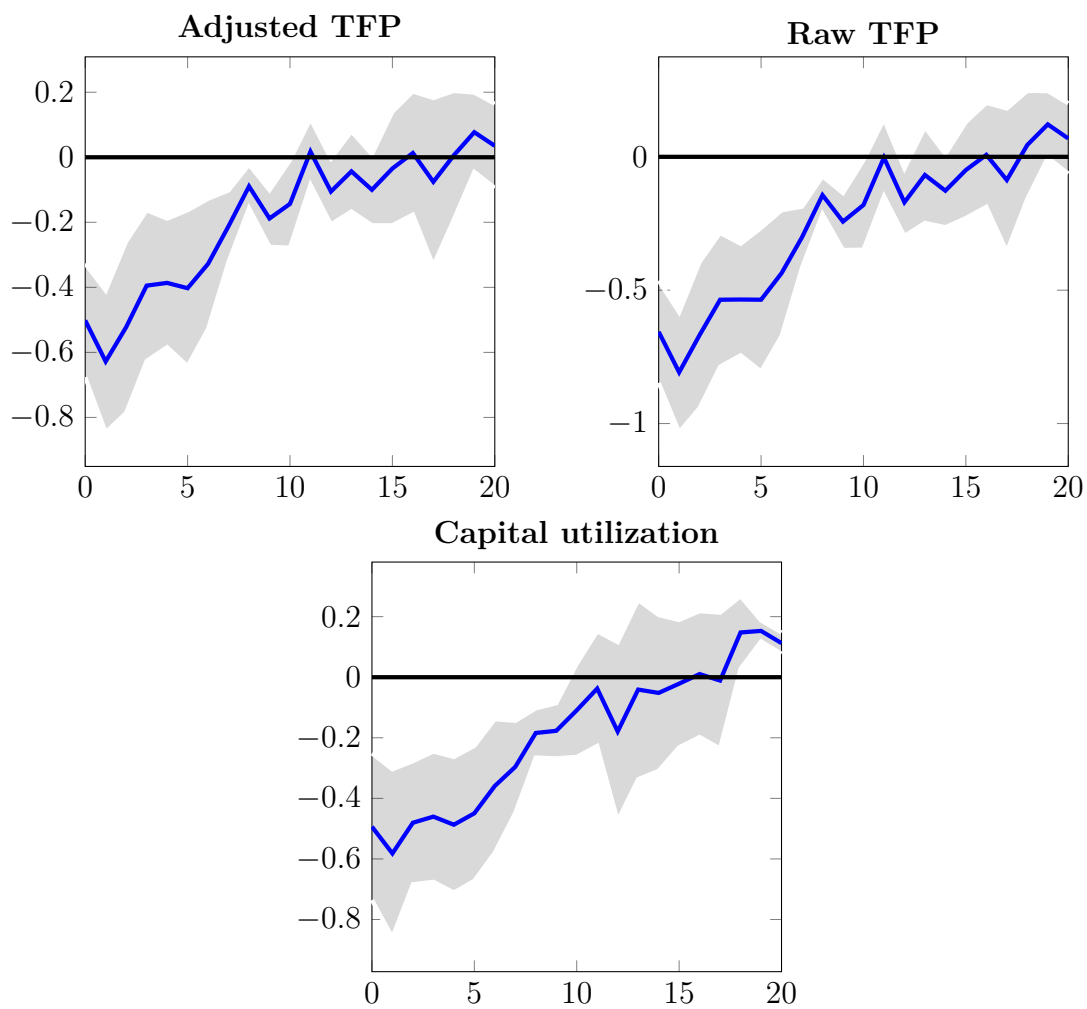


**Figure 6:** Responses of the variables analysed in sections 5.2 and 5.3 considering an initial depreciation rate  $\delta=2.5\%$  in the factor correction TFP adjustment detailed in section 3.2

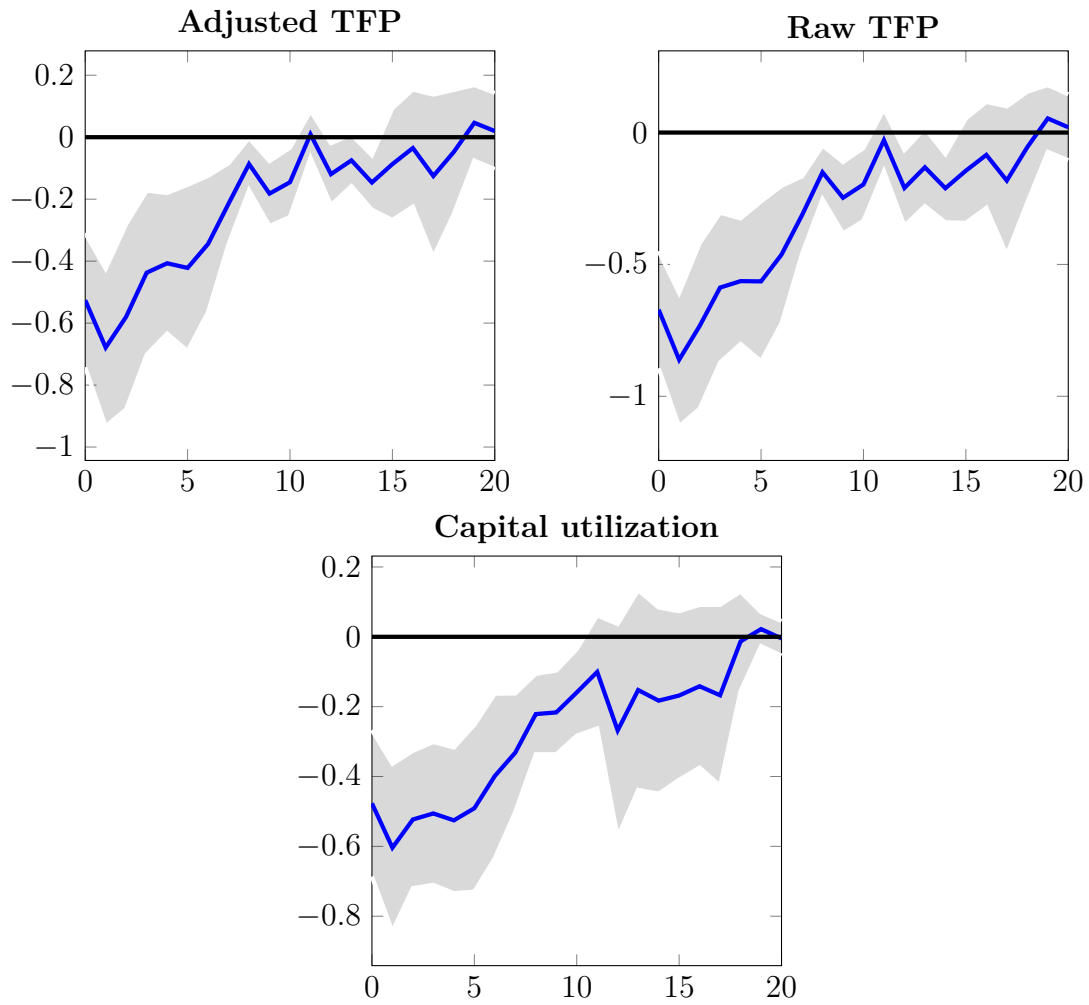


**Figure 7:** Response to a one standard deviation monetary policy shock, instrumented with [Kerresenfischer \(2019\)](#) high frequency shocks, without sign restrictions to disentangle information effects from the ECB announcements.





**Figure 8:** Response of adjusted TFP, raw TFP and capital utilization to a monetary policy shock accounting for structural breaks during the crisis period.



**Figure 9:** Response of adjusted TFP, raw TFP and capital utilization to a monetary policy shock including two lags of the external instrument.

Table 2: Dataset variables

Description	Unit	Source	Adjustment	Start	End
Gross Domestic Product	Millions of Euros, 2015 prices	Eurostat	Seasonally and Calendar Adjusted	2001Q1	2018Q4
Consumer Price Index	Index: 2015=100	OECD	None	2001Q1	2018Q4
Producer Price Index	Index: 2015=100	OECD	None	2001Q1	2018Q4
Consumption Expenditure	Millions of Euros, 2015 prices	Eurostat	Seasonally and Calendar Adjusted	2001Q1	2018Q4
Gross Fixed Capital Formation	Millions of Euros, 2015 prices	Eurostat	Seasonally and Calendar Adjusted	2001Q1	2018Q4
Exports	Millions of Euros, 2015 prices	Eurostat	Seasonally and Calendar Adjusted	2001Q1	2018Q4
Persons in Employment	Thousands	Eurostat	None	2001Q1	2018Q4
2 year German Bond Yields	Percentage (%)	Investing.com	None	2001Q1	2018Q4
R&D Investment	Millions of Euros, 2015 prices	OECD	Seasonally Adjusted	2001Q1	2018Q4
Producer Price Index	Index: 2015=100	OECD	None	2001Q1	2018Q4
Unemployment Rate	Percentage (%)	OECD	None	2001Q1	2018Q4
Share Prices	Index: 2015=100	OECD	None	2001Q1	2018Q4
Credit to the Non Financial Sector	Millions of Euros	bis.com	Adjusted for Breaks	2001Q1	2018Q4
Initial Capital Stock	Millions of Euros	AMECO	None	2000	-

**Note:** No R&D Investment data was available for Belgium, as the analysis excludes the Belgium economy. Moreover, information on the number of persons employed for Luxembourg, France and Germany was not available on Eurostat, as data was extracted from le portail des statistiques for Luxembourg, Trading economics and Statistisches Bundesamt, respectively.