Monetary Policy, Income Distribution, and the Cost Channel of Monetary Policy: Empirical Evidence from Japan, the U.K., and the U.S

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Abstract

This paper aims to assess the impact of a monetary policy tightening on prices and income distribution. To do this, we estimate SVAR models based on data from the United States, United Kingdom, and Japan for the period Q1:1955-Q4:2019. Our findings reveal a cost channel of monetary policy. Indeed, an increase in interest rates produces significantly positive effects on the price level. Furthermore, we highlight the negative effects of restrictive monetary policies on real wages, as price increases are not compensated by an equal increase in nominal wages. The results are confirmed even when different measures of expectations are considered. Finally, we decompose the effect of monetary policy on prices, distinguishing two channels, the demand, and the distributional channels. The former is captured by GDP, while the latter is represented by nominal wages. We show that while the demand channel partially offsets the cost channel, the distributional channel contributes to the positive effect of monetary policy on prices.

Keywords: Monetary policy; Structural vector autoregression; Price puzzle, Functional income distribution

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1. Introduction

The return of inflation in recent years has prompted major central banks to raise interest rates to maintain control over the inflation target. This choice is supported by various traditional economic models. Indeed, they believe that changes in monetary policy influence the economy through a demand transmission channel: an increase in interest rates should reduce economic activity levels, and through this channel, inflation should return to the target value. Hence, much research has focused on quantifying the effects of the monetary policy transmission mechanism on the demand side. However, some economists have emphasized the importance of monetary policy effects on the supply or costs side (Christiano, Eichenbaum, and Evans, 1997; Barth and Ramey, 2002; Gaiotti and Secchi, 2006). A clear picture of this perspective was provided by the then Chairman of the US Joint Economic Committee, Patman, who stated: "raising interest rates to fight inflation is like throwing gasoline on fire" (Patman, 1957, p. 134). However, this view belongs to the roots of the history of economic thought. Tooke (1838) already highlighted the possibility of a positive relationship between prices and interest rates, which Keynes (1930) called the "Gibson Paradox," since interest rates are a component of monetary production costs. Almost two centuries later, this positive relationship was also evident in vector autoregressive (VAR) models by Sims (1992) and was termed the "price puzzle" (Eichenbaum, 1992). In the following three decades, the literature dealt with the evidence of a price puzzle in different ways, both empirically and theoretically. Indeed, not believing in the existence of a cost channel that could override the demand channel, some scholars asserted that this paradoxical relationship could be the result of omitting relevant variables in the model (Sims, 1992; Hanson, 2004; Castelnuovo and Surico, 2010). More precisely, the omission would concern those variables capable of capturing central banks' inflation expectations. Without such expectations in the econometric model, what we interpret as an exogenous shock to interest rates would be an endogenous response of monetary policy to an expectation of price increases (see Sims, 1992). This solution was revived in a recent contribution by Castelnuovo and Surico (2010). They argue that the price puzzle in the United States is present only in the period before the Volcker tightening in 1979, during which the Federal Reserve was "passive" in controlling inflation, having reacted less than proportionally to deviations in inflation from its target. In passive regimes of monetary policy, the VAR model would suffer from a specification error caused by the omission of a latent variable, which can be resolved by including a measure of expected inflation. Therefore, they would reject an explanation of the price puzzle based on the cost channel and reaffirm the traditional inverse relationship between interest rates and prices based on the demand channel.

Considering all this, in the following pages, we will apply the methodology of structural vector autoregressive (SVAR) models to Japan, the United Kingdom, and the United States using quarterly data for the period 1955-2019. This work has three objectives:

1. Evaluate the effect of monetary policy on prices, highlighting the importance of the cost channel of monetary policy. Following the literature on the price puzzle, we will test the robustness of our results using expectation measures such as those related to inflation and economic activity levels.

2. Assess the effect of monetary policy on income distribution, particularly on nominal and real wages (in line with Christiano et al., 2005; Cantore et al., 2022).

3. Through the methodology of counterfactual VARs (Perotti, 2004; Bachmann and Sims, 2012; Samarina and Nguyen, 2022), decompose the effect of monetary policy on prices, distinguishing two channels, the demand, and the distributional channels. The demand channel is captured by GDP, while the distributional channel is represented by nominal wages.

In Section 2, we review the literature on the effects of monetary policy on prices and wages. Section 3 outlines the data, methods, and our multiple identification strategies, while Section 4 provides our main results. We demonstrate that the price puzzle is identifiable for Japan, the United Kingdom, and the United States, even when considering different expectation measures. Furthermore, in line with Christiano et al. (2005), we highlight the negative effects of restrictive monetary policies on real wages, as price increases are not compensated by an equal increase in nominal wages. Finally, by decomposing the effect of interest rates on prices into different channels, we show that while the demand channel partially offsets the cost channel, the distributional channel contributes to the positive effect of monetary policy on prices. Section 5 concludes.

2. Literature review

The aim of this section is to review the literature on the impact of monetary policy on the price level and functional distribution of income, especially real wages. Given the vast number of articles that have studied these issues it may be useful to divide the section into different parts to better schematize the several positions in the literature. So first we will look at the price puzzle debate, consisting of the observed positive relationship between prices and interest rates, then we will analyze the main evidence on the effects of monetary policy on real wages.

2.1 The evidence on the Price Puzzle

Estimating the effects of monetary policy on the general price level has always been a subject of debate among both economists belonging to the academy and policy-making circles. Indeed, a variety of theoretical models, from those of the monetarist line to those of neo-Keynesian theory, would indicate an inverse relationship between monetary contractions, generally identified with an increase in interest rates, and the general price level.

The most widely used methodology in the literature to estimate the effects of changes in interest rates on prices is the SVAR (Structural Vector Auto-Regressive Models) methodology. One of the first applications to monetary policy was by Sims (1992). However, that contribution by Sims was also relevant for the results highlighted in his analysis of five advanced countries (France, Germany, Japan, United Kingdom, and the United States). In fact, starting with a recursive SVAR model with 4 variables (overnight interest rate, money supply (M1), a consumer price index and an industrial production index), Sims (1992) showed the presence of a sustained positive price response to a tight monetary policy shock for France, Japan, and the United Kingdom and, weaklier, for Germany and the United States. The evidence of such a positive relationship between prices and interest rates was thus termed a "price puzzle" (Eichenbaum,1992). This phenomenon for Sims would have been explainable by the fact that PM authorities would have more instructive information about inflationary pressures than that contained by the model variables. From these assumptions for Sims, it would be possible to reconstruct the causal chain evidenced by the impulse responses of his SVARs. Indeed, central banks, awaiting the arrival of inflationary pressures, would raise interest rates to dampen their effects. However, restrictive monetary action would not be sufficient to negate the increase in prices that would also come with the concomitant fall in output. Hence, Sims, identifying potential omitted variables in commodity prices and exchange rates, estimates a second model with 6 variables. The inclusion of these additional variables, although still showing an initially positive price response for all nations, would result in a weakening of the price puzzle, especially for the UK and US, while the phenomenon would remain more persistent for Japan and France.

Since Sims' (1992) contribution, the literature has related to the evidence of a price puzzle in different ways both empirically and theoretically.

- On the one hand, following Sims' lead, many authors have attempted to resolve this paradoxical relationship by asserting how it could be the result of the omission of relevant variables in the model and therefore the "true" relationship between prices and interest rates would be of negative sign, with a demand channel thus prevailing over the cost channel.
- On the other hand, not considering such evidence as paradoxical, other scholars have attempted to motivate it by resorting to the existence of a cost channel that would be stronger than the demand channel (nevertheless present) and hence the effect of a restrictive monetary policy could be inflationary.

In the next two sub-sections we will analyze both positions.

2.1.1. Who tried to *solve* the Price Puzzle: the problem of omission of relevant variables

According to several researchers (Sims, 1992; Giordani, 2004; Hanson, 2004; Boivin and Giannoni, 2006; Castelnuovo and Surico, 2010; Florio, 2018) the positive correlation between prices and interest rates would be a paradoxical phenomenon. Indeed, the origin of this paradox lies in the omission problem of relevant variables that would characterize monetary policy SVARs. More precisely, the omission would concern those variables capable of capturing central banks' inflation expectations. Without such expectations, what we interpret as an exogenous shock to interest rates would be an endogenous response of monetary policy to an expected increase in prices. Hence, we would argue the need to include variables that can approximate central banks' inflation expectations to purify the monetary policy shock. As already seen, Sims (1992), after identifying the price puzzle, immediately proposed such a solution, identifying commodity prices as that variable: "anticipated inflationary pressure signaled by a jump in commodity prices" (Sims, 1992, p. 989). However, later Hanson (2004) points out that the use of commodity prices would not be able to solve this paradox, especially for the United States before the 1980s, that is, in the period before Volcker's presidency at the Fed.

Hence, the literature has proposed several variables that could potentially reduce the omission problem. For example, Leeper and Roush (2003) introduce the monetary aggregate as an additional variable, arguing that the central bank could react to fluctuations in the money supply to achieve the inflation target. If such monetary fluctuations were caused by money demand influenced by interest rates, the exclusion of monetary aggregates would result in misidentification of the monetary policy shock. Another work that attempted to advance a possible omitted variable is that of Giordani (2004) who focuses on the output gap, that is, the difference between actual and potential output, being considered in the monetary policy rule of central banks. Giordani (2004) uses a neo-Keynesian theoretical scheme, in which monetary policy would be transmitted first on the output gap (via IS curve) and then with lags on prices (via Phillips curve). Therefore, if there were increases in the output gap, monetary policy would react by raising interest rates to avoid inflationary acceleration. Then, Bernanke (2004) and Bernanke et al. (2005) point out how the inclusion of inflation expectations, placed at the beginning of the SVAR ordering, can reduce the price puzzle.

The introduction of inflation expectations is a path also followed by Hanson (2004) and Castelnuovo and Surico (2010). More specifically, they argue how the positive relationship between prices and interest rates for the U.S. would recur only in the passive monetary policy regime. For the U.S., this would correspond to the period prior to the Volcker presidency in 1979. Indeed, the VAR model in the passive monetary policy regimes would suffer from a specification error caused by the omission of a latent variable such as inflation expectations. Therefore, one of the main solutions to the price puzzle identified in the literature is to show how it is a phenomenon valid only in certain sub-periods and to emphasize the role of such expectations in mitigating it. However, Barakchian and Crowe (2013), using a new set of exogenous shocks constructed by analyzing fluctuations in FED funds futures, again identify the price puzzle from 1988 to 2008 for the United States during the Volcker era. The evidence of Cucciniello et al. (2022) also seems to go against those that would see the price puzzle as a phenomenon related to passive monetary policy regimes. Indeed, they would detect a positive relationship between prices and interest rates both before and after 1979. Moreover, once the three years of FED control over monetary aggregates are excluded in the second subperiod, the effect of interest rates on prices would be very close in the two-time intervals analyzed. These results are also tested with the inclusion of three measures of expected inflation that, although they slightly reduce the elasticities of price response, do not negate the existence of a monetary policy cost channel.

This issue has also been addressed in the DSGE theoretical models (Rabanal, 2003;2007). Indeed, these models, while having a cost channel, show how it is always overridden by the demand channel for the Euro area and the US. This result would even hold true in the most extreme case, where the totality of firms would be facing the effects of a cost channel, having to finance labor costs. Moreover, according to Rabanal, Romer and Romer's (2004) narrative approach, in which the U.S.

monetary policy shock would be purified by the Fed's endogenous response to a set of expected variables, would be one of the empirical methods most compatible with his theoretical evidence, since the price puzzle is not present.

However, as noted by Ramey (2016), it should be considered that even if Romer and Romer (2004), analyzing monthly data from 1970 to 1996, do not identify a positive price response to restrictive interest rate shocks, they would observe a decline in prices only two years after the monetary tightening. In addition, Coibion (2012) points out the excessive magnitude of Romer and Romer's (2004) estimated values. Values of the estimates probably caused by the choice of the period analyzed and the persistence of the shock. After making some corrections to the methodology of Romer and Romer (2004), using the same time interval Coibion (2012) continues to highlight the presence of price puzzles in some cases.

2.1.2. Who tried to *explain* the Price Puzzle: the evidence on the cost channel

After studying various attempts to solve the price puzzle, we will now move on to analyze some works that have tried to justify the existence of a positive relationship between prices and interest rates in this section. Indeed, in this line of research, monetary policy could have significant supply-side effects, as interest rates are an important component of business costs. Therefore, from this perspective, the evidence of a positive effect of restrictive monetary measures on price levels would not be at all paradoxical. Instead, it would indicate the prevalence of the cost channel over the more traditional demand channel. However, this view is not new in the history of economic thought, both in academic and institutional contexts. In fact, as early as the first half of the nineteenth century, Tooke (1838) highlighted the possibility of a positive relationship between prices and interest rates, as the latter are a component of monetary production costs. Furthermore, during the era of the Volcker tight monetary policy, Nancy Teeters, a member of the FOMC, stated: "Interest rates may be [low] after tax, or in real terms, but they are still contributing to cost and are creating, I think, some of the upward pressure on prices." (Teeters, FOMC meeting, May 1981). Even one of the leading experts in monetary economics, Charles Goodhart (1986, p. 96), emphasized that businessmen "tend to regard interest rates as a cost and look to establish a price rise in response to increased interest rates."

Based on this, as already mentioned, after Sims' (1992) evidence, various economists (Barth and Ramey, 2002; Ravenna and Walsh, 2006; Tillmann, 2008) have attempted their reinterpretation by introducing the cost channel of monetary policy into the debate. More specifically, two hypotheses about the cost structure of firms could justify the relevance of this channel. The first is related to the financial situation of companies, characterized by a temporal misalignment between the sale of the product and the payment of remuneration for production factors, which is always anticipated. The anticipation of costs requires external financing, which obviously imposes interest payments. Another important factor would be inventory and stock holdings, which include interest costs paid on immobilized capital among maintenance costs. Therefore, restrictive monetary policies that transmit to the interest rate structure faced by the production sector would result in an increase in business costs.

One of the first works to propose this perspective is that of Barth and Ramey (2002), which analyzes the US economy from 1959 to 2000. Their analysis is both sectoral and macro-aggregate. From a sectoral point of view, they show that on average, US companies in the period analyzed hold working capital equivalent to 17 months of revenue. Therefore, variations in the interest paid on this capital mass can have significant effects on business costs. The relevance of the cost channel is also confirmed by the responses to impulse of macroeconomic variables: an increase in interest rates would lead to an increase in prices and a reduction in real wages. The evidence of Barth and Ramey (2002) is confirmed by Ravenna and Walsh (2006), who estimate a forward-looking Phillips Curve with the interest rate as a regressor for the USA from 1960 to 2001. To support these results theoretically, they then build a DSGE model with an active cost channel, assuming that the cost of production factors must be incurred before the sale of the product (in line with other DSGE models with a cost channel, see, for example, Bruckner and Schabert, 2003; Christiano et al., 2005;). Another objective of the work is to discuss the optimality of monetary policy in this new scenario. Indeed, changes in the interest rate necessary to stabilize the output gap led to fluctuations in inflation when a cost channel is present. Consequently, the output gap and inflation will fluctuate in response to productivity and demand shocks even when the central bank is pursuing optimal monetary policy. Fujiwara (2004), in line with Bart and Ramey (2002), identifies a significant cost channel for the Japanese economy, applying four different techniques for shock identification and controlling for the inclusion of commodity prices.

The analysis of the cost channel is also sectoral in the work of Gaiotti and Secchi (2006) on a sample of 2000 Italian companies over a period of 14 years. Their discussion of the debt structure of companies would not exclude an effect of interest on marginal costs and pricing policies. Furthermore, as in Barth and Ramey (2002), this effect would be more important the greater the share of working capital held by companies. The conclusion emphasizes the real effects that monetary policy could have through this channel and the need for greater consideration by central banks. Schafer et al. (2017) conduct the same study on a panel of German manufacturing companies and highlight the transmission of interest rates to production prices. Another sectoral cost channel analysis, based on multiple countries, is that of Dedola and Lippi (2005), who study France, Germany, Italy, England, and the United States. Their evidence consists of significant intersectoral heterogeneity in the effects of monetary policy, which, however, would be consistent across different countries. For example, durable goods sectors, especially the motor vehicle sector, would be more sensitive to monetary policy, unlike the food sector, which would not be overly affected by interest rate changes. Moreover, their analysis would highlight a greater impact of monetary policy on companies with a greater need for financing, once again confirming the relevance of the cost channel. Financial characteristics are also related to the cost channel in Chowdhury et al. (2006), who analyze a Phillips Curve with interest rates as explanatory variables for G7 countries from 1980 to 1997. Their results show a positive sign for the interest rate coefficient for all countries analyzed. Canada, the UK, the USA, and Italy would have the largest coefficients. France, Germany, and Japan would show a less disruptive cost channel (especially for the latter two countries, the estimates would not be significant). The explanation for these results is attributed to the country's financial structure. According to Chowdury et al. (2006), greater corporate dependence on bank loans and a slower transmission of monetary policy should lead to a weaker cost channel. These findings are also found in the DSGE model applied to the Eurozone by Hülsewig et al. (2009), which emphasizes how banks tend to absorb interest rate shocks controlled by the central bank and therefore the transmission to bank rates is imperfect. Hence, the model's results show that the cost of loans plays a role in setting prices by companies, but the cost channel is affected by the incomplete transmission of monetary policy, given the strong stickiness of interest rates. However, Kaufmann & Scharler (2009), applying a DSGE model with a cost channel to the Eurozone and the United States, challenge the idea of financial system influence on this channel. Indeed, their evidence suggests that there would not be such clear differences in the financial structure to justify different estimated elasticities. The importance of the cost channel is also identified by Tillmann (2008) for the Eurozone, the UK, and the USA, contradicting the results of Rabanal (2007), which would not show a positive effect of monetary policy on prices for the same countries. Then, Tillmann (2008) notes that while the estimated coefficients for the Eurozone and the USA would be like those of Chowdhury et al. (2006), the cost channel would be less important for UK. More recently, Garcia-Appendini et al. (2023) evaluate the cost channel from the perspective of the health of companies in downstream and upstream sectors of the production chain. Through a financial acceleration mechanism, the results of their dynamic estimates would show that the effects of the cost channel can be broader and more prolonged than those of the demand channel. Finally, Dias and Duarte (2019) highlight an alternative channel to explain the price puzzle. In fact, unlike house prices, rental prices would increase in response to restrictive monetary policy shocks. Therefore, given the significant weight of rental prices in the consumer price index, this channel could explain the positive relationship between interest rates and prices (for further confirmation of these findings, see Goès, 2023).

At this point, considering the different positions on the relationship between interest rates and prices, in the next sections, we will use econometric estimates to understand whether the price puzzle is an artifact of omitted relevant variables or if it is a phenomenon explainable through the cost channel for Japan, the United Kingdom, and the United States.

2.2 Monetary policy and real wages: an overview

The goal of this work is also to highlight potential effects of monetary policy on income distribution, discussing its persistence in the long term. Therefore, it may be useful to review some empirical studies in the literature that have examined this topic, especially the influence of monetary policy on real wages. To begin, Christiano et al. (1997) apply a recursive vector autoregressive (SVAR) structural model to a set of US data for a period between 1965 and 1995, considering the effects of a restrictive monetary policy shock on various quarterly variables. They also analyze the response of real wages at the sectoral level. In all cases, real wages decrease after a restrictive monetary policy shock, although there is heterogeneity among different sectors. Indeed, real wages in the manufacturing sector decline more sharply than in other economic sectors. Further analysis reveals that within the manufacturing sector, real wages decrease more in durable goods industries than in nondurable goods industries. Christiano et al. (1997) argue that these results cast doubt on monetary policy transmission mechanism models based on the assumption of sticky wages. In line with these findings, Barth and Ramey (2002), also for the USA, highlight an inverse relationship between interest rates and real wages. Christiano et al. (2005), analyzing the United States, find that expansionary monetary policy has a positive effect on productivity and real wages. It is also worth noting that similar results have been obtained in the literature using non-recursive shock measures. For example, non-recursive monetary policy shocks by Sims and Zha (2006) applied to the USA still show a negative impact of interest rate increases on real wages. Conversely, in Altig et al. (2011), SVAR estimates do not show a significant response of real wages to a monetary policy shock. More recently, Latsos (2018) analyzes the case of Japan, where the growth rates of productivity and real wages have declined over time despite the increasingly accommodative policies pursued by the BoJ. According to the study's conclusions, expansionary monetary policy can prove detrimental to labor productivity and, thereby, to real wages. The negative effects resulting from the propagation mechanism of a wage decline would also lead to a decrease in household consumption, further reinforcing the negative influence on capital accumulation and long-term productivity. Still focusing on real wages and the labor income share, Cantore et al. (2021) apply SVAR techniques to assess the effect of monetary policy on these variables. The results indicate that restrictive monetary policy has a negative effect on real wages and labor productivity. However, the wage share increases because labor productivity experiences a stronger negative effect than real wages. Recently, Cucciniello et al. (2022) updated the analysis of Christiano et al. (2005) by empirically studying the case of the United States for the period 1959-2018. According to their results, increases in interest rates would lead to price increases in different historical phases of US monetary policy. Following this consideration, the authors also demonstrate that a restrictive monetary policy shock would result in a decline in real wages. Finally, Coibion et al. (2017) analyze the effects of monetary policy on various percentiles of the wage distribution. Their results indicate that rises in interest rates have heterogeneous effects on labor income, increasing incomes in the upper part of the distribution and decreasing those in the lower part. They conclude that among the side effects of restrictive monetary policies is an increase in income and wage inequality.

3. Data, Models, and Identification Strategies

3.1. Data

To assess the impact of monetary policy on both price levels and income distribution, we employ quarterly data sourced from the OECD, and the websites of national central banks and official statistical agencies of Japan, the United Kingdom, and the United States. For the United Kingdom and the United States, our analysis spans from 1955Q1 to 2019Q4, while for Japan, it covers the period from 1960Q1 to 2019Q4.

Specifically, in addition to interest rates, which are the instrument of monetary policy, we include real GDP and the consumer price index in each model. In line with existing research on the cost channel (e.g., Barth and Ramey, 2002; Christiano et al., 2005; Gaiotti and Secchi, 2006;

Cucciniello et al., 2022), we also examine the behavior of nominal wages, as they constitute a component of business costs.

Following the methodologies of Christiano et al. (1999, 2005) and Cantore et al. (2022), we further explore the impact of monetary policy on income distribution, introducing the real wages obtained by deflating the nominal wage with the consumer price index. Additionally, in accordance with the literature addressing the price puzzle (as observed in Sims, 1992; Hanson, 2004; Castelnuovo and Surico, 2010; Florio, 2018), we incorporate measures of inflation and GDP growth rate expectations.

Finally, apart from interest rates, expectations, and real wages, all variables were transformed into logarithmic form. A comprehensive summary and description of all variables utilized in this study can be found in Table 1 and in Appendix A.

Table 1, Variables and description.

ACRONYMS	***DESCRIPTION***
I	Interest rate
P	Consumer price index
GDP	Gross domestic product
W	Nominal wages
WR	Real wages
FINF	Inflation forecasts
FGROWTH	Real GDP Growth Forecast

3.2. Models and identification strategies

Following the common methods used in the applied macroeconomic literature for measuring the effect of monetary policy on main macroeconomic variables (see among others, Bernanke and Gertler, 1995; Christiano et al., 2005; Uhlig, 2005; Castelnuovo and Surico, 2010;), we make use of

Structural Vector Autoregressive (SVAR) models (Kilian and Lütkepohl, 2017). This class of models allows us to identify monetary policy shocks by imposing restrictions on a reduced-form VAR model in levels represented in Eq. (1).

$$y_t = c + \sum_{i=1}^{p} A_i \, y_{t-p} + u_t$$

where y_t is the $kx1$ vector of considered variables, c is the constant term, A_i is the kxk matrix of reduced-form coefficients, and u_t is a $kx1$ vector composed by the error terms. In addition, a lag of 4 quarters was chosen for each model.

Since $Ai = B_0^{-1}B_i$, and $ut = B_0^{-1}\, w_t$, we can obtain the structural model (SVAR) as in Eq. (12).

$$B_0 y_t = a + \sum_{i=1}^{p} B_i \, y_{t-p} + w_t$$

where B_0 represents the matrix of contemporaneous relationships between the k variables in y_t, B_i is the k x k matrix of autoregressive slope coefficients, and w_t is the vector of structural shocks. To isolate an exogenous monetary policy shock, we must impose restrictions on the B_0 matrix derived from economic theory. In line with Christiano et al. (1999) and Castelnuovo and Surico (2010), Cantore et al. (2021), Nekarda and Ramey (2021), as a method to identify the shock we use Cholesky factorization (see Christiano et al., 1999), in which the B_0 matrix turns out to be lower triangular. The identification strategy for Models 1, 2 and, 3 is summarized in (1), (2), and (3):

$$\textbf{Model 1}: B_{0,i} y_{i,t} = \begin{bmatrix} - & 0 & 0 \\ - & - & 0 \\ - & - & - \end{bmatrix} \begin{bmatrix} i \\ P \\ GDP \end{bmatrix} \qquad (1)$$

$$\textbf{Model 2}: B_{0,i} y_{i,t} = \begin{bmatrix} - & 0 & 0 & 0 \\ - & - & 0 & 0 \\ - & - & - & 0 \\ - & - & - & - \end{bmatrix} \begin{bmatrix} W \\ i \\ P \\ GDP \end{bmatrix} \qquad (2)$$

$$\textbf{Model 3}: B_{0,i} y_{i,t} = \begin{bmatrix} - & 0 & 0 & 0 \\ - & - & 0 & 0 \\ - & - & - & 0 \\ - & - & - & - \end{bmatrix} \begin{bmatrix} i \\ P \\ WR \\ GDP \end{bmatrix} \qquad (3)$$

where '−' indicates an unrestricted parameter and '0' represents a zero restriction.

Following Kim and Roubini (2001), Leeper et al. (1996), Sims (1992), Sims and Zha (1998; 2006), the basic assumption guiding our identification strategy in model 1 is that economic information – such as contemporary data of P and GDP – are not known by the FED in setting the rate of interest and monetary policy can affect the economic system within the quarterly observation, namely in the contemporaneous relationship. We assume that "authorities react immediately to the variables they can observe without delay (commodity prices, monetary aggregates, and financial variables), and only with a delay to variables that they can observe only with a delay, such as GDP and the GDP deflator"(Sims, 1998 , p. 940) and, because of the information lag, "policy shocks could reasonably be assumed to be independent of contemporaneous economic disturbances"(Bernanke and Blinder, 1992 , p. 902).[4] If the policy instrument appears to be the most exogenous variable, the price level may react simultaneously only to the monetary policy shock, while GDP may be affected by both the interest rate and prices[5].

Then, in model 2 we add nominal wages to show the effects of monetary policy on income distribution. In addition, since interest rates are already present in the model, which would approximate financial costs, adding wages would allow us to identify another important component of costs to firms. We choose to place wages first in our ordering, considering them the most exogenous variable within the quarterly observation. This choice is based on four reasons: (i) wages are determined by a bargaining process based on institutional and social factors (see, for instance,

[4] Sims and Zha (1998) use quarterly data and find it more reasonable to assume that only contemporaneous money supply and commodity prices are known to the central bank when the interest rate is set, since such indices are released at monthly and daily frequencies, respectively. On the contrary, proper measures of variables such as the real GDP and the GDP deflator are assumed to be known to policymakers only with a lag. Indeed, even if the price level is available as a monthly observation, the federal fund rate is available as a daily variable. Therefore, monetary policy produces effects on the daily rate which in turn may affect the average and therefore the monthly observation. However, when the daily federal fund rate is affected by the Federal Open Market Committee (FOMC), the FOMC decisions cannot be influenced by the current level of price as it will be available only in the following month. Generally, while FF born as daily data and converted in monthly and quarterly observations by averaging daily ones, prices are produced monthly while GDP and its components quarterly. Therefore, the intrinsic nature of the rate of interest allows to consider it exogenous compared to prices and the output level. See also Fragetta and Melina (2013) on this identification.

[5] The FED may observe the monthly industrial production index, but 'One problem is that industrial output accounts for only a fraction of total output and that fraction is unstable over time. Moreover, real GDP is a measure of value added, whereas industrial output is a gross output measure. […] it is well known that the Federal Reserve is concerned with broader measures of real activity, making a policy reaction function based on industrial production growth economically less plausible and hence less interesting.' Kilian and Lütkepohl (2017, p. 225).

Akerlof, 1982 ; Bewley, 1999; Solow, 1980); (ii) the bargaining process is characterized by information lags as macroeconomic data are released with different delays and thus labor market institutions may not react within the quarter to shocks in the other variables in the model; (iii) monetary wages tend to be affected by nominal rigidities and the process of wage adjustment occurs slowly and over a period of time that is longer than the quarterly observation; (iv) monetary wages are not closely related to fluctuations in the business cycle, as the wage bargaining process occurs periodically and not continuously. (Taylor, 1979; Azariadis and Stiglitz, 1983). Moreover, following Christiano et al. (2005) and Cantore et al. (2022) we directly estimate the effects of monetary policy on income distribution by including real wages. In the model 3, we include real wages by substituting them for nominal wages and, in line with Christiano et al. (2005) and Cantore et al. (2022), we order them after prices.[6] Then, given the key role assigned by part of the "price puzzle" literature to inflation expectations (Hanson, 2004; Castelnuovo and Surico, 2010), we will check the robustness of our estimates by including a measure of them. However, in line with the evidence of Sims and Zha (2006) and proponents of a "Taylor Rule" or forward-looking reaction function of monetary policy (see, among others, Clarida et al., 1998; 2000; Levin et al., 2003; Orphanides and Williams, 2008; 2011), to these we will also add a measure of expectations about domestic economic activity. To do this, models 1, 2 and, 3 will be integrated by these expectations, ordered before the interest rate to allow the forward-looking variables to affect the current decisions of the Central Bank[7]. Once restrictions have been imposed and structural shocks estimated, impulse response functions (IRFs) are calculated to identify and quantify causal relationships among the selected variables. Standard errors are

[6] However, for reasons of space we will not report the impulse responses of these models but only some values summarized in the tables. In any case, these impulse responses are available upon request.

[7] In fact, for this literature, monetary policy can respond to variables that are omitted from standard models, namely expectations about domestic economic activity and prices. By allowing forward-looking variables to influence the interest rate, this will affect the estimation of the monetary policy shock, as noted by Clarida et al. (1998, p. 1039): "…the error term e_t is a linear combination of the forecast errors of inflation and output and the exogenous disturbance v_t. Finally, let u_t be a vector of variables within the central bank's information set at the time it chooses the interest rate that are orthogonal to e_t. Possible elements of u_t include any lagged variables that help forecast inflation and output…"

estimated through the Hall's bootstrap method (1000 repetitions), and IRFs will be reported with bands corresponding to both a 68 and 90 percent confidence interval.

4 Empirical findings and discussion

4.1 Baseline models

In this section, we report and discuss the estimated IRFs for models 1 and 2. For clarity, we summarize in Tables 1 and 2 the initial, final, and peak value of the response of prices, nominal wages, and real wages to a monetary policy shock of 1 percent at impact.

Figure 1 displays the impulse responses of prices and GDP to a contractionary monetary policy shock in Model 1. Our results show that an increase in interest rates leads to a positive and persistent price response for Japan, the United Kingdom, and the United States. This would confirm the existence of a cost channel of monetary policy. More specifically, as shown in Table 1, this channel appears to be particularly important for Japan, where a 100-basis point increase in the interest rate would lead to a rise in prices of 5.28 percent after three years. The response is also significantly positive over the entire horizon analyzed for the United Kingdom and the United States, with peaks of 3.16 percent (after 27 quarters) and 1.93 percent (after 21 quarters), respectively. While restrictive monetary policy has a positive effect on prices, the effect on GDP appears to be opposite. In fact, all the countries analyzed show a negative output response to increases in interest rates, although it appears to be persistent only for the United Kingdom and the United States. Thus, though there is an effectiveness of monetary policy on the levels of economic activity, this demand channel would not dominate the cost channel, and the relationship between prices and interest rates is found to be positive.

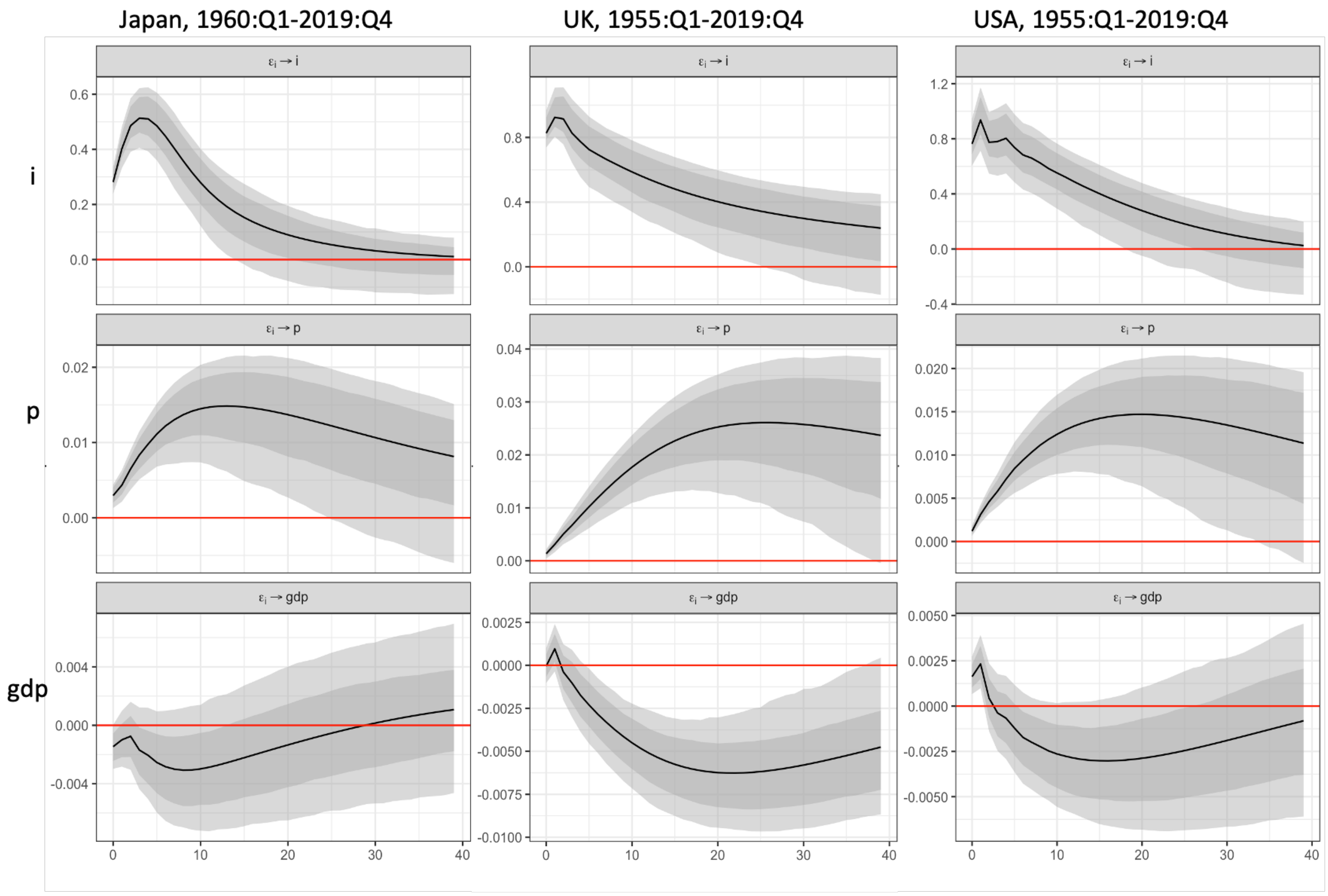

Figure 1. Impulse response functions of variables to a shock of i in model 1. The shaded areas represent the 68% and 90% confidence intervals.

		Model 1: I-P-GDP	Model 2: W-I-P-GDP
JAPAN	Initial	**1.05**	**0.89**
	Final	**2.89**	-0.55
	Peak	**5.28 (14)**	**2.81(6)**
UK	Initial	**0.16**	**0.1**
	Final	**2.87**	1.19
	Peak	**3.16(27)**	**1.93 (23)**
USA	Initial	**0.16**	**0.15**
	Final	**1.49**	1.13
	Peak	**1.93 (21)**	**1.46 (20)**

Table 2. Initial, final, and peak value of price (P) response to a monetary policy shock (i) normalized to 1%. In parentheses the quarter in which the peak occurs and in bold the significant values at 68%.

As already anticipated, in Model 2 the inclusion of nominal wages (W) leads to the following identification strategy: W-i-P-GDP. The impulse responses of wages, prices and output to a restrictive monetary policy shock are shown in Figure 2. Also, for this model, our results show a positive price response after an increase in interest rates in the countries analyzed. In addition, a contractionary monetary shock results in a positive response of nominal wages that take on a similar pattern to prices. More specifically, when nominal wages have a persistent positive response (as in the British and U.S. case), prices also do not show an impulse response that converges to zero. Conversely, when wages, after an initial increase, appear to decline, prices also have a final non-persistent response (see the Japanese example). However, such a positive response appears consistent with an idea of an inflationary process associated with distributional conflict. In fact, workers to counterbalance the effects of a restrictive monetary policy, concerning the negative impact on aggregate demand and the inflationary impact of the cost channel, will claim wage increases to defend real wages. Quantifying these effects, as shown in Table 6 for wages the largest values are noted in Japan, with an increase of 4.14 percent after 16 quarters, and in the United Kingdom, with a change of 1.84 percent after 22 quarters. However, British prices show the highest increase in five years at 1.93% while Japanese prices peak at 2.81% six quarters after the shock. The shape of U.S. impulse responses appears to be very similar to those in the UK but with lower elasticities. In fact, after 21 quarters prices reach a peak of 193 basis points versus that of nominal wages of 89 percentage points after 15 quarters. In each case, the positive price response is not compensated by the increase in nominal wages, which would highlight the negative effect of restrictive monetary policies on real wages.

At this point, to precisely quantify the response of real wages, we include them in place of the nominal ones in an additional model, model 3, whose IRFs we will not report for the reasons of space. It is evident from Table 3 that all countries show negative elasticities of real wages to a contractionary monetary policy shock in both the peak and final value of the impulse response analyzed. Therefore, such evidence would show how monetary policy can induce permanent changes on income distribution.

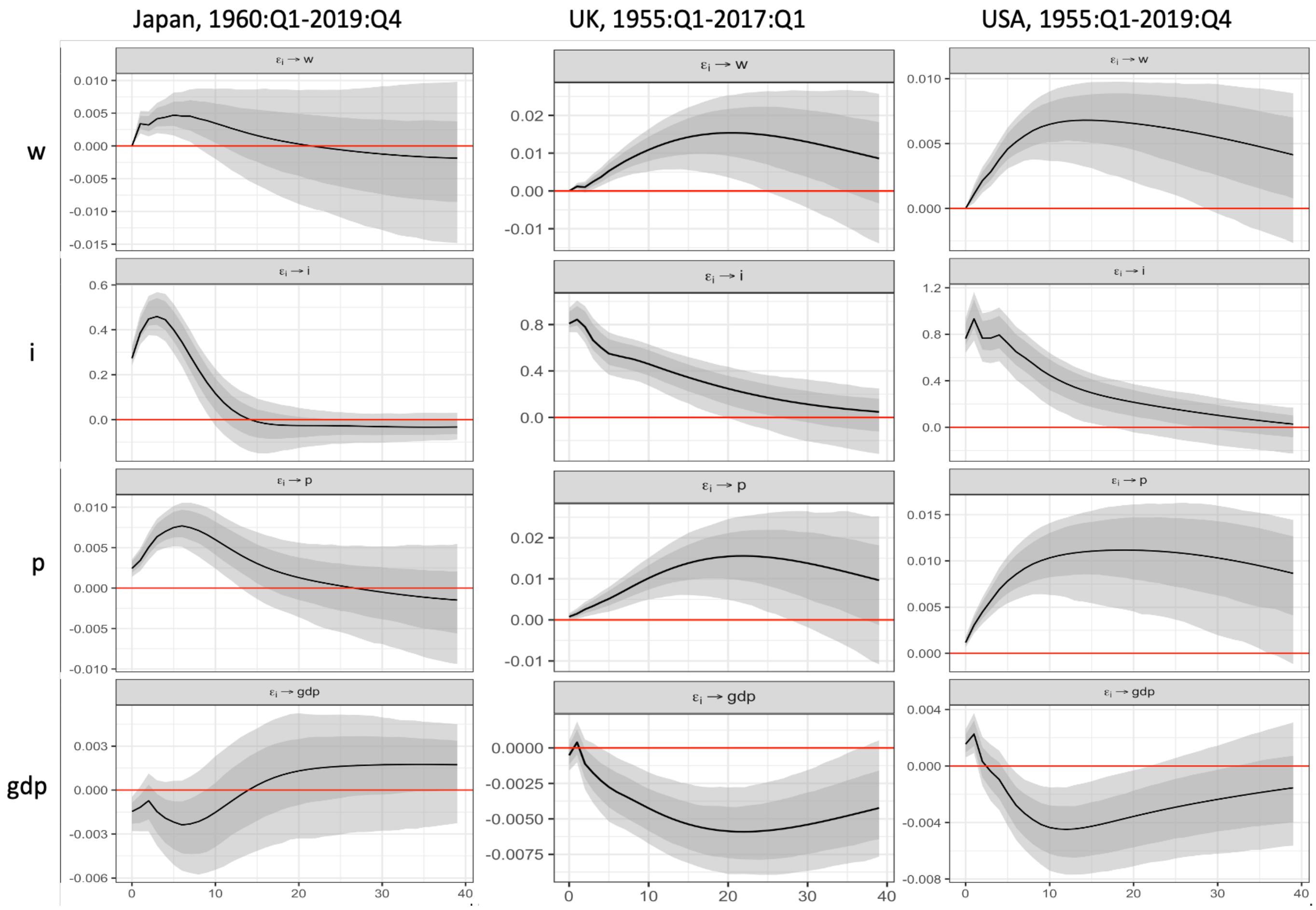

Figure 2. Impulse response functions of variables to a shock of i in model 2. The shaded areas represent the 68% and 90% confidence intervals.

		Model 2 **W-i-P-GDP**	**Model 3** **i-P-WR-GDP**
		Nominal wages response	**Real wages response**
JAPAN	Initial	**1.24**	**-0,6**
	Final	-0.68	-0,12
	Peak	**1.73 (6)**	**-0,6 (1)**
UK	Initial	**0.15**	**0.09**
	Final	1.06	**-0.18**
	Peak	**1.85 (18)**	**-0.18 (31)**
USA	Initial	**0.14**	**-0,05**
	Final	0.54	**-0,55**
	Peak	**0.89 (15)**	**-0,60(29)**

Table 3. Initial, final, and peak value of price (W) and (WR) response to a monetary policy shock (i) normalized to 1%. In parentheses the quarter in which the peak occurs and in bold the significant values at 68%.

4.2 Expectations

In line with the initial contribution of Sims (1992) part of the literature (Giordani, 2004; Hanson, 2004; Castelnuovo and Surico, 2010) has highlighted the primary role of inflation expectations in explaining the price puzzle. Indeed, the positive price response to an increase in interest rates estimated by the VAR model would be caused by a spurious relationship due to the omission of a relevant variable: inflation expectations. Hence, in this section we check the robustness of our results by including a measure of these expectations (FINF) in the baseline models 1, 2 and 3. In this way we obtain model 1.1 (FINF-i-P-GDP), model 2.1 (FINF-W-i-P-GDP) and model 3.1(FINF-i-P-WR-GDP). In addition, following the "Taylor Rule" forward-looking literature (see, among others, Clarida et al., 1998; 2000; Levin et al., 2003; Orphanides and Williams, 2008; 2013), we also add a second measure of expectations such as those on the growth of economic activity (FGROWTH), obtaining models 1.2 (FINF-FGROWTH-i-P-GDP), 2.2 (FINF-FGROWTH-W-i-P-GDP) and 3.2 (FINF-FGROWTH-i-P-WR-GDP) . In this section we will report the IRfs of the models 1.2 and 2.2, while those of models 1.1 and 2.1 are available upon request. As before, for the models with real wages (3.1 and 3.2) we will discuss only the values in the table. Figure 3 shows the IRFs of model 2.1 to a restrictive monetary policy shock, whose initial, final, and peak values are shown in Table 4 along with those of model 1.1 to facilitate comparison.

Also, in the models with expectations, Japan would be confirmed as having the highest absolute value price elasticity, peaking at 3.77 percent in the model with only the inflation expectation and 3.09 percent in the model with both expectations (in both cases after 4 years), although the peak in the model without expected variables was 5.28 percent. The same evidence would be for the United Kingdom where the peak value would fall from 316 basis points in the model without expectations to 100 basis points with the inclusion of expectations. A halving in the peak value would also occur for the United States, which would show a final value that is still positive, thus confirming the persistence of the cost channel for this country as well.

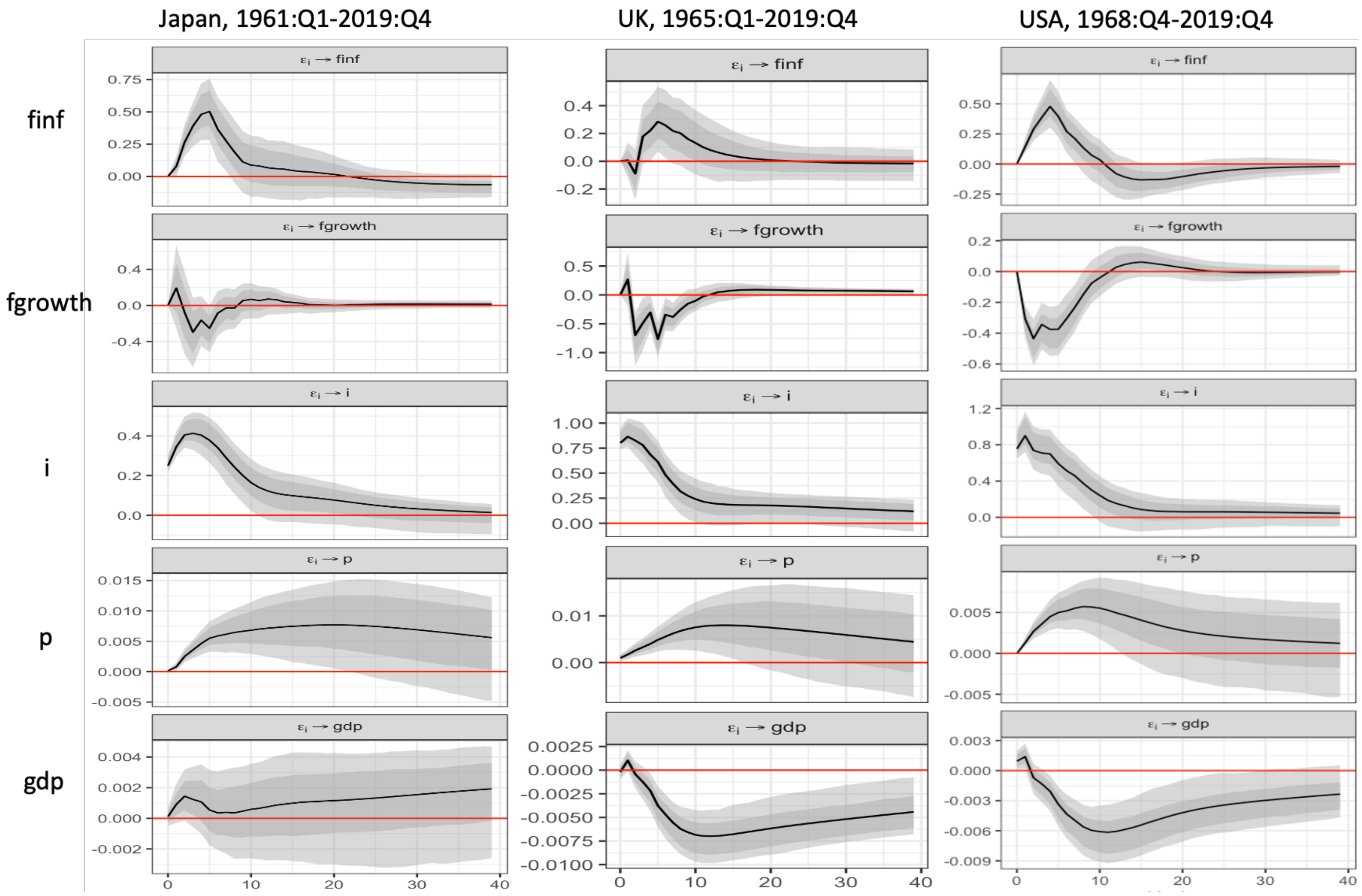

Figure 3. Impulse response functions of variables to a shock of i in model 1.2. The shaded areas represent the 68% and 90% confidence intervals.

		Model 1 i-P-GDP	Model 1.1 FINF-i-P-GDP	Model 1.2 FINF-FGROWTH-i-P-GDP
JAPAN	Initial	**1.05**	**0.04**	**0.06**
	Final	**2.89**	2.23	**2.25**
	Peak	**5.28 (14)**	**3.77 (18)**	**3.09 (21)**
UK	Initial	**0.16**	**0.11**	**0.12**
	Final	**2.87**	0.57	0.55
	Peak	**3.16(27)**	**1.03 (16)**	**1 (15)**
USA	Initial	**0.16**	**-0.002**	**-0.003**
	Final	**1.49**	0.6	0.16
	Peak	**1.93 (21)**	**1.05 (18)**	**0.76 (9)**

Table 4. Initial, final, and peak value of price (P) response to a monetary policy shock (i) normalized to 1%. In parentheses the quarter in which the peak occurs and in bold the significant values at 68%.

To this point we discuss the IRFs of model 2.2 to a restrictive monetary policy shock, showed in figure 4, whose initial, final, and peak values are shown in Table 5 along with those of model 1.2 to facilitate comparison.

Again, the inclusion of expectations would seem to confirm previous impulse responses of prices and wages to monetary policy shocks. Consistent with the idea of distributional conflict inflation, nominal wages would appear to respond positively to tight monetary policies due to workers' attempt to defend real wages from rising prices. However, in line with models 1.1 and 2.1, a decrease in the magnitude of both price and nominal wage impulse responses would be evident, as shown in Tables 4 and 5. In each case, Japan appears to be the country once again with the highest peak in price response; although it would go from a value of 2.81 percent in the model with no expectations to 2.03 percent considering only inflation expectations, to 1.82 percent once the expected GDP growth rate is also added. Subsequently, we also find a persistently positive response of monetary prices and wages for the United Kingdom and the United States, although with a lower magnitude once expectations are included. Indeed, for the British case the addition of expectations results in a halving of the maximum estimated value for both variables from 193 to 100 basis points for prices and from 185 to 109 basis points for wages, respectively. In line with this is the case of the United States. In fact, the peaks in prices (equal to 0.86 percent) and wages (equal to 0.7 percent) in model 2.2 would be positive but lower than those in the basic model (equal to 146 basis points for prices and 90 basis points for wages). As done previously, we include real wages instead of nominal wages in the models with expectations to quantify the effects of monetary policy on income distribution. As summarized in Table 6, both the peak and final value of real wage impulse responses would be significantly and persistently negative. A 1 percent shock to interest rates would lower the real wage by about 40 basis points for Japan (after 8 quarters) and the United States (after 34 quarters) and by 30 basis points for the United Kingdom (after 28 quarters). This would confirm the persistently negative effect of tight monetary policies on the distributional position of workers.

Finally, we briefly summarize the results of the models discussed in this section. The inclusion of various measures of expectations, although mitigating the positive effect on prices of tight monetary policy, does not solve the price puzzle for the three countries analyzed. In fact, the increase in prices appears to be persistent and significant over the 10 years analyzed and would confirm the importance of the cost channel in the transmission mechanism of monetary policy. The inclusion of nominal wages in our models would confirm the positive dynamics of this variable following a contractionary monetary shock, although as with prices the values are lower after the inclusion of expectations. However, nominal wage growth would not keep pace with price growth and so would not allow workers to defend a given real wage in the distributional conflict with other social classes. Therefore, in line with Christiano et al. (1999), Cantore et al (2022) and Cucciniello et al. (2022) even with the addition of expectations, the price increase generated by tight monetary policy would produce a fall in real wages and a permanent change in the distribution of income to the disadvantage of workers for both Japan, the United Kingdom, and the United States.

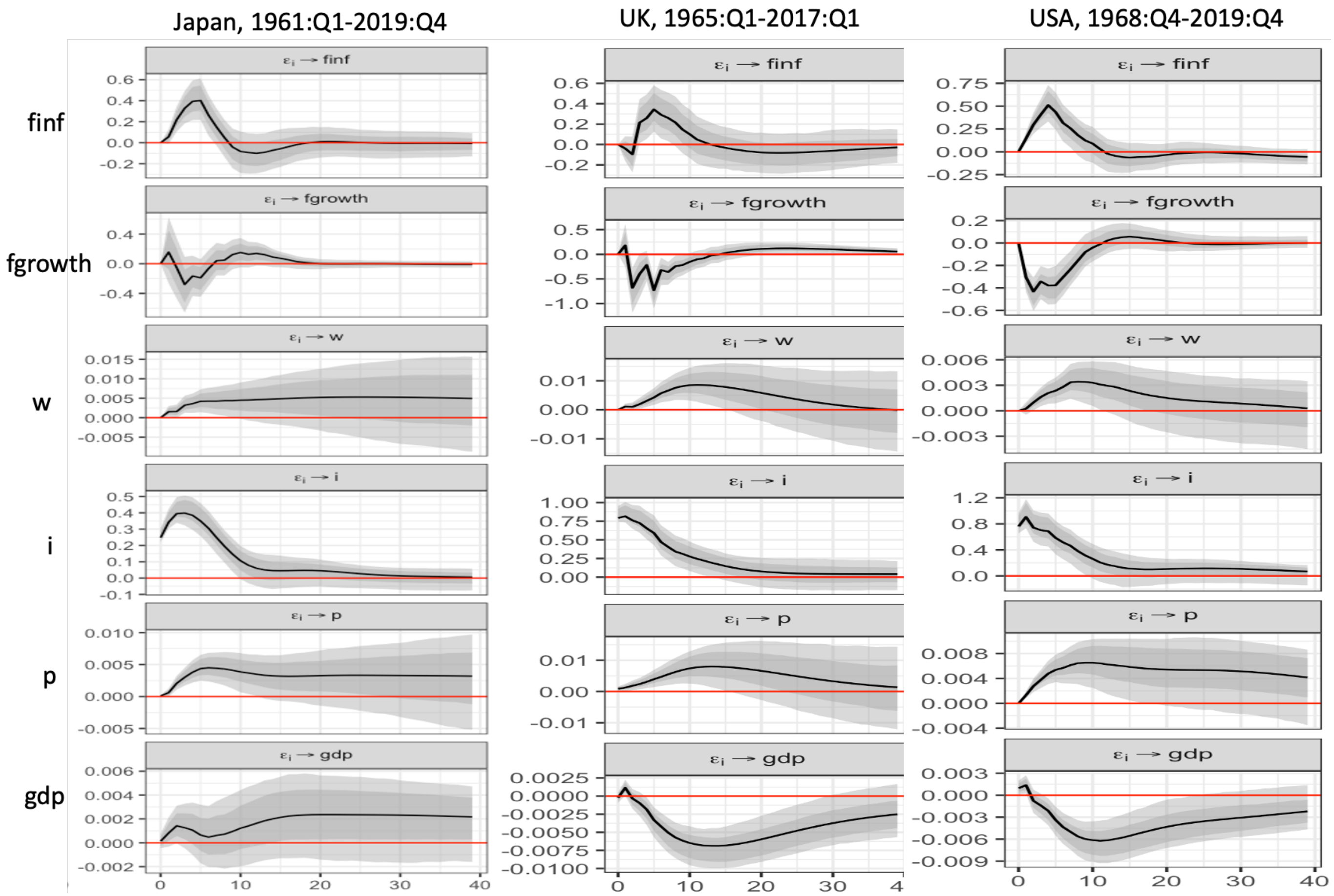

Figure 4. Impulse response functions of variables to a shock of i in model 2.2. The shaded areas represent the 68% and 90% confidence intervals.

		Model 2 W-i-P-GDP	Model 2.1 FINF-W-i-P-GDP	Model 2.2 FINF-FGROWTH-W-i-P-GDP
JAPAN	Initial	**0.89**	**0.02**	**0.04**
	Final	-0.55	1.01	1.29
	Peak	**2.81(6)**	**2.03 (8)**	**1.82(7)**
UK	Initial	**0.1**	**0.11**	**0.11**
	Final	1.19	0.26	0.17
	Peak	**1.93 (23)**	**1.10 (15)**	**1.01 (14)**
USA	Initial	**0.15**	**-0.001**	**-0.004**
	Final	1.13	**0.95**	**0.55**
	Peak	**1.46 (20)**	**1.15 (26)**	**0.86 (10)**

Table 5. Initial, final, and peak value of price (P) response to a monetary policy shock (i) normalized to 1%. In parentheses the quarter in which the peak occurs and in bold the significant values at 68%.

		Nominal wages response		Real wages response	
		Model 2.1 FINF-W-I-P-GDP	Model 2.2 FINF-FGROWTH-W-I-P-GDP	Model 3.1 FINF-I-P-WR-GDP	Model 3.2 FINF-FGROWTH-I-P-WR-GDP
JAPAN	Initial	**0.58**	**0.62**	-0.16	-0.18
	Final	1.49	1.99	-0.12	-0.03
	Peak	**1.93 (11)**	**2.14 (26)**	**-0.52(10)**	**-0.4 (8)**
UK	Initial	**0.12**	**0.14**	**0.11**	**0.1**
	Final	0.08	-0.01	**-0.19**	**-0.21**
	Peak	**1.09 (13)**	**1.08 (12)**	**-0.27 (27)**	**-0.28 (28)**
USA	Initial	**0.06**	**0.03**	0.04	0.04
	Final	0.42	0.04	**-0.48**	**-0.43**
	Peak	**0.7 (14)**	**0.45 (9)**	**-0.50 (34)**	**-0.44 (34)**

Table 6. Initial, final, and peak value of nominal (W) and real wages (WR) response to a monetary policy shock (i) normalized to 1%. In parentheses the quarter in which the peak occurs and in bold the significant values at 68%.

4.3 The transmission of monetary policy on prices: the demand and distributive channels

In this section we further test the effect of monetary policy on prices by attempting to highlight some transmission channels. In fact, as we have seen from previous estimates, a contractionary monetary policy shock would often lead to a reduction in output. Many economists argue how such a reduction would exert a downward pressure on prices. This would result in the demand channel of monetary policy. However, prices are also driven by cost elements. The inclusion of nominal wages in the previous analysis allowed us to highlight how they would rise after a contractionary monetary policy shock because of workers' attempt to defend the real wage from the action of the cost channel. Thus, given this convolution between prices and wages, we would be interested in trying to quantify how much nominal wages amplify the positive effect of monetary policy on prices, namely the distributional channel. Two questions we will try to answer in this section: How much of the price response to the interest rate is due to the movement of GDP? And how much to the movement of wages?

To do this, we will use the counterfactual VAR technique (Perotti, 2004; Bachmann and Sims, 2012; Samarina and Nguyen, 2022), in which we would place additional restrictions on the autoregressive coefficients and those of the contemporaneous relations matrix such that the response of the variable of interest (nominal wages or GDP) to the monetary policy shock is muted throughout the horizon analyzed (see Bachmann and Sims, 2012, p. 240). More specifically, in our model 2 (W-i-P-GDP), by silencing the response of GDP (W) to the monetary policy shock, we could indirectly quantify the role of the demand (distributional) channel, which will be given by the difference between the IRF of prices in the baseline model (i.e., where no variable is muted) and that in the model with GDP (W) blocked. On the following pages we report the IRFs solely of prices to the monetary policy shock. The blue responses are those of the basic models, already seen in the previous pages, which we will report to compare with the responses of the counterfactual models where the channels are alternately muted. The dashed red lines indicate the IRF with the demand channel closed (GDP cannot react to shocks in the other variables), the dashed green lines those with the distributive channel silenced (nominal wage cannot react to shocks in the other variables). Following the literature that has applied this methodology, confidence intervals are not reported to make comparison of IRFs easier.

At this point we comment on the IRFs shown in Figure 5 of the counterfactual VAR applied to model 2. For greater clarity, the initial, final, and peak values of the IRFs with the muted channels are compared in Table 7 with those already discussed for the baseline model. About the demand channel, generally all countries show the same pattern of IRFs as in the base model (blue line) but with higher values (red line), highlighting how the contraction in demand triggered by a restrictive monetary policy can partially offset the cost channel. As shown in Table 7 the weight of the demand channel seems most important in the United Kingdom where the difference between the peak of the base model and that with the demand channel muted is 200 basis points. Japan and the United States show a much smaller difference, which would point to a lower importance of the demand channel for these countries.

On the other hand, it is interesting to analyze that the price response (green line), once nominal wages are blocked, turns out to be significantly smaller than that of the base model represented by the blue line. This result, which is homogeneous across the three countries, would indicate how the nominal wage dynamic would feed into the price dynamic triggered by the monetary policy cost channel. This would keep a role in the analysis for the distributional conflict already mentioned in the previous pages. In fact, wage increases demanded by workers, to defend real wages from increases in the cost of living, would translate the price response upward. Reading the results more closely, we can highlight how the UK and the U.S. maintain a persistent price response over the horizon analyzed. Silencing the wage response for these countries would imply a peak IRF lower by 150 basis points for the UK case and 50 basis points for the US. Again, these values would indicate how much wages would fuel the positive price response to a monetary policy shock. Similarly, Japanese IRFs appear to be of interest. Indeed, in the baseline model nominal wages and prices showed a negative tract 7 years after the monetary shock. In contrast, now, after 7 years the price response with nominal wages muted (green line) would appear higher than the blue line (base model), allowing the final tract in the base model to be linked back to the negative path assumed by nominal wages.

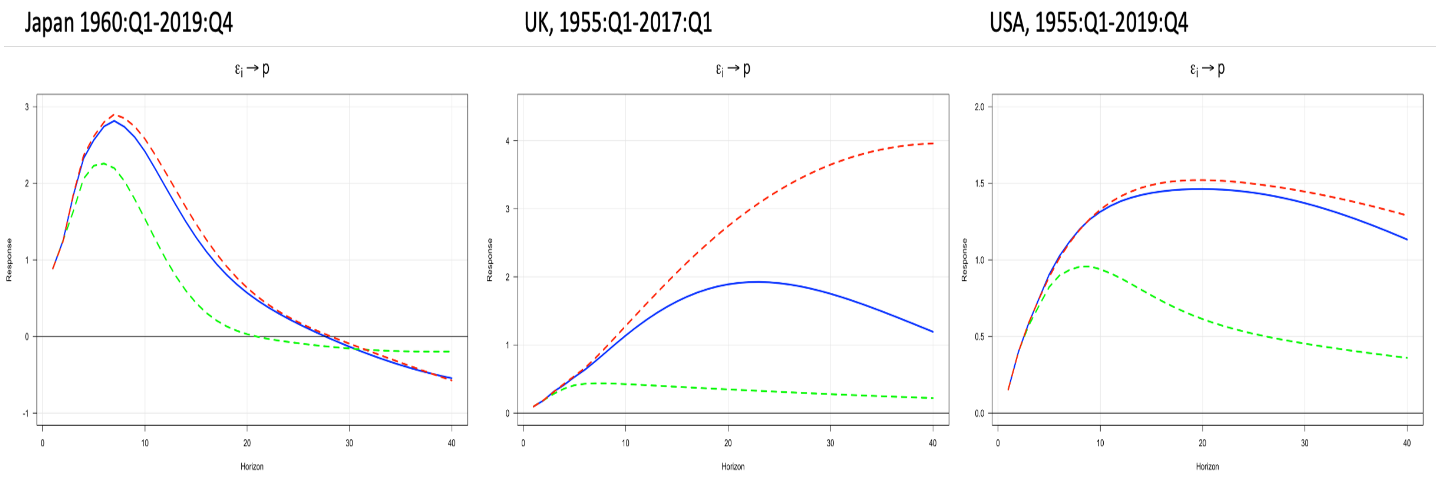

Figure 5. IRFs of variables to a shock of i in model 2. In blue, the response to the monetary impulse of prices in the basic model while in dashed red, that in the model with the demand channel muted, and in dashed green, that in the model with the distribution or wage channel muted.

		Model 1.2: W-i-P-GDP		
		Baseline model	**Distributive channel muted**	**Demand channel muted**
JAPAN	Initial	0.89	0.89	0.89
	Final	-0.55	-0.2	-0.58
	Peak	2.81 (7)	2.26 (6)	2.9 (7)
UK	Initial	0.1	0.1	0.1
	Final	1.19	0.22	3.96
	Peak	1.93 (23)	0.44 (7)	3.96 (40)
USA	Initial	0.15	0.15	0.15
	Final	1.13	0.36	1.29
	Peak	1.46 (20)	0.96 (9)	1.52 (20)

Table 7. Initial, final, and peak value of price (P) response to a monetary policy shock (i) normalized to 1%. First column corresponds to the baseline model, the second to the muted distribution channel, and the third to the muted demand channel.

Next, we also apply the counterfactual estimate to model 2.2, which includes both inflation and economic activity level expectations. However, we can again show substantial homogeneity across countries, being generally the blue line[8] (base model) between the red line (closed demand channel) and the green line (closed wage channel), as shown in Figure 6 and Table 8. This would confirm two

[8] However, the exception of Japan, whose blue line after three years would be higher than the red line, should be pointed out. This response could be explained by the positive reaction of GDP to the interest rate increase in the base model.

results: the model would be able to detect a demand channel capable of slowing down the positive effect of monetary policy on prices; at the same time there is a wage (or distributional) channel based on distributional conflict that could foster further increases in prices originating in the monetary policy cost channel. In such a case, it would appear useful to refer to the decisions of the monetary authorities and the distributional conflict between social classes as a possible explanation for inflationary dynamics within a country.

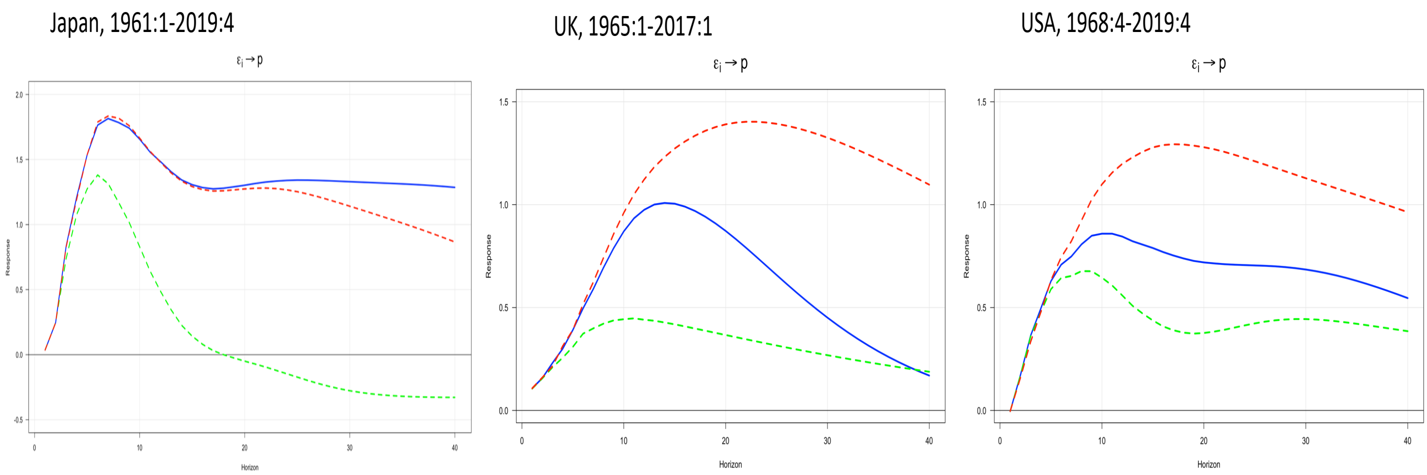

Figure 6. IRFs of variables to a shock of i in model 2.2. In blue, the response to the monetary impulse of prices in the basic model while in dashed red, that in the model with the demand channel muted, and in dashed green, that in the model with the distribution or wage channel muted.

		Model 2.2: FINF-FGROWTH-W-i-P-GDP		
		Baseline model	**Distributive channel muted**	**Demand channel muted**
JAPAN	Initial	0.04	0.04	0.04
	Final	1.29	-0.33	0.87
	Peak	1.82 (7)	1.38 (6)	1.83 (7)
UK	Initial	0.11	0.11	0.11
	Final	0.17	0.19	1.1
	Peak	1.01 (14)	0.45 (11)	1.4 (23)
USA	Initial	-0.004	-0.004	-0.004
	Final	0.55	0.39	0.96
	Peak	0.86 (10)	0.68 (8)	1.29 (17)

Table 8. Initial, final, and peak value of price (P) response to a monetary policy shock (i) normalized to 1%. First column corresponds to the baseline model, the second to the muted distribution channel, and the third to the muted demand channel.

6 Conclusions

This paper examines the impact of monetary policy on prices and income distribution in Japan, the United Kingdom, and the United States for the period 1955-2019. Our empirical evidence can be summarized as follows:

1. Firstly, an increase in interest rates would result in a significant positive price change for all three analyzed countries. This confirms the existence of a cost channel of monetary policy that prevails over the demand channel, contrary to traditional models that suggest an inverse relationship between interest rates and prices. These results remain robust even with the inclusion of various expectation measures, such as those related to inflation and economic activity levels. In fact, the addition of expectations, while mitigating the positive effect of restrictive monetary policy on prices, does not resolve the price puzzle for Japan, the United Kingdom, and the United States.
2. Furthermore, we have introduced nominal and real wages into our models to assess the impact of monetary policy on income distribution. In line with inflation from distributive conflict, restrictive monetary policies, by inducing price increases, would trigger higher wage claims by workers, leading to a positive response in nominal wages. However, this positive response is never sufficient to offset the price increase due to the cost channel, resulting in a decrease in real wages for all countries considered (in line with Christiano et al., 2005; Cucciniello et al., 2022; Cantore et al., 2022).
3. Additionally, we have decomposed the effect of monetary policy on prices, distinguishing between two channels: the demand channel captured by GDP and the distributional channel represented by nominal wages. Generally, the demand channel would only partially offset the cost channel. In contrast, the distributional channel would contribute to the positive effect of interest rate increases on prices. This confirms that a portion of the estimated price increase may be due to workers' attempts to avoid a reduction in real wages caused by the cost channel.

> These findings highlight the close connection between distributive conflict and monetary policy (for a broader discussion on this aspect, see Levrero, 2023).

These results would align with the effects of monetary policy from the cost or supply side and would echo Patman's assertion that "raising interest rates to fight inflation is like throwing gasoline on fire" (Patman, 1957, p. 134).

Finally, contextualizing our results, we can infer several implications for the current monetary policy debate. The first concerns the inflation targeting strategy adopted by major central banks in recent decades, which presupposes an inverse relationship between interest rates and prices. Indeed, the relevance of the cost channel would pose serious challenges to the control of inflation by monetary authorities through the instrument of interest rate maneuvers. These difficulties could be exacerbated, especially when considering doubts about the effectiveness of the monetary policy transmission mechanism at the economic activity levels. Secondly, there is a need for greater attention to the distributive effects of monetary policy. Our evidence suggests that restrictive monetary policies would be unfavorable to workers, contrary to the neo-Keynesian modeling based on sticky wages (Ascari, 2000; Galì, 2011), where interest rate increases would lead to a decrease in prices and an increase in real wages. Furthermore, this impact on income distribution would be permanent, in stark contrast to the view of neutral monetary policy in the long run.

Appendix

Appendix A

Below is a description and sources of the data used for each country.

- **Interest rate (i)**

  For Japan, we used the discount interest rate downloaded from the Bank of Japan website ("The Basic Discount Rate and Basic Loan Rate") and available at the quarterly level since 1946.

  For the UK, we downloaded the "Bank rate," the official rate of the Bank of England, taken from the central bank's website and available quarterly since 1694.

  For the U.S., we used the Federal funds rate, downloaded from the FRED website, and available since 1955 on a quarterly basis.

- **Consumer price index (P)**

  For Japan, we used the CPI provided by the OECD economic outlook.

  For the UK and the U.S., we took the CPI contained in the OECD national accounts being available data before 1960.

- **Real gross Domestic Product (GDP)**

  For Japan, we employed GDP from the OECD economic outlook (VOBARSA: National currency, volume estimates, OECD reference year, annual levels, seasonally adjusted).

  For the UK and the U.S., we took the GDP contained in the OECD national accounts being available data before 1960 (VOBARSA: National currency, volume estimates, OECD reference year, annual levels, seasonally adjusted).

- **Nominal wages (W)**

  For Japan, we used quarterly hourly earnings in the manufacturing sector, available on the OECD website (Hourly Earnings (MEI), Manufacturing Index, SA, 2015=100) from 1960.

For the United Kingdom, we used a nominal weekly earnings series taken from the Bank of England dataset "A Millennium of Macroeconomic Data for the UK”. The series is called the "Spliced Average Weekly Earnings series" and is available on a quarterly basis from 1915 to the first quarter of 2017.

For the U.S., nominal wages are constructed as Wages and Salaries from NIPA 1.12 divided by hours worked in the total economy from the BLS.

- **Real wages (W)**

  For all countries analyzed, real wages correspond to nominal wages (W) deflated by Concumer price index (P).

- **Inflation expectations (FINF)**

  For Japan and the U.S., these are the inflation expectations provided in the OECD economic outlooks available from the first quarter of 1961.

  For UK, we used the 1-year inflation expectations of the National Institute of Economic and Social Research (NIESR) available from the first quarter of 1965.

- **Real GDP growth expectations (FGROWTH)**

  For Japan and the UK, these are the Real GDP growth expectations provided in the OECD economic outlooks available from the first quarter of 1961.

  For the U.S., we used the one-quarter ahead Real GDP growth forecasts from the Survey of Professional Forecasters (SPF), made available by The Federal Reserve Bank of Philadelphia from the last quarter of 1968.

References

Akerlof, G. A. (1982). Labor contracts as partial gift exchange. *The quarterly journal of economics*, *97*(4), 543-569.

Altig, D., Christiano, L. J., Eichenbaum, M., & Linde, J. (2011). Firm-specific capital, nominal rigidities and the business cycle. *Review of Economic dynamics*, 14 (2), 225-247.

Ascari, G. (2000). Optimising agents, staggered wages and persistence in the real effects of money shocks. *The Economic Journal*, 110(465), 664-686.

Azariadis, C., & Stiglitz, J. E. (1983). Implicit contracts and fixed price equilibria. *The Quarterly Journal of Economics*, 2-22.

Bachmann, R., and Sims, E. R. (2012). Confidence and the transmission of government spending shocks. *Journal of Monetary Economics*, 59(3), 235-249.

Barakchian, S. M., & Crowe, C. (2013). Monetary policy matters: Evidence from new shocks data. *Journal of Monetary Economics*, *60*(8), 950-966.

Barth III, M. J., & Ramey, V. A. (2001). The cost channel of monetary transmission. *NBER Macroeconomics Annual*, 16, 199-240.

Bernanke, B., & Blinder, A. S. (1992). The federal funds rate and the transmission of monetary policy. *American Economic Review*, 82 (4), 901-921.

Bernanke, B. S., & Mihov, I. (1998). Measuring monetary policy. The quarterly journal of economics, 113(3), 869-902.

Bernanke, B. S., Boivin, J., & Eliasz, P. (2005). Measuring the effects of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach. The Quarterly journal of economics, 120(1), 387-422.

Bewley, T. F. (1999). *Why wages don't fall during a recession*. Harvard university press.

Brückner, M., & Schabert, A. (2003). Supply-side effects of monetary policy and equilibrium multiplicity. *Economics Letters*, *79*(2), 205-211.

Cantore, C., Ferroni, F., & León-Ledesma, M. (2021). The missing link: monetary policy and the labor share. *Journal of the European Economic Association*, 19 (3), 1592-1620.

Castelnuovo, E., & Surico, P. (2010). Monetary policy, inflation expectations and the price puzzle. *The Economic Journal*, 120 (549), 1262-1283.

Chowdhury, I., Hoffmann, M., & Schabert, A. (2006). Inflation dynamics and the cost channel of monetary transmission. *European Economic Review*, 50 (4), 995-1016.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (1997). Sticky price and limited participation models of money: A comparison. *European Economic Review*, 41 (6), 1201-1249.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (1999). Monetary policy shocks: What have we learned and to what end?. *Handbook of macroeconomics*, 1, 65-148.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113 (1), 1-45.

Clarida, R., Galı, J., & Gertler, M. (1998). Monetary policy rules in practice: some international evidence. *european economic review*, *42*(6), 1033-1067.

Clarida, R., Gali, J., & Gertler, M. (2000). Monetary policy rules and macroeconomic stability: evidence and some theory. *The Quarterly journal of economics*, *115*(1), 147-180.

Coibion, O. (2012). Are the effects of monetary policy shocks big or small?. *American Economic Journal: Macroeconomics*, *4*(2), 1-32.

Coibion, O., Gorodnichenko, Y., Kueng, L., & Silvia, J. (2017). Innocent Bystanders? Monetary policy and inequality. *Journal of Monetary Economics*, 88, 70-89.

Cucciniello, M. C., Deleidi, M., & Levrero, E. S. (2022). The cost channel of monetary policy: The case of the United States in the period 1959–2018. *Structural Change and Economic Dynamics*, 61, 409-433.

Dedola, L., & Lippi, F. (2005). The monetary transmission mechanism: evidence from the industries of five OECD countries. *European Economic Review,* 49(6), 1543-1569.

Dias, D. A., & Duarte, J. B. (2019). Monetary Policy, Housing Rents and Inflation Dynamics. *International Finance Discussion Papers*.

Eichenbaum, M. (1992). 'Comments on 'Interpreting the Time Series Facts: The Effects of Monetary Policy'by Christopher Sims,''. *European Economic Review*, 36(5), 1001-1011.

Florio, A. (2018). Nominal anchors and the price puzzle. *Journal of Macroeconomics*, 58, 224-237.

Fragetta, M., & Melina, G. (2013). Identification of monetary policy in SVAR models: a data-oriented perspective. *Empirical Economics*, 45, 831-844.

Fujiwara, I. (2004). Output composition of the monetary policy transmission mechanism in Japan. *Contributions in Macroeconomics*, *4*(1), 20121024.

Furceri, D., Loungani, P., & Zdzienicka, A. (2018). The effects of monetary policy shocks on inequality. *Journal of International Money and Finance*, 85, 168-186.

Gaiotti, E., & Secchi, A. (2006). Is there a cost channel of monetary policy transmission? An investigation into the pricing behavior of 2,000 firms. *Journal of Money, Credit and Banking*, 2013-2037.

Galí, J. (2011). The return of the wage Phillips curve. *Journal of the European Economic Association,* 9(3), 436-461.

Giordani, P. (2004). An alternative explanation of the price puzzle. Journal of Monetary Economics, 51(6), 1271-1296.

Góes, M. C. B. (2023). A tale of three prices: Monetary policy and autonomous consumption in the US. *Structural Change and Economic Dynamics,* 67, 115-127

Goodhart, C. (1986). Financial innovation and monetary control. Oxford Review of Economic Policy, 2(4), 79-102.

Hanson, M. S. (2004). The "price puzzle" reconsidered. *Journal of Monetary Economics*, 51(7), 1385-1413.

Hülsewig, O., Mayer, E., & Wollmershäuser, T. (2009). Bank behavior, incomplete interest rate pass-through, and the cost channel of monetary policy transmission. *Economic Modelling,* 26(6), 1310-1327.

Kaufmann, S., & Scharler, J. (2009). Financial systems and the cost channel transmission of monetary policy shocks. *Economic Modelling*, *26*(1), 40-46.

Keynes, J. M. (1930). *A treatise on money*.

Kilian, L., & Lütkepohl, H. (2017). *Structural vector autoregressive analysis*. Cambridge University Press.

Latsos, S. (2018). Real wage effects of Japan's monetary policy. *ORDO*, 2018 (69), 177-215.

Leeper, E. M., Sims, C. A., Zha, T., Hall, R. E., & Bernanke, B. S. (1996). What does monetary policy do?. *Brookings Papers on Economic Activity*, 1996 (2), 1-78.

Leeper, E. M., & Roush, J. E. (2003). Putting "M" Back in Monetary Policy. *Journal of Money, Credit and Banking*, 35(6), 1217–1256. http://www.jstor.org/stable/3649882

Levin, A., Wieland, V., & Williams, J. C. (2003). The performance of forecast-based monetary policy rules under model uncertainty. *American Economic Review*, *93*(3), 622-645.

Levrero, E. S. (2023). The Taylor rule and its aftermath: An interpretation along Classical-Keynesian Lines. *Review of Political Economy*, 1-19.

Nekarda, C. J., & Ramey, V. A. (2020). The cyclical behavior of the price-cost markup. *Journal of Money, Credit and Banking*, *52*(S2), 319-353.

Orphanides, A., & Williams, J. C. (2008). Learning, expectations formation, and the pitfalls of optimal control monetary policy. *Journal of Monetary Economics*, *55*, S80-S96.

Orphanides, A., & Williams, J. (2011). *Monetary policy mistakes and the evolution of inflation expectations* (No. w17080). National Bureau of Economic Research.

Patman, W. (1957). *Hearings* before the Subcommittee on Economic Stabilization of the Joint Economic Committee of the United States, Congress of the United States, Eighty-Fourth Congress (2nd Session, December 10-11 1956). Washington: UGPO.

Perotti, R. (2004). Public investment: another (different) look. IGIER, Università Bocconi and Centre for Economic Policy Research.

Rabanal, M. P. (2003). The cost channel of monetary policy: further evidence for the United States and the euro area. *International Monetary Fund.*

Rabanal, P. (2007). Does inflation increase after a monetary policy tightening? Answers based on an estimated DSGE model. *Journal of Economic Dynamics and control*, 31(3), 906-937.

Ramey, V. A. (2016). Macroeconomic shocks and their propagation. *Handbook of macroeconomics*, *2*, 71-162.

Ravenna, F., & Walsh, C. E. (2006). Optimal monetary policy with the cost channel*. Journal of Monetary Economics*, 53(2), 199-216.

Romer, C. D., & Romer, D. H. (2004). A new measure of monetary shocks: Derivation and implications. *American economic review,* 94(4), 1055-1084.

Samarina, A., & Nguyen, A. D. (2023). Does Monetary Policy Affect Income Inequality in the Euro Area?. *Journal of Money, Credit and Banking*. https://doi.org/10.1111/jmcb.1301.

Sims, C. A. (1992). Interpreting the macroeconomic time series facts: The effects of monetary policy. *European Economic Review*, 36 (5), 975-1000.

Sims, C., & Zha, T. (1998). Does monetary policy generate recessions?. *Federal Reserve Bank of Atlanta Working Paper* 98-12.

Sims, C. A., & Zha, T. (2006). Does monetary policy generate recessions?. *Macroeconomic Dynamics*, 10 (2), 231-272.

Solow, R. M. (1995). On theories of unemployment. *Essential Readings in Economics*, 264-279.

Taylor, J. B. (1979). Staggered wage setting in a macro model. *The American Economic Review*, *69*(2), 108-113.

Teeters, N. (1981). FOMC meeting, May 1981.

Tillmann, P. (2008). Do interest rates drive inflation dynamics? An analysis of the cost channel of monetary transmission. *Journal of Economic dynamics and Control*, 32(9), 2723-2744.

Tooke, T. (1838). *A History of Prices and of the State of the Circulation, from 1793 to 1837: Preceded by a Brief Sketch of the State of Corn Trade in the Last Two Centuries* (Vol. 7). Longman, Orme, Brown, Green, and Longmans.

Uhlig, H. (2005). What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics*, 52 (2), 381-419.