EUROPEAN CENTRAL BANK

EUROSYSTEM

Working Paper Series

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Fiscal announcements and households' beliefs: evidence from the euro area

No 3139

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Abstract

This paper studies the effects of fiscal policy announcements on household expectations. We document announcements of price-related expansionary fiscal measures in response to the cost-of-living crisis in the four largest euro area economies and exploit the exogenous timing of fiscal actions relative to household survey participation to estimate their causal effects. Following fiscal announcements, households revise their beliefs: inflation perceptions rise, and unemployment perceptions fall. The latter effect persists into short-run unemployment expectations, while inflation expectations remain unchanged and suggest households perceived inflationary pressures as temporary. These results suggest a significant signaling channel of fiscal policy, as fiscal announcements reveal information about the underlying economic conditions and the government's commitment to stabilization. We rationalize these findings through a general equilibrium New Keynesian model extended with information frictions and an inflation-stabilizing role for fiscal policy. The model isolates the informational content of fiscal policy and shows that belief revisions are consistent with demand-driven dynamics.

JEL: D12, D83, D84, E3, E62

Keywords: fiscal stabilization policies, macroeconomic uncertainty, inflation expectations, household expectations, euro area

Non-technical summary

Governments frequently implement fiscal measures, such as tax cuts or subsidies, to address economic challenges. Beyond their direct impact on the economy, these policies also shape how people perceive economic conditions. This paper examines how household expectations in the euro area respond to fiscal policy announcements, particularly during periods of heightened economic uncertainty.

Drawing on data from the four largest euro area economies, we analyze fiscal policy announcements made during the cost-of-living crisis in the second half of 2021 and 2022. Our findings indicate that these announcements led households to revise their beliefs about the economic outlook: perceptions of current inflation increased, while concerns about unemployment declined. However, despite these shifts in economic perceptions, fiscal announcements did not significantly change households' expectations of future inflation. By carefully comparing survey responses in the ECB's Consumer Expectations Survey (CES) just before and just after fiscal announcements, we isolate their causal effect on household expectations.

To ensure precise identification, we construct a detailed timeline of fiscal announcements using a confidential dataset compiled by public finance experts from the European System of Central Banks (ESCB). We validate the announcement dates by examining spikes in Google search activity for relevant terms related to the policies. This allows us to pinpoint when households were first exposed to the new information conveyed by the fiscal announcements.

To explain these findings, we develop a theoretical model in which fiscal policy serves not only as an economic instrument for economic stabilization but also as a source of information. In the model, households interpret government actions as signals about underlying economic conditions and policymakers' commitment to stabilization. For example, if the government introduces VAT cuts, this may be perceived as an indication that inflation is temporarily high or that the government is responding to economic weakness.

Our analysis underscores the importance of considering the broader implications of fiscal policy. Beyond its direct economic effects, fiscal policy plays a role in shaping household behavior and the public perceptions of the economy. Understanding this signaling effect is essential for designing effective economic policies, particularly in times of high uncertainty.

1 Introduction

In the second half of 2021, inflation in the euro area rose sharply because of supply and demand mismatches during the recovery from the COVID-19 pandemic. Inflationary pressures intensified with the onset of the energy crisis. In response, the European Central Bank (ECB) increased interest rates to maintain price stability and keep inflation expectations well anchored. At the same time, fiscal authorities took swift action (mainly through tax cuts and energy subsidies) to mitigate the impact of high energy prices on firms' and households' income.

However, it remains unclear how households interpreted these events, particularly fiscal policy measures and their announcements. Understanding economic developments requires extracting signals and forming beliefs, something that becomes more complex during periods of heightened uncertainty. Thus, fiscal policy might not only have direct effects on economic conditions and inflation but also serve as an information device for less informed households, revealing information about current economic conditions, prices, and the government's commitment to achieve economic stabilization.

This paper studies the relationship between fiscal policy announcements and households' perceptions and expectations of the economy. We estimate the causal effects of fiscal announcements by leveraging a new detailed narrative of price-related fiscal measures for the four largest economies of the euro area, combined with microdata on household expectations in a Regression Discontinuity (RD) design. We then interpret our empirical findings through the lens of a New Keynesian (NK) model, extended to include information frictions and an inflation-stabilization role for fiscal policy.

We construct a new narrative of official announcements of price-related expansionary fiscal measures in response to the cost-of-living crisis in the four largest economies of the euro area during the second half of 2021 and 2022. We build on a confidential dataset compiled by public finance experts of the European System of Central Banks (ESCB). The dataset records the most relevant discretionary changes of fiscal policy with significant budgetary impact. We extend this 'ESCB dataset' by documenting the announcement process, tracking their first appearance in the media and in the political discourse, even before they are passed as legislation. Given the importance of the announcement date for our empirical design, we further validate our dating (and in some cases slightly adjust it) against observed spikes in Google searches for key words related to each fiscal announcement to ensure an accurate identification of the date when households most likely first heard about the measures.[1]

Note that our fiscal announcements differ from monetary policy announcements in that they do not occur at a regular frequency and are therefore less likely to be anticipated. Furthermore, we date the announcement when we estimate households are the most likely to update their information set. In line with this, we see no clear signs of anticipation from households in their Google search behavior ahead of the announcements. Still, we cannot entirely rule out that some of the fiscal announcements we consider were partially anticipated by some households, but we note that this would only have an attenuation effect on the information shock at the date of the official announcement.

We then implement an RD design that exploits the exact timing of survey responses around fiscal announcements.[2] Using the Consumer Expectations Survey (CES), a monthly panel survey administered by the ECB on the perceptions and expectations of households about the economy, inflation, and household economic behavior, we compare responses of households surveyed just before and just after fiscal announcements. Since these two groups of households are observationally equivalent except for the available information about fiscal announcements, this allows us to isolate the causal impact of fiscal announcements on household expectations.[3] The two main identifying assumption are that fiscal announcements are exogenous with respect to the exact date when households complete the survey and that fiscal announcements do not exactly coincide in time with the release of other relevant economic information. We carry out a number of robustness checks to back these two assumptions, including additional controls in the regressions for CPI releases and energy prices, and a thorough exploration of the distribution of survey responses and fiscal announcement dates.

[1] Our dating approach aims to pin down the exact date when households are the most likely to update their information set, which often precedes the formal approval and can already trigger economic responses, as shown in García-Uribe (2023). Note that Mertens and Ravn (2012) take the day legislation becomes law as the announcement date, but since their analysis is carried out at quarterly frequency, this can encompass the period between announcement and approval of the fiscal measures. Our definition is closer to that of Melosi et al. (2025), based on the first official announcement of the eventually passed legislation.

[2] Others have previously exploited the timing of fiscal actions with respect to household survey participation to estimate the economic impact of fiscal policy. See, for example, Johnson et al. (2006); Parker et al. (2013); Misra and Surico (2014). However, the existing literature focused on the observed outcomes of implemented fiscal policies in the United States. Instead, we study the effects of fiscal announcements on household expectations in the euro area.

[3] Because we observe multiple fiscal announcements across different countries over the period of analysis, we effectively implement a staggered RD where each announcement date is normalized and staggered, greatly increasing statistical power of our analysis and allowing for the inclusion of a rich set of fix effects (including country, year-month, weekday, and day of the month).

Our results show that fiscal announcements lead households to revise upwards their inflation perceptions and downwards their perception about the unemployment rate. The effects on the latter persist into the short-run expectations about the unemployment rate. In contrast, we find no significant effects on inflation expectations in the short or the long run, providing evidence that households perceive the increase in inflation as temporary. Robustness tests confirm these findings.

Our findings suggest a significant signaling channel of fiscal policy. Fiscal announcements provide households with relevant information to update their beliefs about economic conditions. We show that a NK model with involuntary unemployment and information frictions captures this mechanism. In the model, private agents (households, firms and the labor union) have imperfect information, while the government observes the true state of the economy and sets fiscal policy to stabilize inflation and output. Private agents, observing fiscal actions imperfectly, learn about the state of the economy and infer the underlying economic conditions. The model matches well the empirically estimated moments and allows to isolate the informational content of fiscal policy. Counterfactual exercises show that this signaling channel explains most of the observed response in household expectations. Beliefs revisions also align more closely with demand-driven dynamics, leading to less persistent inflation perceptions but more persistent shifts in unemployment expectations.

Related Literature. Recent empirical and theoretical studies how fiscal announcements shape beliefs. Melosi et al. (2025) develop a stylized model of fiscal signaling and test it using daily stock prices and exogenous fiscal shocks in Japan. Bachmann et al. (2021) and D'Acunto et al. (2022) both consider the announcement of a VAT tax-cut to study its impact on households' expectations.[4] More closely related to our work, Fiore et al. (2024) use an event-study strategy to estimate causal effects of fiscal announcements exploiting survey participation in the Survey of Consumer Expectations in the US. Compared with the existing literature our study offers two main advances. First, our empirical design exploits quasi-experimental variation from multiple announcements across countries and quasi-random survey participation, allowing the use of a staggered RD design that has high statistical power and allows for rich fixed effects. Furthermore, the time lag between announcement and implementation of the fiscal measures we

[4]To identify causal effects, Bachmann et al. (2021) use a differences-in-differences strategy with other countries forming the control group, and D'Acunto et al. (2022) define control and treatment groups based on households' beliefs about the pass-through of the VAT-cut

study, together with the RD strategy, allows us to directly estimate the empirical causal effects of the announcement (both the information and direct effects) clean from any implementation effects. Second, we develop a general equilibrium New Keynesian model with information frictions and an inflation-stabilizing role for fiscal policy. The model allows us to further decompose our empirical moments into a direct fiscal effect and an information effect.

A much larger body of work studies the macroeconomic effects of fiscal policy, as opposed to the effect of announcements on beliefs. Early contributions use structural VARs with recursive identification schemes (Blanchard and Perotti, 2002; Mountford and Uhlig, 2009), while other papers exploit narrative measures of military spending (Rotemberg and Woodford, 1997; Ramey and Shapiro, 1998; Ramey, 2011) or examine tax and transfer changes (Mertens and Ravn, 2011; Oh and Reis, 2012; Parraga Rodriguez, 2018). We relate to this literature by adding new complementary estimates of the impact of fiscal policy announcements. Our estimates complement those in the existing literature on fiscal announcements because of the breath of the outcomes considered (perceptions and expectations on inflation, economic activity and the labor market) as well as for the relevance of the setting considered: the stark increase in inflation experienced from 2022 followed by a number of salient fiscal measures implemented across different European countries.

Finally, a recent literature focused on monetary policy shows that central bank announcements affect expectations through a signaling channel: households and markets update their beliefs about the state of the economy when monetary authorities reveal private information (e.g Campbell et al., 2012; Nakamura and Steinsson, 2018a; Jarociński and Karadi, 2020). In contrast, fiscal policy announcements are widely discussed by the public but their impact on expectations is far less studied. Survey evidence indicates that clear fiscal communication can magnify output responses (Ricco et al., 2016), and the effectiveness of fiscal policy depends on the salience and comprehensibility of announcements (Ramey, 2021). Our paper speaks to this strand of the literature by explicitly modeling the signaling channel in a general equilibrium NK model, as opposed to most of the literature that uses reduced-form approaches. In doing so, we bring the study of fiscal policy announcements somewhat closer to the literature on monetary policy announcements.

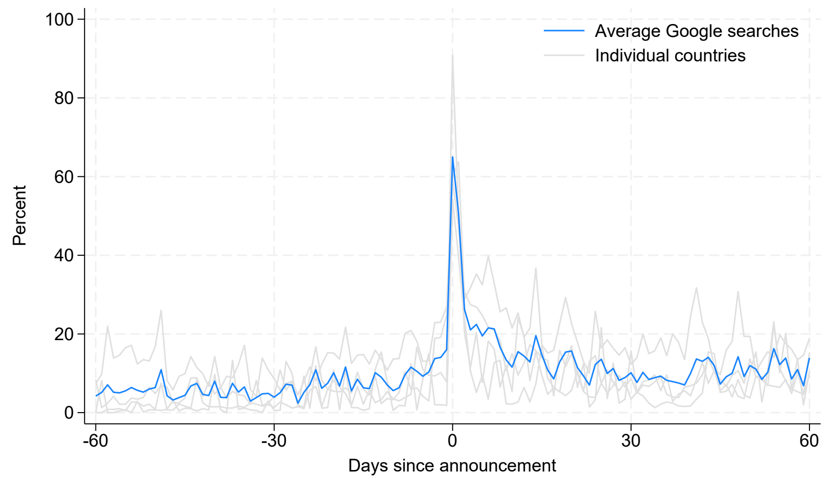
2 Data

2.1 Discretionary Fiscal Policy Announcements

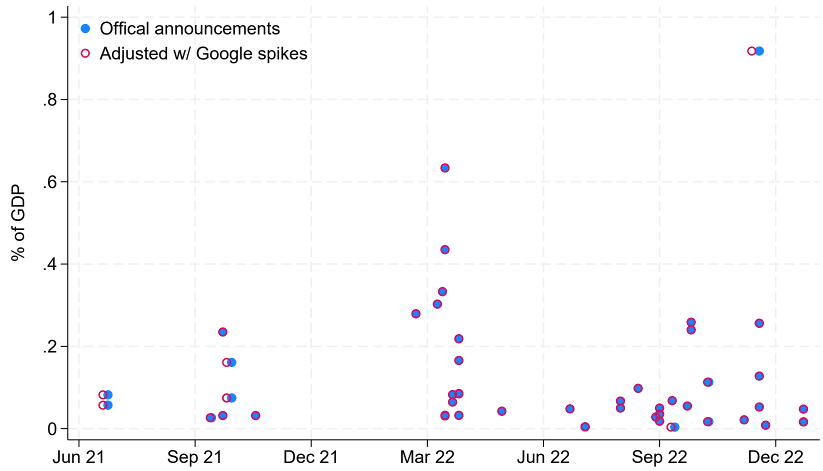
The narrative analysis builds on a dataset of discretionary fiscal measures compiled by public finance experts of the European System of Central Banks (ESCB). The 'ESCB dataset' compiles the most relevant discretionary changes of fiscal policy with significant budgetary impact. We complement the available information with the narrative record. Among others, we consulted country-specific legislation and government reports, official government websites, the Bruegel fiscal tracker of national fiscal policy responses to the energy crisis and news from sources such as the Financial Times and other national newspapers.

The euro area members covered in this paper include Germany (DE), Spain (ES), France (FR) and Italy (IT). The ESCB dataset is not publicly available though and we cannot disclose data by country. We restrict our attention to fiscal announcements related to price measures during the cost-of-living crisis between the second half of 2021 and throughout 2022. In total we identify 50 distinct price-related expansionary fiscal measures, although occasionally they can be collectively presented as a set of measures. We cover three fiscal instruments: indirect taxes, subsidies to firms and households, and direct price discounts.

To ensure that we are capturing the precise day when households update their information set, we complement the announcement date from our narrative record with an analysis of Google searches about key words closely related to the official announcements. Panel (a) of Figure 1 shows that there is a clear spike in Google searches around the time of the official announcements. The chart also illustrates that these policies did not go unnoticed, as they triggered a sharp increase in Google searches with no significant anticipation in the preceding days. Note that potential anticipation would have an attenuation effect on the size of the information shock from the official announcements. Panel (b) of Figure 1 reports the budgetary impact of the fiscal measures as a % of GDP at prices of 2022 with both timings, according to the narrative record and that implied by spikes in traffic of Google searches. In most cases, the dating with the narrative record coincides with a spike in Google searches for keywords related to the measures implemented. In the cases when the spike in Google traffic precedes the narrative dating (about 20% of the measures), the deviation is on average three days earlier. For these cases we advance the dating to the one indicated by the Google searches spike. Moreover, despite a bunching of announcements following the Russian invasion of Ukraine on February 2022, notice that some measures were



(a) Google Searches Around the Official Dating of the Fiscal Announcement



(b) Fiscal Announcements' Official and Google Dating

Figure 1: Dating of Fiscal Announcements

Notes: Panel (a) shows the average Google searches, defined as the arithmetic mean of the share of daily Google searches of key words related to each fiscal announcements in France, Germany, Italy and Spain relative to the narrative record. Panel (b) shows the budgetary size of fiscal announcements and their dating according to the narrative record and to Google searches.

already announced in the second half of 2021, while further announcements continued to be made throughout the second half of 2022.[5]

[5]The fiscal measures are quantified as percentage of GDP and calculated as the average present value of the annual charges to government budgets. We use the average 10-year government debt yield for the period when the measures are in effect for the calculations (see https://www.ecb.europa.eu/pub/projections). For example, if a measure implies payments of x_t in $t = 2022, 2023, 2024$, and $\bar{i}$ refers to the average 10-year bond yield for 2022-2024, the quantification would be $\left[x_{2022} + x_{2023}(1+\bar{i})^{-1} + x_{2024}(1+\bar{i})^{-2}\right]/3$.

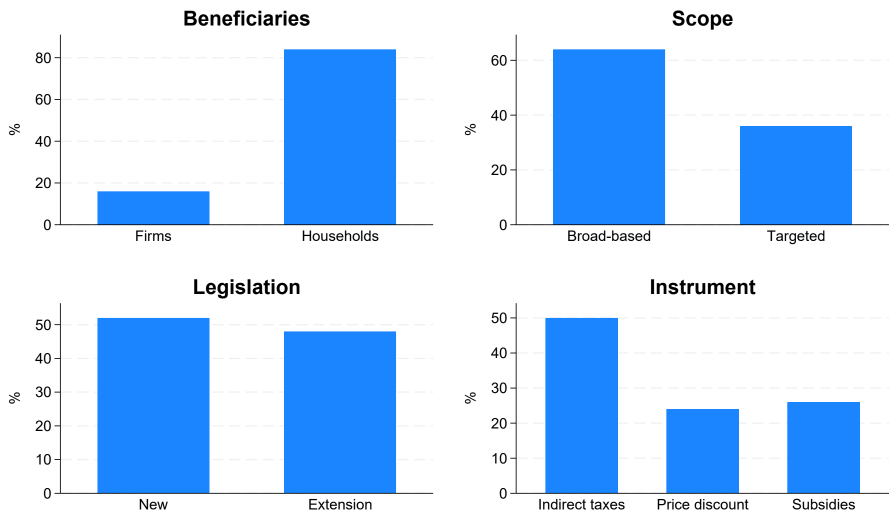


Figure 2: Characteristics of Price Measures in Response to the Cost-of-Living Crisis

Notes: Fiscal announcements of price-related measures in response to the cost-of-living crisis in France, Germany, Italy and Spain between April 2021 and December 2022.

Figure 2 provides further insights of the dataset breaking down the fiscal announcements by some relevant characteristics. Four observations stand out. First, most measures are directed at households. Second, about 40% of the measures are targeted, which supports the view that governments had to adjust their fiscal impulse following the deterioration of public finances during the pandemic, as well as a design of fiscal measures that preserved the incentives to energy savings (OECD, 2022). Third, it is noticeable the number of extensions of temporary fiscal measures. And fourth, half of the price measures were instrumented with indirect taxes, while the other half were equally split between direct price discounts and subsidies to households and firms.

As an illustration, Appendix D provides details of the price-related fiscal measures adopted in Spain. We also provide a description of the Google trends related to the Spanish fiscal measures, as well as a full list of sources.

2.2 The Consumer Expectations Survey of the European Central Bank

Household expectations come from the Consumer Expectations Survey (CES), an online mixed frequency panel survey administered by the ECB since April 2020. The CES collects information on the perceptions and expectations of over 10,000 households about the economy, inflation, as well as household economic and financial behavior including household consumption, investment, borrowing decisions and labor market transitions. The survey is composed of three modules. A

"Background" questionnaire captures a range of relatively time-insensitive information, including household composition, educational attainment, housing tenure, and total net income. Two other regular modules, the "Monthly" and "Quarterly" questionnaires, collect time-varying information, including quantitative and qualitative estimates, probabilistic data and measures of uncertainty.

Experience with the CES to date has demonstrated a strong panel component (Georgarakos and Kenny, 2022). Between April 2020 and December 2022, 81.2% of respondents had completed more than 12 survey rounds and 28.0% more than 24 rounds. France, Germany, Italy and Spain contribute 20-22% of the observations each, while the Netherlands and Belgium have a smaller representation providing about 8% of the observations, respectively.

The sample includes households from France, Germany, Italy and Spain from 2021m4 to 2023m1. Thus, including the biggest four economies of the euro area and a time period covering the cost-of-living crisis but after the worst of the COVID-19 pandemic. We focus on 7 outcome variables: Perceived inflation now compared with 12 months ago ($infpast$ in the figures and tables); Perceived unemployment rate now compared with 12 months ago ($unempast$); Expected inflation 12 months from now ($inf1y$); Expected inflation 3 years from now ($inf3y$); Expected economic growth during the next 12 months ($gowth1y$); Expected unemployment rate 12 months from now ($unemp1y$); Expected percent change in household spending during the next 12 months ($spend1y$). We follow the common practice of Winsorizing quantitative measures of household expectations to clean out outliers. In the baseline specification, the trimming threshold is set to 5%; however, we checked the robustness of our results to varying this threshold.

3 The Impact of Fiscal Announcements on Expectations

3.1 Empirical Strategy

We use a Regression Discontinuity (RD) design to identify the causal effects of fiscal announcements on household expectations. This empirical strategy compares households who filled in their survey just before and after a fiscal announcement. Any discontinuous change in household expectations that occurs right at the time of the announcement is interpreted as its causal effect, given that any other factors that could influence household expectations evolve smoothly around the time of the announcement.

To exploit all available information and improve the statistical precision of our estimates, we implement our RD analysis for all fiscal announcements jointly, in a staggered manner. Specifically, we normalize the date of each fiscal announcement to zero, and then define a "running variable" that reflects, for each household in the sample, the days between the announcement and the moment they answered the survey. Therefore, we obtain a running variable that takes negative values for survey responses that preceded the announcement (which constitutes the control group) and positive values for survey responses that followed the announcement, with zero reflecting the day of the announcement.

In our baseline specification we consider a bandwidth of 56 days, which means that we restrict the sample to those surveys filled within 56 days of a given announcement. Note that identification comes from the discontinuity in outcomes just around each of the announcements (the normalized cut-off) but we use a larger bandwidth to increase precision, as it is normally done in this type of empirical strategy. We also use triangular weights to assign more weight to observations close to the cut-off. We provide evidence of the robustness of our results to varying the bandwidth and to not using triangular weights.

It is worth noting two features inherent to RD designs, given the panel structure of the data. First, the same household may appear in the sample multiple times. The recurrence derives from individuals filling in the survey on a monthly basis and our baseline bandwidth of 56 days on each side of the cutoff. Then, some survey responses might occur before the announcement and some after. Second, because we stagger together many fiscal announcements, a given survey response might occur right after a given fiscal announcement while also right before a different announcement if two announcements in a country occur close to one another. We incorporate these features in the analysis by expanding our sample of analysis as many times as policy announcements occur (within country), effectively multiplying the number of individuals. More precisely, each unique household h appears as many times in the sample as fiscal announcements a are relevant to them. Therefore, we define each "expanded household" i as the product of h and a within each country. We cluster our standard errors at the h level.

Our estimating equation is then based on the following standard RD specification:

$$\begin{aligned} y_{it} = \beta \cdot [date_{it} \geq c_a] + \gamma \cdot (date_{it} - c_a) + \delta \cdot (date_{it} - c_a) \cdot [date_{it} \geq c_a] + \\ \alpha_c + \alpha_{wv} + \alpha_c \cdot \alpha_{wv} + \alpha_m + \alpha_w + \Gamma \cdot X_{it} + \epsilon_{it} \end{aligned} \tag{1}$$

where $date_{i,t}$ refers to calendar time for expanded household i, c_a refers to the date of announcement of each fiscal announcement a, $date_{it} - c_a$ corresponds to the running variable, and $\alpha_c, \alpha_{wv}, \alpha_m$

and α_w represent, respectively, fixed effects for country, wave (that is year-month), day of the month, and day of the week. X_{it} is a matrix of controls that, in our baseline specification include age, gender, household income, and education.

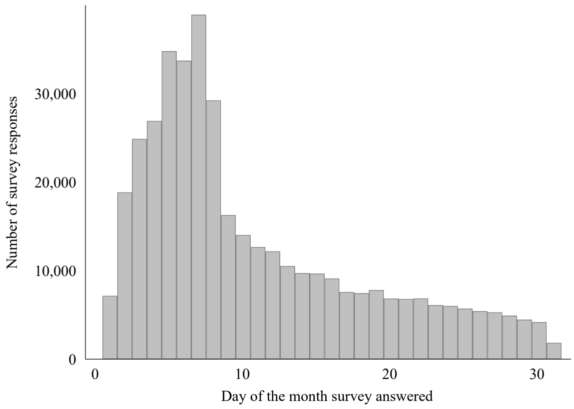
3.2 Threats to Identification and Validation Tests

The main identifying assumption in our RD design is that factors that influence the outcome variables (household expectations) evolve smoothly around the cutoff (the time of the fiscal announcements). Under this assumption, any discontinuous change in household expectations observed at the date of the announcements can be interpreted as the causal effect of fiscal announcements.

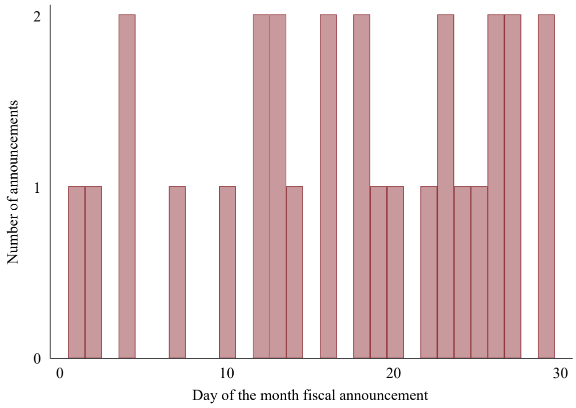
Two threats usually challenge RD designs. The first threat is manipulation, by which agents sort themselves around the cutoff date. In our case, this would occur if households change the date they answer the survey so as to answer after the fiscal announcements. This seems unlikely. Households do not have any incentive to delay their survey answers after fiscal announcements, as the potential benefits of such announcements do not depend in any way on the date of participation in the survey.

Manipulation is often evaluated by the smoothness of the running variable, which in our setting depends on the distribution of the survey responses and the fiscal announcements across time, as shown in Figure 3. Panel (a) plots the daily histogram of survey responses within each month. We see that the distribution is not uniform, as surveys responses are more concentrated in the beginning of each month, although they span over the entire month, ensuring good coverage.[6] Fiscal announcements, on the contrary, seem more spread out through each month (as shown in panel (b)). As a result of these two distributions, the histogram of the running variable is shown in panel (c). The graph shows the number of survey responses recorded each day around the cutoff date, which corresponds to each of the fiscal announcements normalized as day cero. We do not observe a discontinuity in survey responses around the cut-off that could suggest manipulation. We estimate local polynomials on each side of the cutoff and do not find a significant difference. We do observe that the number of responses exactly one day before the cutoff seems particularly low, a pattern we attribute to the seasonality of the data. Nevertheless, we show that our results are robust to excluding survey responses that occur between one day before and one day after

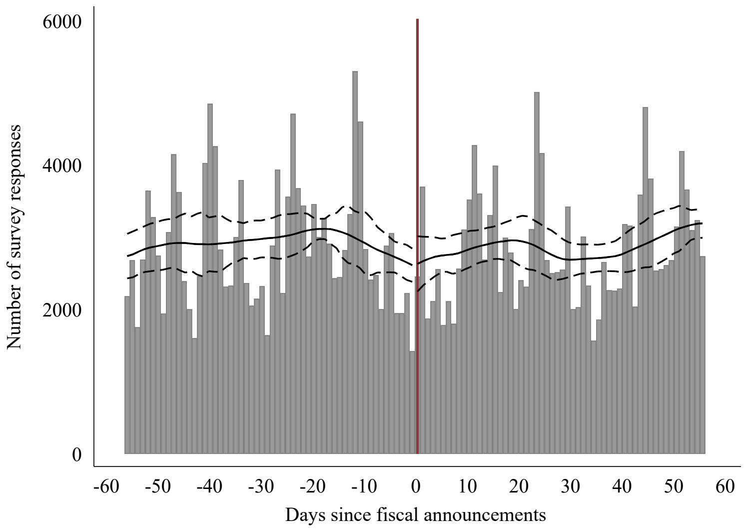
[6]The seasonality observed in the date of survey responses motivates the inclusion of various fixed effects to account for any potential calendar effect in our baseline specification introduced in equation 1



(a) Within-month distribution of survey responses



(b) Within-month distribution of fiscal announcements



(c) Histogram of the running variable

Figure 3: Histogram of the Running Variable and its Underlying Determinants

Notes: The figure shows the distribution over time of survey responses and of fiscal announcements. Panel (a) shows the daily distribution of survey responses within each month. Panel (b) shows the daily distribution of fiscal announcements within each month. Panel (c) combines the two previous distributions normalizing all announcement dates to zero, and defining survey response dates as the number of days relative to each announcement, that is, the running variable. The red line reflects the normalized date of the announcement (the cutoff used for the regression discontinuity analysis). Superimposed on top of the histogram are smoothed values and 95% confidence intervals from local polynomial regressions.

the fiscal announcements. We also show in Appendix Figure A.1 that we do not observe any discontinuity in any control variable (age, gender, education and income).

The second threat is the presence of confounding factors, such as other information shocks that coincide in time with fiscal announcements. While we are not aware of other confounding policies or announcements by the government, a potential concern in our setting is that fiscal announcements might occur in response to the releases of CPI or news about energy prices. We explore this possibility in Appendix Figure A.2. We find no evidence of any discontinuous change in the probability that CPI releases (or "flash" CPI releases) at the time of fiscal announcement.[7] Our results are also robust to controlling for international Brent and European gas prices, as we show in subsection 3.4 together with other robustness exercises.

3.3 Empirical Results

We begin by analyzing the effects of fiscal announcements on perceived inflation and unemployment. Figure 4 shows the results of our main RD specification. On the left-hand side, we plot the perceived inflation and unemployment by households before and after the announcements, together with the RD estimation for a symmetric bandwidth of 56 days. The outcomes are averaged in one-week bins, which are of similar sample size, as indicated by the size of the circles. On the right-hand side, we show the point estimate for different bandwidths. Households clearly increase their inflation perception, approximately 0.2 percentage points. Similarly, we find a negative effect on household perceived unemployment rate, with a downward revision of comparable magnitude and precision.

Next, Figure 5 shows the results for inflation expectations. The effects on both short run (one year ahead) and medium/long run (three years ahead) expectations are not statistically significant and the point estimates are very close to zero. Therefore, the increase in inflation perceptions does not lead to a similar increase in inflation expectations, providing evidence of households perceiving the increase in inflation as temporary.

Similarly, Figure 6 presents the results of the RD estimation on other expected outcomes. We do not find any significant effects on spending or growth expectations. However, we find a significant negative effect on the expected unemployment rate, which could reflect varying persistence of shocks depending on the outcome variable, and the unemployment rate exhibiting higher persistence than inflation or economic growth.

[7] Flash CPI releases refer to preliminary estimates released some days earlier.

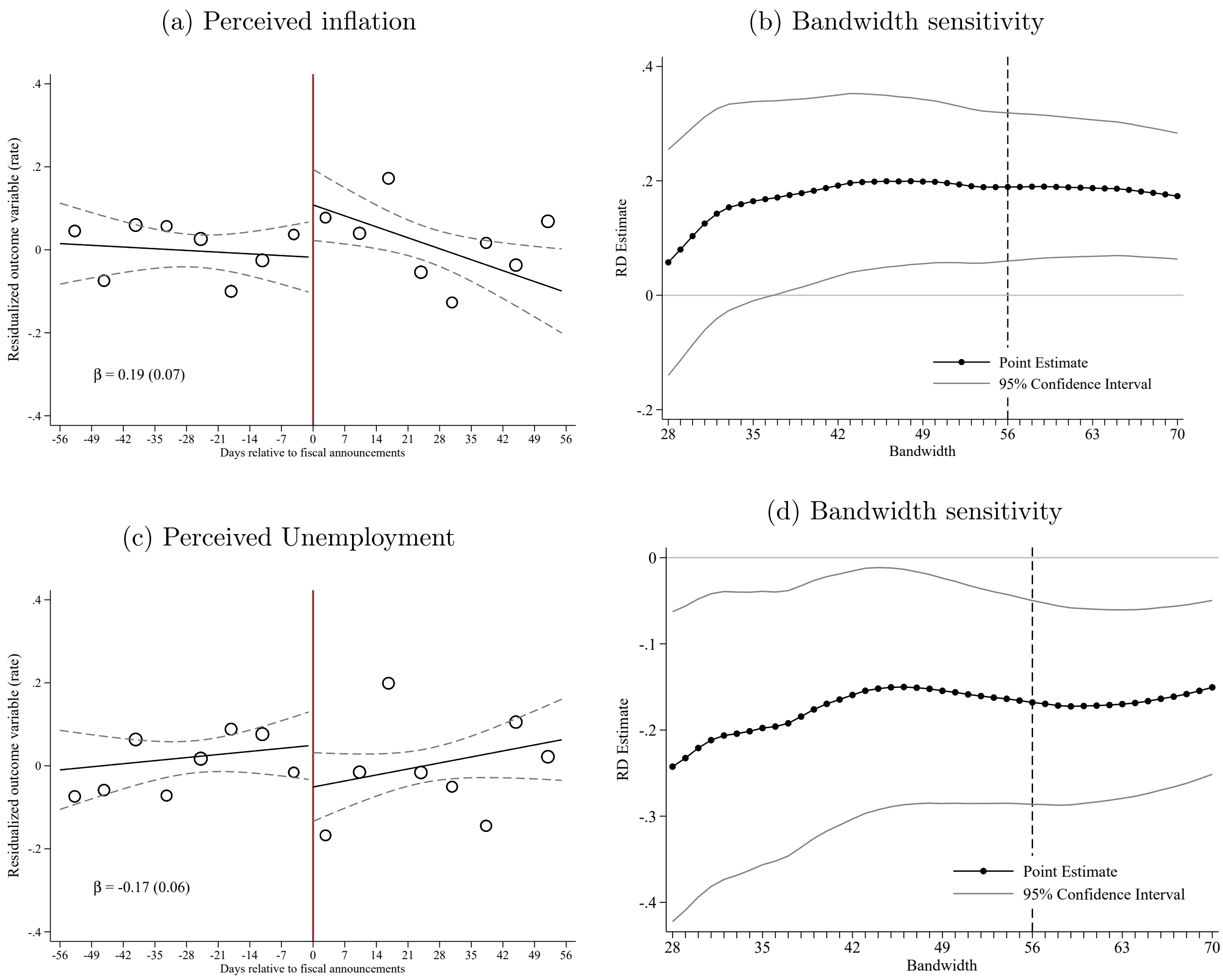


Figure 4: The Effects of Fiscal Announcements on Household Perceived Economic Conditions. RD Graphs and Bandwidth Sensitivity.

Notes: The left-hand side graphs show the RD estimation for a bandwidth of 56 days around the cutoff (red vertical line corresponding to the dates of fiscal announcements normalized to zero). Each outcome of interest is averaged in one-week bins, with circle sizes reflecting the number of observations in each bin. The overlapping regression lines are based on the underlying unbinned data. Right-hand side graphs show the sensitivity of the RD results to the choice of bandwidth, with the dashed vertical line indicating the 56-days bandwidth.

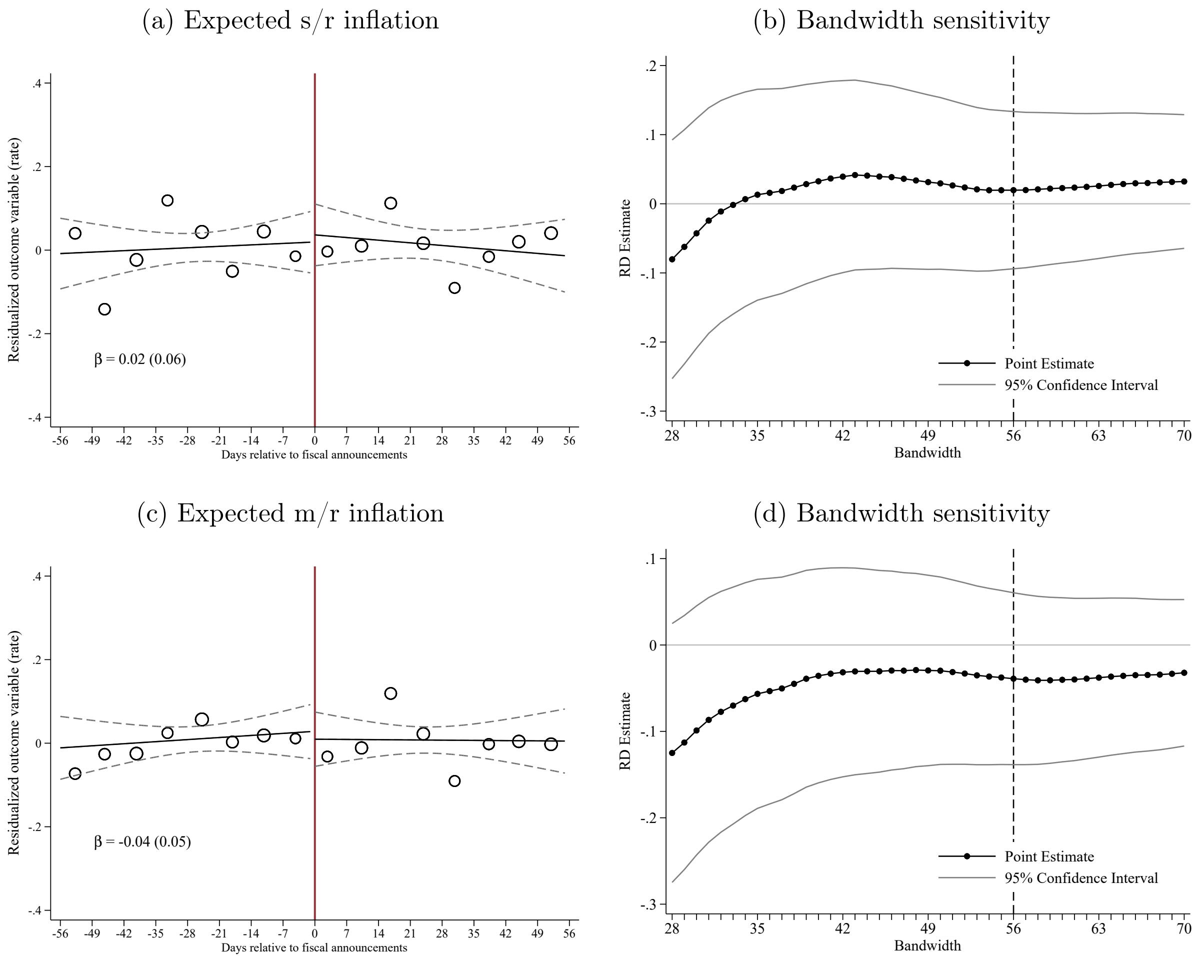


Figure 5: The Effects of Fiscal Announcements on Household Inflation Expectations. RD Graphs and Bandwidth Sensitivity.

Notes: The left-hand side graphs show the RD estimation for a bandwidth of 56 days around the cutoff (red vertical line corresponding to the dates of fiscal announcements normalized to zero). Each outcome of interest is averaged in one-week bins, with circle sizes reflecting the number of observations in each bin. The overlapping regression lines are based on the underlying unbinned data. Right-hand side graphs show the sensitivity of the RD results to the choice of bandwidth, with the dashed vertical line indicating the 56-days bandwidth.

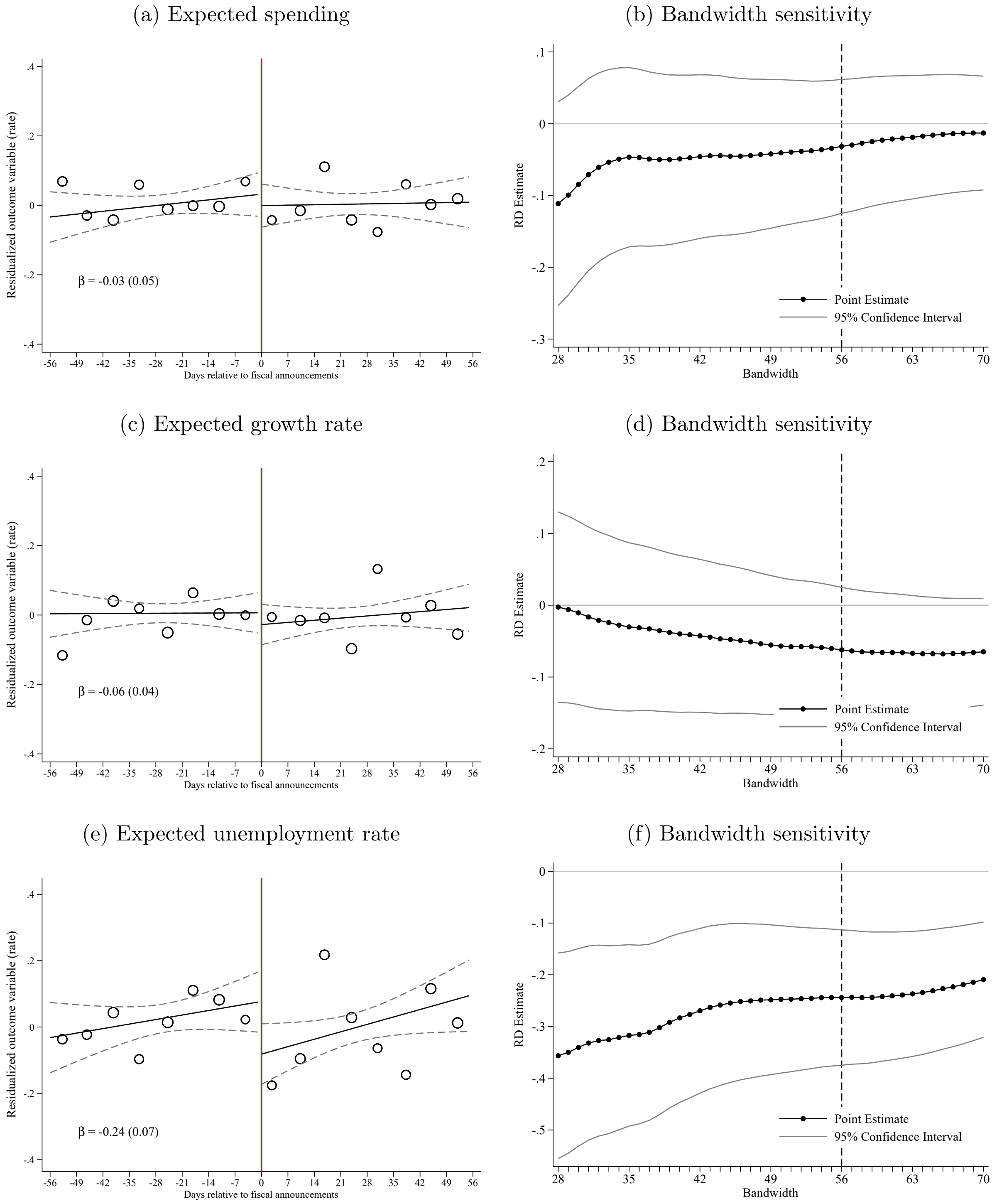


Figure 6: The Effects of Fiscal Announcements on Other Household Expectations. RD Graphs and Bandwidth Sensitivity.

Notes: The left-hand side graphs show the RD estimation for a bandwidth of 56 days around the cutoff (red vertical line corresponding to the dates of fiscal announcements normalized to zero). Each outcome of interest is averaged in one-week bins, with circle sizes reflecting the number of observations in each bin. The overlapping regression lines are based on the underlying unbinned data. Right-hand side graphs show the sensitivity of the RD results to the choice of bandwidth, with the dashed vertical line indicating the 56-days bandwidth.

Table 1: Effects of Fiscal Announcements on Household Expectations

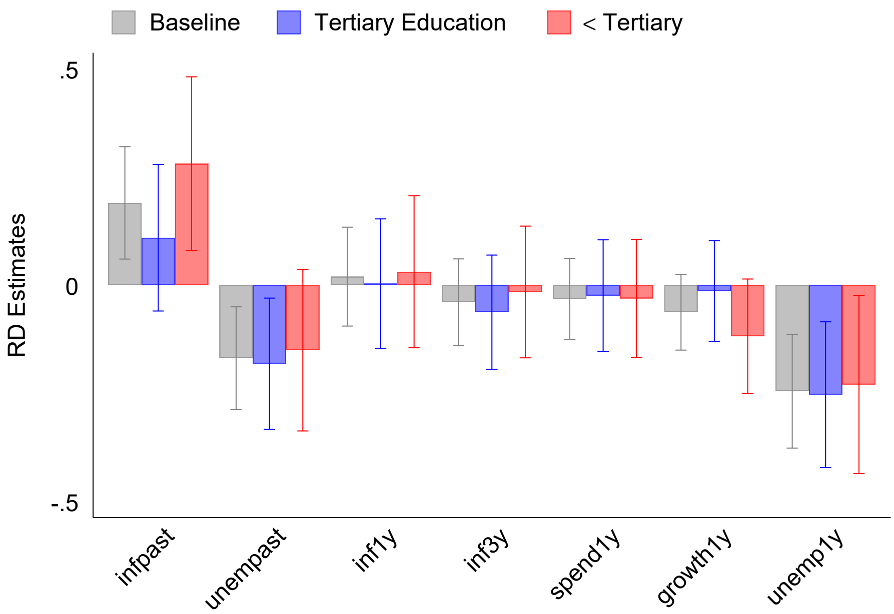
	(1) **infpast**	(2) **unempast**	(3) **inf1y**	(4) **inf3y**	(5) **spend1y**	(6) **growth1y**	(7) **unemp1y**
RD estimate	0.189***	-0.168***	0.020	-0.039	-0.031	-0.062	-0.244***
	(0.066)	(0.060)	(0.058)	(0.051)	(0.048)	(0.044)	(0.067)
Mean	8.40	12.36	6.23	4.26	3.09	-1.14	12.94

Notes: Each point estimate corresponds to the β coefficient in equation 1 and reflects the causal effect of a fiscal announcement on a given outcome variables. Baseline regressions use triangular weights and a bandwidth of 56 days. Winsorized outcomes at 5% . $N = 320,219$. Standard errors clustered by household. *($p < 0.1$), **($p < 0.05$), ***($p < 0.01$).

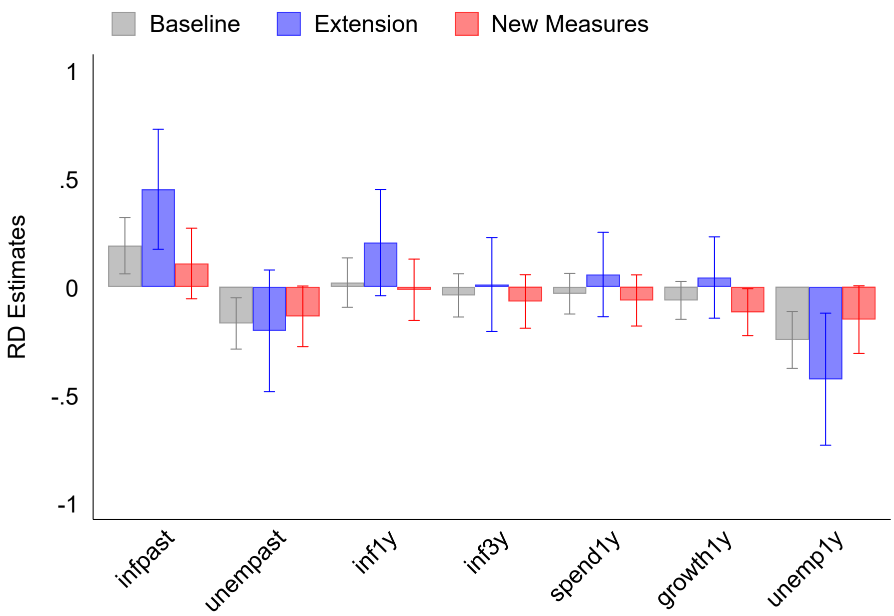
The precise estimates of the RD estimation for the preferred bandwidth are presented in Table 1. As can be seen, mean perceived inflation for households during the sample was above 8%, clearly above expected inflation. By contrast, in the case of unemployment, the perceived unemployment rate remains very close to the expected unemployment rate. This is further evidence that shocks to current inflation were not fully passed-through to expected inflation.

Finally, to better understand the signaling channel of fiscal announcements, we explore their heterogeneous effects across household characteristics and announcement types. Socioeconomic factors such as educational attainment or energy expenditure might affect the information households extract from fiscal announcements. Likewise, whether announcements are for new measures or extensions of previously implemented ones could shape how households interpret signals about the economic situation and the government's commitment to stability measures.

Figure 7 shows the RD estimates for the different outcome variables distinguishing by household education attainment and announcement type. For convenience, the figure also illustrates the baseline estimates presented in Table 1. The stronger and significant RD estimate for perceived inflation for households with less than tertiary education suggests that these households may extract more signals from fiscal announcements. However, the differences with more educated households are not statistically significant, and these households also exhibit a higher mean of perceived inflation (see Table A.2 in the Appendix). Regarding announcement type, extensions seem to reinforce the signaling channel, confirming a high-inflation state of the world (stronger effects on perceived and 1-year ahead expected inflation) and signaling the government's commitment to stabilization (as shown by stronger revisions in 1-year ahead unemployment rate forecasts). Yet, these differences are again not statistically significant.



(a) Education



(b) Extension of Fiscal Measures

Figure 7: Heterogeneous Effects of Fiscal Announcements: Education Attainment and Extension of Fiscal Measures

Notes: Bars represent the RD Estimates, and whiskers the 95 percent confidence level intervals. Standard errors clustered by household. Regressions use triangular weights and a bandwidth of 56 days. Observations are 176,683 for households with tertiary education, 143,536 less than tertiary education, 117,880 for extensions and 202,339 for announcements of new measures.

For brevity, the main text focuses on the most relevant heterogeneous effects for understanding the signaling channel of fiscal announcement, but Figure A.3 in the Appendix provides additional results by age, gender and the intensity of energy-related expenditures. Notably, women revise their inflation perceptions less following fiscal announcements. In the context of high inflation, this finding, combined with women's higher average perceived inflation (see Table A.2 again), aligns with previous literature suggesting that women infer better inflation dynamics from their own shopping experiences, as they more often handle household grocery shopping (D'Acunto et al., 2021).

3.4 Robustness

We carry out a number of robustness tests to ensure that our results are not driven by specific choices regarding the definition of our sample of analysis or our choice of specification. Table 2 confirms our results are robust to different tests. Row A shows the baseline estimates for ease of comparison. In row B, we exclude our main control variables (income, gender, age and education) from the specification. In row C, we add further controls related to other potentially relevant economic information: an indicator whether a country's CPI was released on the day the survey was answered or in the two days prior (and the same for the flash estimate of CPI), as well as daily series of oil and gas prices. In row D, we drop the triangular weights. In row E, we drop the observations that answered the survey on the same day of the announcement, and, in row F, we further drop those who responded the day just before or just after. In row G, we do not winsorize the data, while in rows H and I we, respectively, decrease and increase the winsorization threshold with respect to our baseline of 5%.

Furthermore, we replicate our analysis but assigning a placebo date of announcement for each of the measures to 56 days before or 56 days after the true announcement date, so the true announcement date is excluded from the placebo analysis. The results, reported in Appendix Table A.1, show no significant effects among any of the outcome variables considered.

4 The Theoretical Model

In this section, we introduce a theoretical model to rationalize our empirical findings. The previous empirical analysis implies a significant signaling channel of fiscal policy, as fiscal announcements provide households with useful information to update their beliefs about the state of the economy

Table 2: Robustness to Alternative Specifications and Sample Definitions

	(1) **infpast**	(2) **unempast**	(3) **inf1y**	(4) **inf3y**	(5) **spend1y**	(6) **growth1y**	(7) **unemp1y**
A. Baseline	0.189***	-0.168***	0.020	-0.039	-0.031	-0.062	-0.244***
	(0.066)	(0.060)	(0.058)	(0.051)	(0.048)	(0.044)	(0.067)
B. No controls	0.195***	-0.160***	0.025	-0.035	-0.030	-0.069	-0.236***
	(0.066)	(0.061)	(0.059)	(0.051)	(0.048)	(0.045)	(0.068)
C. Further controls	0.165**	-0.175***	0.038	-0.039	-0.038	-0.065	-0.254***
	(0.066)	(0.060)	(0.058)	(0.050)	(0.047)	(0.044)	(0.066)
D. No Tri. Weights	0.189***	-0.189***	0.005	-0.067	-0.013	-0.104***	-0.225***
	(0.054)	(0.050)	(0.047)	(0.042)	(0.039)	(0.036)	(0.055)
E. Donut 0	0.187***	-0.155**	0.025	-0.025	-0.026	-0.084*	-0.242***
	(0.067)	(0.062)	(0.059)	(0.052)	(0.049)	(0.045)	(0.068)
F. Donut 1	0.215***	-0.114*	0.062	-0.012	-0.022	-0.080*	-0.200***
	(0.069)	(0.063)	(0.061)	(0.053)	(0.050)	(0.047)	(0.070)
G. No Winsorizing	0.241**	-0.174**	0.125	-0.030	-0.026	-0.008	-0.282***
	(0.102)	(0.086)	(0.097)	(0.092)	(0.080)	(0.086)	(0.091)
H. Winsorizing 1%	0.223**	-0.163**	0.075	-0.049	-0.035	-0.035	-0.270***
	(0.089)	(0.081)	(0.081)	(0.076)	(0.064)	(0.066)	(0.086)
I. Winsorizing 10%	0.151***	-0.144***	0.005	-0.009	-0.019	-0.054	-0.201***
	(0.052)	(0.045)	(0.047)	(0.040)	(0.031)	(0.035)	(0.051)

Notes: Baseline regressions use triangular weights and a bandwidth of 56 days. Winsorized outcomes at 5% except in rows G, H and I. $N = 320,219$. Standard errors clustered by household. *($p < 0.1$), **($p < 0.05$), ***($p < 0.01$).

and the government's commitment to foster economic stabilization. While households perceived the inflation increase as temporary—with fiscal expansions affecting their perception of current inflation but not their inflation forecasts—they persistently revised downwards their unemployment rate expectations. Thus, our empirical findings also point to a demand-sided interpretation of fiscal announcements.

Since the interest lies on understanding better the effects of fiscal announcements on unemployment and inflation, we build a New Keynesian (NK) model enlarged with involuntary unemployment. In order to provide room for information effects stemming from fiscal announcements, we extend the model to include information frictions. Specifically, we assume that private agents (that is, households, labor unions, and firms) have imperfect and asymmetric information about the state of nature in the economy, while the government has perfect information. We assume that private agents are aware of this information asymmetry in favor of the government and can learn about the state of nature when the government sets its policy following a systematic rule based on fundamentals. Three features of the model are essential to rationalize the empirical responses to fiscal announcements: (i) an inflation-stabilizing fiscal rule, (ii) the presence of information frictions, and (iii) heterogeneity in agents' uncertainty regarding the nature of shocks.

In particular, households appear better informed about demand-side forces, and fiscal policy actions are interpreted through this lens. As a result, beliefs revisions align more closely with demand-driven dynamics, leading to less persistent inflation perceptions but more persistent shifts in unemployment expectations.

The purpose of introducing the theoretical framework is twofold. First, we can estimate the degree of information frictions necessary to generate a signaling effect of fiscal policy that is consistent with our previous empirical evidence. Second, we use our estimated model to disentangle the information content of fiscal announcements from their pure macroeconomic effect. A VAT cut (the shock) has two effects: a pure macroeconomic effect and an information effect. Empirically, we cannot separately identify these effects. In the model, once fiscal announcements are stripped of the information effect, the macroeconomic component alone induces pessimism about the future economic outlook—households expect inflation to fall and unemployment to rise, consistent with a negative demand shock. Intuitively, a VAT cut is equivalent to a reduction in government spending in our theoretical model, as we assume the government runs a balanced budget and finances public spending through an indirect tax on consumption. Thus, the macroeconomic effect resembles a standard negative demand shock. The estimated signaling channel of fiscal announcements reverses the dampening impact of the VAT shock on the economic outlook, making it consistent with the empirical findings.

At this point, a short comment about notation is worth making. In the empirical analysis, we referred to household reports of current economic variables such as inflation and unemployment as perceptions. In the model, these perceptions are formalized as backcasts, reflecting households' estimates of current conditions based on noisy information.

4.1 Model Derivation

The NK dimension of the model is identical to that of Galí (2015, Ch. 7), extended with private and noisy information about the state of nature along the lines of Angeletos and Huo (2021).

The private sector consists of three types of agents: households, firms, and labor unions. Each of them faces information frictions on the state of nature. Households value consumption and leisure, and make their savings decisions based on their assessment of the future individual and aggregate economic conditions. Firms set prices facing nominal rigidities à la Calvo (1983) to maximize profits. Similarly, the labor union sets staggered wages à la Erceg et al. (2000) to maximize households' utility.

The public sector sets the fiscal and monetary policy. The government taxes consumption and uses the revenues on government spending, with the tax decision being subject to a systematic rule. The monetary authority sets the nominal interest rate based on a standard Taylor rule.

Uncertainty is introduced in the model with six different types of shocks, which private agents observe imperfectly. We break down demand shocks into a households' discount factor shock z_t in the DIS curve, a monetary policy shock v_t in the Taylor rule, and a VAT shock q_t to the VAT rule. Supply side shocks are represented through a TFP shock a_t to the production function, and two cost-push shocks, μ_t^p and μ_t^w, on the price and wage Phillips curves.

For simplicity, we present a concise version of the model, which, in its linearized form, consists of four equations capturing the dynamics and interrelations in the private sector. The full details of the model derivations can be found in the Appendix B.

Private Sector The first core equation is usually referred to as the individual-level DIS curve (2),

$$\widetilde{c}_{i,t} = -\frac{\beta}{\sigma}\mathbb{E}_{i,t}r_t + (1-\beta)\,\mathbb{E}_{i,t}\widetilde{c}_t + \beta\mathbb{E}_{i,t}\widetilde{c}_{i,t+1} + \beta\psi\mathbb{E}_{i,t}\Delta a_{t+1} - \frac{\beta}{\sigma}\mathbb{E}_{i,t}\Delta z_{t+1} + \frac{\beta(1-\sigma S_G)}{\sigma}\mathbb{E}_{i,t}\Delta\tau_{t+1} \tag{2}$$

where $\widetilde{c}_t = \int \widetilde{c}_{i,t}\,di$ denotes the aggregate consumption gap with respect to the flexible-prices equilibrium and i indexes households, $r_t = i_t - \pi_{t+1}^p$ denotes the ex-post real interest rate, i_t denotes the central bank policy rate, π_t^p denotes the price inflation rate, and τ_t denotes the consumption tax rate. For a general variable b_t, we write the growth rate as $\Delta b_t = b_t - b_{t-1}$. Furthermore, β denotes the households' discount factor, σ denotes the households' intertemporal elasticity of substitution, $S_G = G/Y$ denotes the government spending share of GDP in steady-state, and $\psi \equiv (1+\varphi)/[\sigma(1-\alpha)+\varphi+\alpha]$, where $1-\alpha$ denotes the labor share and φ denotes the inverse Frisch elasticity.[8]

[8]Conditions (2)-(4) are derived under a general information structure, in which we relax the assumption that the aggregate household/firm/union expectation operator satisfies the Law of Iterated Expectations and where agents do not observe aggregate variables. Each household/firm/union's decision (2)-(4) can be described as a beauty contest in which it needs to forecast current exogenous shocks, and current and future endogenous macroeconomic variables, which in turn depend on each other agents' actions.

Second, the so-called firm-level price Phillips curve is given by

$$\pi^p_{f,t} = \theta_p \lambda_p \mathbb{E}_{f,t}\mu^p_t + \theta_p \kappa_{pu} \mathbb{E}_{f,t}\widetilde{u}_t + \theta_p \kappa_{py} \mathbb{E}_{f,t}\widetilde{y}_t + (1 - \theta_p - \theta_p \lambda_p \sigma S_G \psi_\tau)\, \mathbb{E}_{f,t}\pi^p_t + \beta\theta_p \mathbb{E}_{f,t}\pi^p_{f,t+1} \tag{3}$$

where $\widetilde{u}_t$ denotes the unemployment gap with respect to the flexible-prices equilibrium, $\pi^p_t = \int \pi^p_{f,t}\, df$ and f indexes the firm, $\lambda_p = (1-\theta_p)(1-\beta\theta_p)(1-\alpha)/[\theta_p(1-\alpha+\alpha\epsilon)]$, $\kappa_{pu} = \lambda_p \varphi$, $\kappa_{py} = \lambda_p\left(\sigma + (\varphi+\alpha)/(1-\alpha)\right)$. Furthermore, θ_p denotes the Calvo (1983) inaction probability, and ϵ denotes the elasticity of substitution between good varieties.

Third, the individual-level wage Phillips curve is given by

$$\pi^w_{j,t} = \theta_w \lambda_w \mathbb{E}_{j,t}\mu^w_t - \theta_w \lambda_w \varphi \mathbb{E}_{j,t}\widetilde{u}_t + (1-\theta_w)\mathbb{E}_{j,t}\pi^w_t + \beta\theta_w \mathbb{E}_{j,t}\pi^w_{j,t+1} \tag{4}$$

where $\pi^w_t = \int_{\mathcal{I}_j} \pi^w_{j,t}\, dj$ denotes the wage inflation rate, and j indexes the labor union, and $\lambda_w = (1-\theta_w)(1-\beta\theta_w)/[\theta_w(1+\varphi\epsilon_w)]$, where θ_w denotes the Erceg et al. (2000) inaction probability and ϵ_w denotes the elasticity of substitution between labor varieties.

Fourth, unemployment dynamics can be described by the following aggregate equation

$$\widetilde{\omega}_t = \varphi\widetilde{u}_t + \left(\sigma + \frac{\varphi}{1-\alpha}\right)\widetilde{y}_t - \sigma S_G \psi_\tau \pi^p_t, \tag{5}$$

where ψ_τ is a parameter of the fiscal policy block, introduced below.

Government The public sector sets the fiscal and monetary policy. Regarding the former, the government collects consumption tax revenues and levies lump-sum taxes to fund government spending under a zero deficit restriction: $g_t = \tau_t + c_t$. We assume that consumption taxes follow a rule that depends on the inflation rate,

$$\tau_t = \psi_\tau \pi^p_t + q_t, \tag{6}$$

where $\psi_\tau < 0$ is an inflation stabilizer. We consider the policy rule (6) to be a good approximation of how fiscal policy has been conducted in the onset of the cost-of-living crisis, in the recent period.

Monetary policy is conducted following a Taylor rule of the form

$$i_t = \phi_\pi \pi_t + \phi_u \widetilde{u}_t + v_t. \tag{7}$$

Finally, all structural shocks are assumed to follow independent a AR(1) processes

$$b_t = \rho_b b_{t-1} + \sigma_b \varepsilon_t^b \tag{8}$$

for a general shock $b \in \{v, z, a, q, \mu^p, \mu^w\}$, with $\varepsilon_t^b \sim \mathcal{N}(0,1)\ \forall b$.

Information structure All private agents are subject to information frictions: they do not observe the fundamental shocks and are uncertain about the state of nature. Every period, each agent receives a dose of private information on the aggregate fundamental. Formally, there is a collection of private Gaussian signals on each fundamental, one per agent and per period. In particular, the period–t signal received by agent l in group g is given by

$$x_{lgt} = b_t + \sigma_{gb} u_{lgt}^b, \qquad u_{lgt}^b \sim \mathcal{N}(0,1) \tag{9}$$

where $g = \{\text{household}, \text{firm}, \text{union}\}$, $\sigma_{gb} \geq 0$ parametrizes the noise in group g related to fundamental b. Notice that, by allowing σ_{gb} to differ by g, we accommodate rich information heterogeneity. For example, firms could on average be more informed than households and labor unions.

The signaling channel Including price inflation in the fiscal rule (6) generates an informative content of government actions. For example, consider a VAT shock defined as $s_{t,\delta}^\tau \equiv \tau_t - \overline{\mathbb{E}}_{t-\delta}^c \tau_t$, where δ is an integer that determines the period in which the forecast is made, and $\overline{\mathbb{E}}_{t-\delta}^c(\cdot)$ is the average household's forecast at time $t-\delta$ on a given variable.

Inserting the fiscal rule (6), we can identify two components: a pure VAT change arising from the unexpected exogenous component, $q_t - \overline{\mathbb{E}}_{t-\delta}^c q_t$, and an information or signaling effect, arising from the inflation stabilization component and imperfect expectation formation, $\psi_\tau(\pi_t^p - \overline{\mathbb{E}}_{t-\delta}^c \pi_t^p)$.

Throughout this subsection, we assume that the econometrician has access to the sequence of fiscal announcements $s_{t,\delta}^\tau$, which are contaminated with the information effect. In section 4.2, where the model is estimated, we target the belief responses reported on Table 1 after a contaminated shock $s^{\tau}_{t,\delta}$. Finally, in section 4.3 we quantify the contribution of the signaling channel to the total effect.

Our definition of the signaling effect differs from the one in Melosi et al. (2025). In their reduced-form framework, fiscal actions affect the state of nature and they quantify the signaling channel as the change in agents' forecast after the fiscal action. In contrast, we disentangle this causal effect into a pure fiscal effect, and an information effect stemming from the systematic component of the fiscal rule. Our definition is closer to the literature exploring the information effect of monetary decisions (Nakamura and Steinsson, 2018b; Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2021).

Equilibrium dynamics The economy is described as a set of across–group dynamic beauty contests between consumers (the spending-income multiplier 2), firms (the strategic complementarity in price-setting 3), and labor unions (the strategic complementarity in wage-setting 4), jointly determining the inflation-spending NK multiplier. The following definition and proposition introduce the model equilibrium dynamics.

Definition 1. *The equilibrium model dynamics must satisfy the individual-level optimal policy functions* (2)*,* (3)*, and* (4)*, and rational expectation formation must be consistent with the aggregate unemployment dynamics* (5)*, the Taylor rule* (7)*, the exogenous shock processes* (8) *and the signal processes* (9)*.*

We show in Proposition 1 that the solution to the fixed points is the sum of seven VARX(1), where the exogenous component is each shock separately.

Proposition 1. *In equilibrium, the aggregate outcome obeys the following law of motion* $\boldsymbol{x}_t = \sum_{b\in\{v,z,a,q,\mu^p,\mu^w\}} \boldsymbol{x}_{bt}$*, where* $\boldsymbol{x}_{bt} = A_b(\vartheta_{1b},\vartheta_{2b},\vartheta_{3b},\vartheta_{4b})\boldsymbol{x}_{b,t-1} + B_b(\vartheta_{1b},\vartheta_{2b},\vartheta_{3b},\vartheta_{4b})b_t$*, and* $\boldsymbol{x}_t = \begin{bmatrix}\widetilde{y}_t & \pi^p_t & \pi^w_t & \widetilde{u}_t\end{bmatrix}^\intercal$ *is a vector containing the output gap, price inflation, wage inflation and the unemployment gap,* A_b *are* 4×4 *matrices and* B_b *are a* 4×1 *vectors, defined in appendix C.*

Proof. See Appendix C. □

4.2 Model Estimation

With the theoretical model at hand, we can now quantify the relevance of the informational effect of fiscal announcements. That is, the theoretical degree of information frictions that can explain the empirical moments reported in Table 1.

To achieve this quantification, we first derive in the proposition C.1 (relegated to Appendix C) the model-implied coefficients that match the empirical counterparts presented in Table 1. For the computation of the backcasts and forecasts, we use households beliefs, which are the closest mapping to the surveyees of the CES survey used in the empirical section. In particular, we capture *infpast* as the backcast of price inflation to an announced VAT change, $s^{\tau}_{t,0}$: $\beta^{\text{backcast}}_{\pi} = \mathbb{C}\left[\mathbb{E}^{c}_{t}\pi_{t-1}, s^{\tau}_{t,0}\right]/\mathbb{V}\left[s^{\tau}_{t,0}\right]$. Similarly, we model *unempast* as the backcast of the unemployment gap to an announced VAT change, $s^{\tau}_{t,0}$: $\beta^{\text{backcast}}_{u} = \mathbb{C}\left[\mathbb{E}^{c}_{t}\widetilde{u}_{t-1}, s^{\tau}_{t,0}\right]/\mathbb{V}\left[s^{\tau}_{t,0}\right]$. Equivalently, $inf1y$ and $unemp1y$ are captured by the response of the one-year-ahead forecasts to the contaminated VAT change: $\beta^{\text{forecast}}_{\pi} = \mathbb{C}\left[\mathbb{E}^{c}_{t}\pi_{t+4}, s^{\tau}_{t,0}\right]/\mathbb{V}\left[s^{\tau}_{t,0}\right]$ and $\beta^{\text{forecast}}_{u} = \mathbb{C}\left[\mathbb{E}^{c}_{t}\widetilde{u}_{t+4}, s^{\tau}_{t,0}\right]/\mathbb{V}\left[s^{\tau}_{t,0}\right]$

Using these theoretical counterparts, we estimate the degree of information frictions, the exogenous shock processes, and the stabilization parameter in the fiscal rule by minimizing the distance between the model and the empirical estimates for the backcast and forecast of price inflation and unemployment.[9] The estimation uses a weighting matrix with the inverse standard deviations of the moments on the diagonal and zeros for the off-diagonal elements.

4.3 Results

Table 3 reports the estimated moments. For convenience the first row reproduces the targeted empirical estimates, reported in Table 1. The second row reports the backcast and forecast on inflation and the unemployment gap in the theoretical model. We find that our empirical findings can be rationalized with information frictions.

Table 4 reports the calibrated and estimated parameters. We find that, in order to explain the empirical estimates on the change in the backcasts and forecasts after a fiscal announcement, the theoretical model requires a relatively large degree of household information frictions on the VAT shock and the supply side shocks. Instead, households are relatively better informed about the demand side of the economy. Intuitively, since we estimate the information effects of VAT announcements on households beliefs, the model requires a high degree of information frictions on the VAT shock itself, and on the shocks that mainly drive price inflation.

In the data, we find that an expansionary fiscal policy shock increases households' backcasts of inflation and decreases their backcasts of unemployment. At the same time, fiscal expansions have a null effect on the forecast of inflation and cause a decline in the forecast of the unemployment

[9]The empirical analysis uses survey forecasts on annual variables. Since the theoretical model is calibrated to quarterly data, we use $(\beta^{\text{backcast}}_{g})^{1/4}$ and $(\beta^{\text{forecast}}_{g})^{1/4}$ to make the empirical and theoretical estimates comparable.

Table 3: Effect of fiscal announcements on households' macroeconomic expectations (model)

	(1) **infpast**	(2) **unempast**	(3) **inf1y**	(4) **unemp1y**
Data	0.189	-0.168	0.020	-0.244
	(0.066)	(0.060)	(0.058)	(0.067)
Model (baseline)	0.159	-0.217	0.020	-0.199
Model (counterfactual)	-0.063	-0.058	-0.047	0.043

Notes: This table presents the estimated moments from the empirical analysis (first row), the theoretical model (second row) and a counterfactual exercise discounting the informational effect of the fiscal announcements (third row). Empirical standard error in parenthesis.

rate. The joint response of inflation and employment suggests a demand-side interpretation of the fiscal shock. Notably, the revision in inflation perceptions is considerably less persistent than the revision in unemployment expectations.

Three modeling assumptions are key to rationalizing these findings: (i) the fiscal rule linking VAT to inflation (equation 6), (ii) the presence of information frictions and the associated signaling channel, and (iii) heterogeneous uncertainty across agents regarding the nature and origin of shocks.

Consider, for instance, an increase in the VAT rate. Agents face uncertainty about whether the change stems from the exogenous component q_t, or from an endogenous adjustment linked to a rise in inflation, which in turn may be driven by cost-push shocks or by demand shocks. Conditional on interpreting it as driven by unemployment, they remain uncertain as to whether the underlying force is demand- or supply-related.

The parameter estimates reported in Table 4 suggest that households are relatively better informed about demand-side disturbances. Consequently, they place greater weight on signals related to demand conditions, and their beliefs respond more strongly to demand shocks than to supply shocks. Moreover, demand shocks are estimated to be less persistent than supply shocks. Taken together with the strong estimated stabilizing role of fiscal policy ($\psi_\tau \approx -1$), these features help explain why household expectations display a predominantly demand-driven adjustment to fiscal policy during the cost-of-living crisis.

The Pure Effect Knowing that the theoretical model can replicate the dynamics of beliefs after a fiscal announcement, next we turn to the quantification of the information effect of fiscal announcements. To quantify the contribution of the information effect we conduct a

Table 4: Model Parameters

Parameter	Description	Value	Target / Source
Standard NK			
β	Discount Factor	0.99	Galí (2015)
σ	Int. Elas. Subs.	1	Galí (2015)
φ	Inv. Frisch Elas.	5	Galí (2015)
$1-\alpha$	Labor Share	0.75	Galí (2015)
$1-\theta_p$	Price Calvo Reset Prob.	0.25	Galí (2015)
$1-\theta_w$	Wage Calvo Reset Prob.	0.25	Galí (2015)
ϵ_p	Elas. Subs. Goods	9	Galí (2015)
ϵ_w	Elas. Subs. Labor	4.5	Galí (2015)
S_G	Gov. Spending (% GDP)	0.4	40% Gov. Spending
ϕ_π	Inflation Coef. Taylor Rule	1.5	Galí (2015)
ϕ_y	Unemployment Coef. Taylor Rule	-0.5	Galí (2015)
Fiscal Rule			
ψ_π	Inflation Stab. VAT	-0.9998	Estimated
Exogenous Shocks: Persistence			
ρ_v	Persistence Monetary Shock	0.4413	Estimated
ρ_z	Persistence Demand Shock	0.4704	Estimated
ρ_a	Persistence TFP Shock	0.9165	Estimated
ρ_q	Persistence VAT Shock	0.4706	Estimated
ρ_p	Persistence Price Cost-Push Shock	0.7631	Estimated
ρ_w	Persistence Wage Cost-Push Shock	0.8065	Estimated
Exogenous Shocks: Variance			
σ_v^2	Var. Monetary Shock	0.0010	Estimated
σ_z^2	Var. Demand Shock	0.0014	Estimated
σ_a^2	Var. TFP Shock	0.0008	Estimated
σ_q^2	Var. VAT Shock	0.0022	Estimated
σ_p^2	Var. Price Cost-Push Shock	0.0001	Estimated
σ_w^2	Var. Wage Cost-Push Shock	0.0126	Estimated
Information: Variance Signal			
σ_{1v}^2	Var. Monetary Signal (households)	0.0564	Estimated
σ_{1z}^2	Var. Demand Signal (households)	0.0195	Estimated
σ_{1a}^2	Var. TFP Signal (households)	0.0088	Estimated
σ_{1q}^2	Var. VAT Signal (households)	0.0885	Estimated
σ_{1p}^2	Var. Price Cost-Push Signal (households)	0.0333	Estimated
σ_{1w}^2	Var. Wage Cost-Push Signal (households)	0.0160	Estimated
σ_{2v}^2	Var. Monetary Signal (firms)	0.0831	Estimated
σ_{2z}^2	Var. Demand Signal (firms)	0.0371	Estimated
σ_{2a}^2	Var. TFP Signal (firms)	0.0529	Estimated
σ_{2q}^2	Var. VAT Signal (firms)	0.0023	Estimated
σ_{2p}^2	Var. Price Cost-Push Signal (firms)	0.0590	Estimated
σ_{2w}^2	Var. Wage Cost-Push Signal (firms)	0.0135	Estimated
σ_{3v}^2	Var. Monetary Signal (union)	0.0099	Estimated
σ_{3z}^2	Var. Demand Signal (union)	0.1035	Estimated
σ_{3a}^2	Var. TFP Signal (union)	0.0151	Estimated
σ_{3q}^2	Var. VAT Signal (union)	0.0399	Estimated
σ_{3p}^2	Var. Price Cost-Push Signal (union)	0.0012	Estimated
σ_{3w}^2	Var. Wage Cost-Push Signal (union)	0.0222	Estimated

counterfactual exercise that decomposes the portion of the estimated effects that is driven by information frictions, and the portion driven by the pure VAT shock.

Consider for example the causal change in the forecast of inflation after a contaminated announcement, $\beta_{\pi}^{\text{forecast}} = \mathbb{C}\left[\overline{\mathbb{E}}_t^c \pi_{t+4}, s_{t,0}^{\tau}\right] / \mathbb{V}\left[s_{t,0}^{\tau}\right]$. Disaggregating the fiscal shock as $s_{t,0}^{\tau} = \psi_{\tau}(\pi_t^p - \overline{\mathbb{E}}_t^c \pi_t^p) + q_t - \overline{\mathbb{E}}_t^c q_t$, we compute the share coming from the pure VAT shock as $\beta_{\pi}^{\text{forecast,pure}} = \mathbb{C}\left[\overline{\mathbb{E}}_t^c \pi_{t+4}, q_t - \overline{\mathbb{E}}_t^c q_t\right] / \mathbb{V}\left[s_{t,0}^{\tau}\right]$. We report in the third row in Table 3 the theoretical results of this counterfactual exercise.

Interestingly, we find that most of the action in past inflation and unemployment perceptions observed in the data is driven by the signaling channel of fiscal policy. We also find that, after cleaning for the information effect, agents interpret a VAT cut shock as a negative demand shock: households expect a simultaneous fall in price inflation and increase in the unemployment gap. Intuitively, a cut in VAT taxes is equivalent to a cut in government spending in our theoretical model, since we assume that government spending adjusts every period to close budget deficits. This explains the pessimism that a pure VAT cut generates on the economic outlook. Thus, the signaling channel of fiscal announcements is driving most of the effects we reported in the previous section. Taken together, our theoretical results highlight the relevance of the signaling channel of fiscal policy.

5 Conclusions

This paper examines the link between fiscal policy announcements and household expectations. We estimate the causal effects of fiscal announcements on household economic perceptions and expectations. To do so, we construct a new narrative of official fiscal measures in response to the cost-of-living crisis in the euro area's four largest economies. Starting from the ESCB's confidential dataset of discretionary fiscal measures we document the announcement dates of price-related fiscal measures. We validate our dating against observed spikes in Google searches for key words related to each fiscal announcement. We then implement an RD design that exploits the exact timing of survey responses around fiscal announcement and analyze the causal changes in household expectations using the ECB's Consumer Expectations Survey.

Our findings indicate that fiscal announcements lead households to revise their beliefs about the prevailing economic conditions: household inflation perceptions rise, and unemployment perceptions fall, without significant revisions to short- or long-term inflation expectations. These results imply a significant signaling channel of fiscal policy. Fiscal announcements provide households with relevant information to update their beliefs about economic conditions, prices, and the government's commitment to achieve economic stabilization. In short, the estimated effects on household perceptions highlight the importance of considering the informational content of fiscal policy.

To account for these information effects, we develop a New Keynesian model incorporating involuntary unemployment and information frictions such that while private agents have imperfect information, the government has perfect information. This model helps us understand the mechanisms at play and highlights the significant role of fiscal policy as an information device. Our analysis underscores the need for policymakers to recognize the broader implications of fiscal announcements on household behavior and economic perceptions. While we do not find evidence that fiscal policy in our context jeopardized price stabilization through household beliefs, our findings also imply that fiscal communication can affect household beliefs beyond the direct effects of fiscal action.

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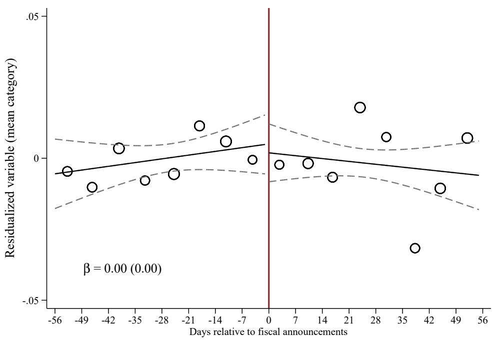
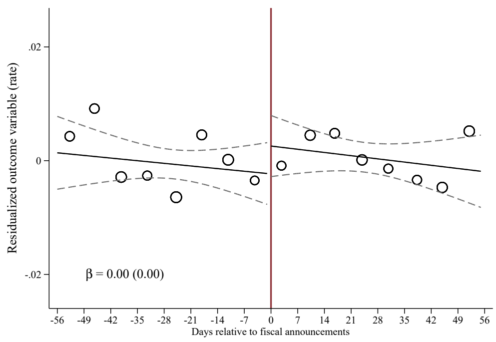
A Empirical Appendix: Supplementary Figures and Tables

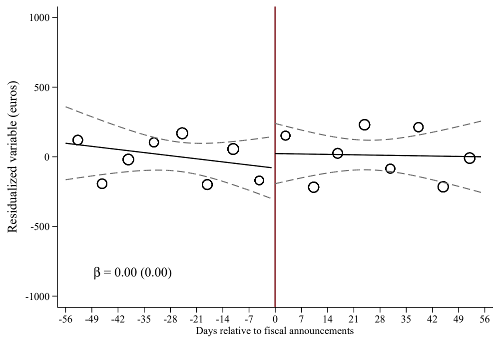
(a) Age



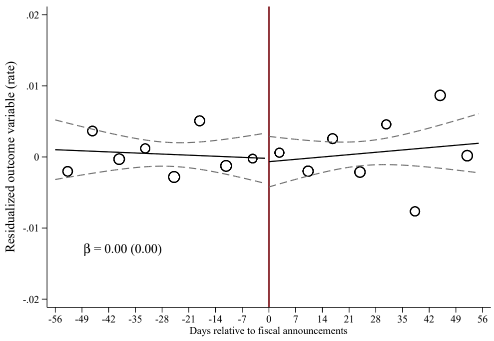
(b) Sex



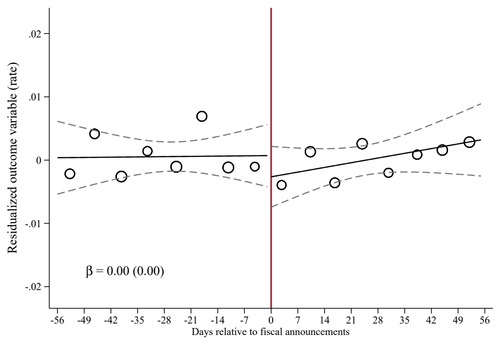
(c) Income



(d) Primary Education



(e) Secondary Education



(f) Tertiary Education

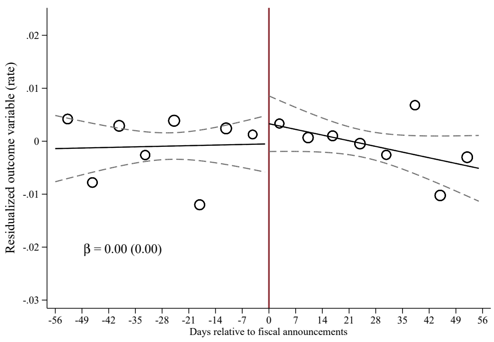


Figure A.1: Validation test. Control variables.

Notes: This figure replicates our RD design over a number of control variables that should not be affected by the fiscal announcement. Reassuringly, we find no evidence of discontinuous changes in these variables. This further supports our identifying assumption that there is no changes in the composition of individuals answering the survey just before or just after the fiscal announcements.

(a) CPI release (b) CPI flash release

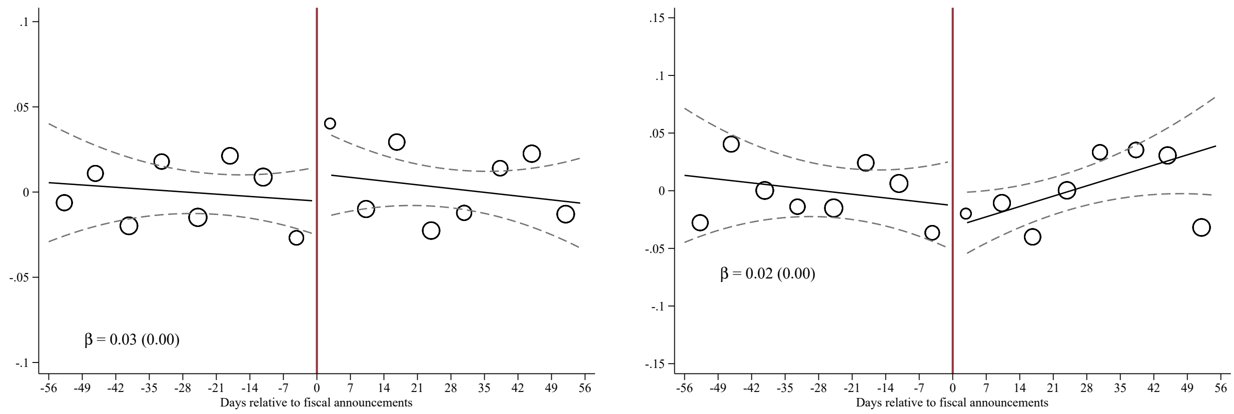
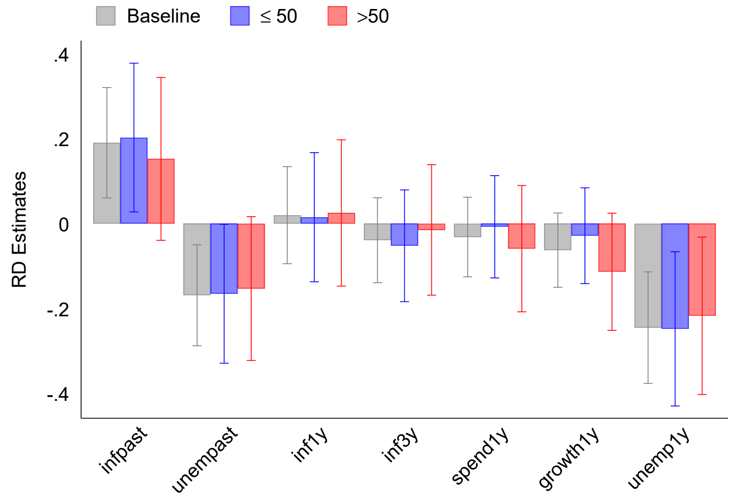
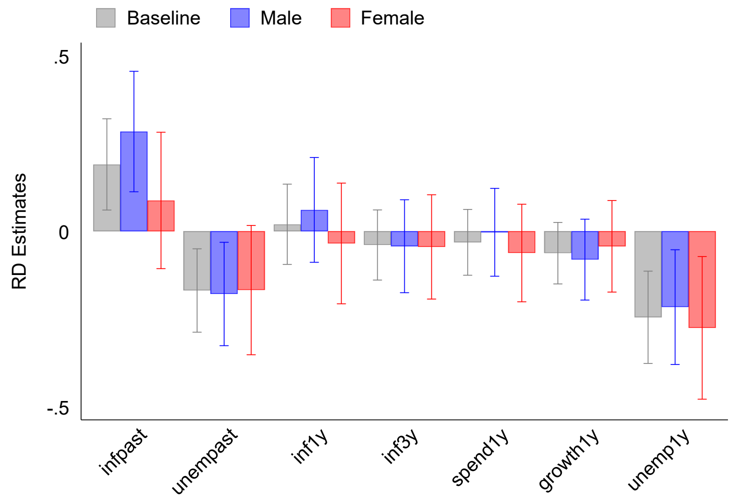


Figure A.2: Validation test: CPI releases.

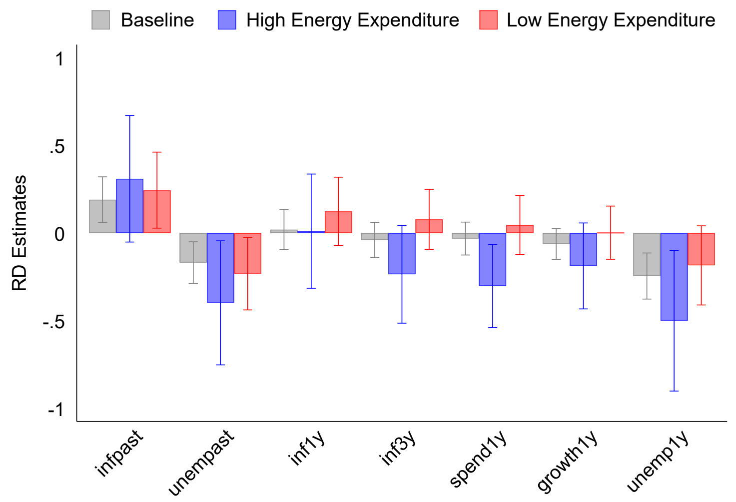
Notes: This figure replicates our RDD design over two outcomes. In panel (a) the outcome is an indicator variable that takes value one if there was a release of CPI information on the day an individual answered the survey or in the two days just before. In panel (b), the indicator is defined in the same manner, but for the release of "flash estimates" of the CPI. Reassuringly, we do not see any evidence of CPI releases being more common just before the fiscal announcements, which supports our identification strategy to isolate the causal effect of the fiscal announcement alone, and not other information shocks about the economy.



(a) Age



(b) Gender



(c) Energy-related Expenditure

Figure A.3: Heterogeneous Effects of Fiscal Announcements: Age, Gender, and Energy-related Expenditure

Notes: Bars represent the RD Estimates, and whiskers the 95 percent confidence level intervals. Regressions use triangular weights and a bandwith of 56 days. Standard errors clustered by household.

Table A.1: Placebo test

	(1) **infpast**	(2) **unempast**	(3) **inf1y**	(4) **inf3y**	(5) **spend1y**	(6) **growth1y**	(7) **unemp1y**
Placebo cutoff (+56)	0.035	-0.024	0.015	0.060	-0.009	0.010	-0.011
	(0.059)	(0.055)	(0.051)	(0.045)	(0.043)	(0.038)	(0.060)
Placebo cutoff (-56)	0.027	0.014	0.005	0.070	0.021	0.049	0.050
	(0.061)	(0.056)	(0.052)	(0.046)	(0.044)	(0.039)	(0.061)

Notes: This table replicates our baseline results but assigning fake placebo dates of announcement, either 56 earlier or later than the true announcement dates. The bandwidth of the analysis is 56 days, so the true announcement date is excluded from the placebo regressions. $N = 320,219$. Standard errors clustered by household. *($p < 0.1$), **($p < 0.05$), ***($p < 0.01$)

Table A.2: Mean Value of Outcome Variables by Group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		Age		Gender		Education		Energy Exp.		Extension	
	Baseline	$\leq$ 50	>50	male	female	tertiary	< tertiary	high	low	YES	NO
infpast	8.399	7.865	9.121	7.751	9.036	7.895	9.024	8.822	7.875	10.063	7.443
	(0.021)	(0.028)	(0.031)	(0.027)	(0.031)	(0.026)	(0.033)	(0.055)	(0.031)	(0.038)	(0.024)
unempast	12.362	12.579	12.070	11.306	13.399	11.625	13.276	14.865	13.113	13.738	11.571
	(0.021)	(0.029)	(0.030)	(0.026)	(0.033)	(0.025)	(0.035)	(0.057)	(0.032)	(0.038)	(0.025)
inf1y	6.225	5.717	6.911	5.635	6.805	5.890	6.641	6.540	5.794	7.232	5.646
	(0.017)	(0.023)	(0.026)	(0.022)	(0.026)	(0.022)	(0.027)	(0.045)	(0.026)	(0.031)	(0.020)
inf3y	4.261	3.990	4.625	3.749	4.763	4.002	4.581	4.704	4.048	4.686	4.016
	(0.015)	(0.020)	(0.022)	(0.019)	(0.023)	(0.019)	(0.024)	(0.039)	(0.023)	(0.027)	(0.017)
spend1y	3.093	2.698	3.628	3.048	3.138	3.129	3.050	2.316	2.915	3.132	3.071
	(0.014)	(0.018)	(0.023)	(0.019)	(0.021)	(0.019)	(0.022)	(0.033)	(0.022)	(0.025)	(0.017)
growth1y	-1.142	-1.123	-1.167	-0.535	-1.737	-1.051	-1.254	-1.364	-0.832	-1.920	-0.694
	(0.014)	(0.017)	(0.022)	(0.017)	(0.021)	(0.017)	(0.021)	(0.036)	(0.021)	(0.024)	(0.016)
unemp1y	12.941	13.287	12.473	11.760	14.099	12.076	14.011	15.624	13.508	14.628	11.970
	(0.023)	(0.032)	(0.033)	(0.028)	(0.036)	(0.028)	(0.038)	(0.063)	(0.034)	(0.042)	(0.027)

Notes: standard errors in parenthesis.

B Model Derivation and Proofs of Propositions in Main Text

In this section, we extend the baseline NK framework to information frictions, allowing for an information superiority of the government vs. households and firms.

B.1 Households

There is a continuum of infinitely-lived, ex-ante identical households indexed by $i \in \mathcal{I}_h = [0,1]$. Each household consists of a continuum of members indexed by $(j,s) \in [0,1]^2$, where j is the type of labor services the individual is specialized in, and s is the disutility from work: χs^{φ} if employed, zero otherwise, with $\chi > 0$ parameterizing the disutility from work. We assume that there is full risk-sharing within the household, so that consumption is equalized within household members. Household i's per-period utility is the integral of the members' utilities, given by

$$U\left(C_{i,t}, \mathcal{N}_{j,t}\right) \equiv \left(\frac{C_{i,t}^{1-\sigma}}{1-\sigma} - \chi \int_0^1 \int_0^{\mathcal{N}_{j,t}} s^{\varphi}\, ds\, dj\right) Z_t = \left(\frac{C_{i,t}^{1-\sigma}}{1-\sigma} - \chi \int_0^1 \frac{\mathcal{N}_{j,t}^{1+\varphi}}{1+\varphi}\, dj\right) Z_t$$

where $C_{i,t} = \left(\int_{\mathcal{I}_f} C_{if,t}^{\frac{\epsilon_t^p - 1}{\epsilon_t^p}}\, df\right)^{\frac{\epsilon_t^p}{\epsilon_t^p - 1}}$ is a consumption index at household i, with $C_{if,t}$ denoting the quantity of good f consumed by household i in period t, where each consumption good is indexed by $f \in \mathcal{I}_f = [0,1]$, ϵ_t^p denotes the time-varying elasticity of substitution between good varieties, $\mathcal{N}_{j,t}$ denotes the fraction of members specialised in type-j labor who are employed at time t, Z_t is an exogenous preference shifter, σ denotes the intertemporal elasticity of substitution, and φ denotes the inverse Frisch elasticity. Each household i seeks to maximize $\mathbb{E}_{i0} \sum_{t=0}^{\infty} \beta^t U(C_{i,t}, N_{j,t}; Z_t)$. Notice that we relax the benchmark framework and assume that households might differ in their beliefs, their expectation formation, and as a result on their optimal choices. We will come back to this later and specify a belief structure.

Households decide how much to consume and save subject to the budget restriction

$$(1+\tau_t) P_t C_{i,t} + Q_{t,t+1} B_{i,t} = B_{i,t-1} + \int_0^1 W_{j,t} \mathcal{N}_{j,t}\, dj + D_t + T_t = B_{i,t-1} + \overline{Y}_t \tag{B.1}$$

where $B_{i,t}$ denotes savings (or bond purchases) by household i, $Q_{t,t+1}$ is the bond price at time t, $W_{j,t}$ denotes the nominal wage at time t, D_t denotes dividends received from the profits produced by firms, T_t denotes lump-sum taxes paid, and $\overline{Y}_t$ denotes non-financial income. Notice that, due to the existence of labor unions, households do not take any labor supply decision. The optimality condition of the household problem satisfies $C_{i,t}^{-\sigma} = \beta \mathbb{E}_{i,t}\left(Q_{t,t+1}^{-1} \frac{P_t}{P_{t+1}} \frac{1+\tau_t}{1+\tau_{t+1}} \frac{Z_{t+1}}{Z_t} C_{i,t+1}^{-\sigma}\right)$. The intertemporal Euler condition can be log-linearized to

$$c_{i,t} = -\frac{1}{\sigma} \mathbb{E}_{i,t}\left(r_t - \Delta\tau_{t+1}\right) + \frac{1-\rho_z}{\sigma} \mathbb{E}_{i,t} z_t + \mathbb{E}_{i,t} c_{it+1} \tag{B.2}$$

where we define the ex-post real interest rate as $r_t = i_t - \pi_{t+1}^p$, $\Delta\tau_{t+1} := \tau_{t+1} - \tau_t$, $\pi_t^p = p_t - p_{t-1}$, and $z_t \equiv \log Z_t$ follows an exogenous AR(1) process

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z \tag{B.3}$$

with persistence $\rho_z \in [0,1)$ and conditional volatility $\varepsilon_t^z \sim \mathcal{N}(0, \sigma_z^2)$. Let us now focus on the budget constraint (B.1). In real terms, we can write it as $C_{i,t} + B_{i,t+1} = R_{t-1} B_{i,t} + \overline{Y}_t^r$, where $\overline{Y}_t^r = Y_t - G_t = C_t$. At any state, the life-time budget constraint can be rewritten as

$$\sum_{k=0}^{\infty} \frac{C_{i,t+k}}{\prod_{j=1}^{k} R_{t+j-1}} = R_{t-1} B_{i,t} + \sum_{k=0}^{\infty} \frac{\overline{Y}_{t+k}^r}{\prod_{j=1}^{k} R_{t+j-1}}$$

which can be log-linearized to $\sum_{k=0}^{\infty}\beta^k c_{i,t+k} = \sum_{k=0}^{\infty}\beta^k \overline{y}^r_{t+k}$. Combining this with the log-linearized version of the households' Euler equation (B.2), we obtain

$$c_{i,t} = -\frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_{i,t}r_{t+k} + \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_{i,t}\Delta\tau_{t+1+k} + \frac{\beta(1-\rho_z)}{\sigma}\sum_{k=0}^{\infty}\beta^k \mathbb{E}_{i,t}z_{t+k} + (1-\beta)\sum_{k=0}^{\infty}\beta^k \mathbb{E}_{i,t}c_{t+k}$$

Finally, notice that this is implied by the following beaty-contest game,

$$c_{i,t} = -\frac{\beta}{\sigma}\mathbb{E}_{i,t}r_t + \frac{\beta}{\sigma}\mathbb{E}_{i,t}\Delta\tau_{t+1} + \frac{\beta(1-\rho_z)}{\sigma}\mathbb{E}_{i,t}z_t + (1-\beta)\,\mathbb{E}_{i,t}c_t + \beta\mathbb{E}_{i,t}c_{i,t+1} \tag{B.4}$$

where $c_t = \int c_{i,t}\, di$.

B.2 Firms

Each firm f is a monopolist producing a differentiated intermediate-good variety, producing output $Y_{f,t}$ and setting nominal price $P_{f,t}$. Technology is represented by the production function

$$Y_{f,t} = A_t N_{f,t}^{1-\alpha} \tag{B.5}$$

with $N_{f,t} \equiv \left(\int_0^1 N_{fj,t}^{\frac{\epsilon_{w,t}-1}{\epsilon_{w,t}}}\right)$, where $N_{fj,t}$ denotes the quantity of type-j labor employed by firm f in period t, $\epsilon_{w,t}$ denotes the time-varying elasticity of substitution between good varieties; and A_t is the level of technology, common to all firms, which follows an exogenous log-AR(1) process

$$a_t = \rho_a a_{t-1} + \varepsilon^a_t \tag{B.6}$$

where $a_t = \log A_t$, with persistence $\rho_a \in [0,1)$ and conditional volatility $\varepsilon^a_t \sim \mathcal{N}(0,\sigma_a^2)$.

Aggregate Price Dynamics Nominal price rigidities take the form of a Calvo-lottery friction. In each period, each firm can reset its price with probability $(1-\theta_p)$, independent of the time of the last price change. A measure $(1-\theta_p)$ of firms can reset their prices in a given period, and the average duration of a price is given by $1/(1-\theta_p)$. Such an environment implies that the aggregate price dynamics is given (in logarithmic linear terms) by $\pi^p_t = \int_{\mathcal{I}_f}\pi^p_{f,t}\,df = (1-\theta_p)\left[\int_{\mathcal{I}_f}p^*_{f,t}\,df - p_{t-1}\right] = (1-\theta_p)\,(p^*_t - p_{t-1})$.

Optimal Price Setting A firm re-optimizing in period t will choose the price $P^*_{f,t}$ that maximizes the current market value of the profits generated while the price remains effective. Formally,

$$P^*_{f,t} = \arg\max_{P_{f,t}}\sum_{k=0}^{\infty}\theta^k \mathbb{E}_{f,t}\left\{\Lambda_{t,t+k}/P_{t+k}\left[P_{f,t}Y_{f,t+k|t} - \mathcal{C}_{t+k}(Y_{f,t+k|t})\right]\right\},$$

subject to the sequence of the demand schedules $Y_{f,t+k|t} = (P_{f,t}/P_{t+k})^{-\epsilon^p_t}\,Y_{t+k}$, where $\Lambda_{t,t+k} \equiv \beta^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}$ is the stochastic discount factor, $\mathcal{C}_t(\cdot)$ is the (nominal) cost function, and $Y_{f,t+k|t}$ denotes output in period $t+k$ for a firm j that last reset its price in period t. The FOC of the optimal price setting problem is $\sum_{k=0}^{\infty}\theta^k\mathbb{E}_{f,t}\left[\Lambda_{t,t+k}Y_{f,t+k|t}\frac{1}{P_{t+k}}\left(P^*_{f,t} - \mathcal{M}\Psi_{f,t+k|t}\right)\right] = 0$, where $\Psi_{f,t+k|t} \equiv \mathcal{C}^{\intercal}_{t+k}(Y_{f,t+k|t})$ denotes the (nominal) marginal cost for firm j, and $\mathcal{M}^p_t = \frac{\epsilon^p_t}{\epsilon^p_t - 1}$. Log-linearizing around the zero inflation steady-state, we obtain the familiar price-setting rule

$$p^*_{f,t} = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k\mathbb{E}_{f,t}\left(\psi_{f,t+k|t} + \mu^p_t\right) \tag{B.7}$$

where $\psi_{f,t+k|t} = \log\Psi_{f,t+k|t}$ and $\mu^p_t = \log\mathcal{M}^p_t$.

B.3 Labor Unions

Consider now how the labor union specialized in a given labor type j sets wages. Wage rigidities are introduced in a way analogous to price rigidities in the goods/firms market: workers specialized in any given labor type can reset their nominal wage only with probability $1-\theta_w$ each period, independently of the time elapsed since the last reset.

Aggregate Wage Dynamics Analogously to the price-setting frictions, aggregate wage dynamics are given (in log-linear terms) by $\pi_t^w = \int_{\mathcal{I}_j} \pi_{j,t}^w \, dj = (1-\theta_w)\left[\int_{\mathcal{I}_j} w_{j,t}^* \, df - w_{t-1}\right] = (1-\theta_w)\,(w_t^* - w_{t-1})$.

Optimal Wage Setting Consider then a union resetting its members' wage in period t, and let $W_{j,t}^*$ denote the newly set wage. The union chooses $W_{j,t}^*$ in a way consistent with household utility maximization, taking as given the decisions of other unions as well as the path for aggregate consumption and prices. Specifically, the union seeks to maximize $\mathbb{E}_{j,t}\sum_{k=0}^{\infty}(\beta\theta_w)^k\left(C_{t+k}^{-\sigma}\frac{W_{j,t}^*}{P_{t+k}}N_{j,t+k|t} - \chi\frac{N_{j,t+k|t}^{1+\varphi}}{1+\varphi}\right)$, subject to the sequence of labor demand schedules $N_{j,t+k|t} = \left(\frac{W_{j,t}^*}{W_{t+k}}\right)^{-\epsilon_w} N_{t+k}$, where $N_{j,t+k|t}$ denotes the level of employment in period $t+k$ among workers in union j that last reset their wage in period t. The FOC of the labor union program is $\sum_{k=0}^{\infty}(\beta\theta_w)^k\mathbb{E}_{j,t}\left[N_{j,t+k|t}\left(C_{t+k}^{-\sigma}\frac{W_{j,t}^*}{P_{t+k}} + \mathcal{M}_{w,t}\chi N_{j,t+k|t}^{\varphi}\right)\right] = 0$, where $\mathcal{M}_{w,t} = \frac{\epsilon_{w,t}}{\epsilon_{w,t}-1}$. Letting $\text{MRS}_{j,t+k|t} \equiv \chi C_{t+k}^{\sigma}N_{j,t+k|t}^{\varphi}$ denote the marginal rate of substitution between consumption and employment in period $t+k$ relevant to the type-j workers resetting their wage at period t, the above optimality condition can be rewritten as $\sum_{k=0}^{\infty}(\beta\theta_w)^k\mathbb{E}_{j,t}\left[N_{j,t+k|t}C_{t+k}^{-\sigma}\left(\frac{W_{j,t}^*}{P_{t+k}} - \mathcal{M}_{w,t}\text{MRS}_{j,t+k|t}\right)\right] = 0$. Log-linearizing the above condition around a frictionless steady-state yields the individual wage setting rule

$$w_{j,t}^* = (1-\beta\theta_w)\sum_{k=0}^{\infty}(\beta\theta_w)^k\mathbb{E}_{j,t}(\text{mrs}_{j,t+k|t} + \mu_t^w + p_{t+k}) \tag{B.8}$$

where $\mu_t^w = \log\mathcal{M}_{w,t}$ and $\text{mrs}_{j,t+k|t} \equiv \sigma c_{t+k} + \varphi n_{j,t+k|t} + \log\chi$. Union j's optimal wage is increasing in expected future prices, because households care about the purchasing power of their nominal wage, and increasing in the marginal disutility of labor (in terms of goods) over the life of the wage, because households want to adjust their expected average real wage accordingly.

B.4 Unemployment

Consider an individual (i,j,s) in household i, specialized in type j labor and with disutility of work χs^{φ}. Using his welfare as a criterion and taking as given current labor market conditions, he will be willing to work if the relevant real wage exceeds the disutility from work, $\frac{W_{ij,t}}{P_t} \geq \chi C_{i,t}^{\sigma}s^{\varphi}$. The marginal supplier of type j labor at household i, denoted by $L_{ij,t}$, is therefore $\frac{W_{ij,t}}{P_t} = \chi C_{i,t}^{\sigma}L_{ij,t}^{\varphi}$. Define the aggregate labor force (or participation rate) in the economy as $L_t \equiv \int_0^1\int_0^1 L_{ijt}\,dj\,di$. Taking logs and integrating over j and i we obtain an aggregate labor supply or participation equation $w_t - p_t = \sigma c_t + \varphi l_t + \log\chi$. Define unemployment as $u_t \equiv l_t - n_t$. Therefore, we can write the average wage markup as the difference between the real wage, $\omega_t \equiv w_t - p_t$, and the marginal rate of substitution, $\sigma c_t + \varphi n_t + \log\chi$, as

$$\mu_t^w \equiv \omega_t - (\sigma c_t + \varphi n_t + \log\chi) = \varphi u_t. \tag{B.9}$$

That is, the average wage markup is proportional to the unemployment rate, and the natural rate of unemployment is thus defined as $\mu_t^w = \varphi u_t^n$.

B.5 Public Institutions

Monetary Policy Monetary policy is conducted following a Taylor rule of the form (7) where the monetary policy shock v_t follows the AR(1) process

$$v_t = \rho_v v_{t-1} + \varepsilon_t^v \tag{B.10}$$

with persistence $\rho_v \in [0, 1)$ and conditional volatility $\varepsilon_t^v \sim \mathcal{N}(0, \sigma_v^2)$.

Fiscal Policy The government collects consumption tax revenues and levies lump-sum taxes to fund government spending under zero deficit. We assume that consumption taxes follow a rule that depends on the price level, (6), where the tax policy shock q_t follows the AR(1) process

$$q_t = \rho_q q_{t-1} + \varepsilon_t^q \tag{B.11}$$

with persistence $\rho_q \in [0, 1)$ and conditional volatility $\varepsilon_t^q \sim \mathcal{N}(0, \sigma_q^2)$.

B.6 Equilibrium Conditions

Goods and Labor Market Clearing Market clearing in the goods market implies that $Y_{f,t} = C_{f,t} + G_{f,t} = \int_{\mathcal{I}_h} (C_{if,t} + G_{if,t})\, di$ for each f good/firm. Aggregating across firms, we obtain the aggregate market clearing condition: since assets are in zero net supply production equals consumption plus government spending: $\int_{\mathcal{I}_f} Y_{f,t}\, df = \int_{\mathcal{I}_h} \int_{\mathcal{I}_f} (C_{if,t} + G_{if,t})\, df\, di \implies Y_t = C_t + G_t$. Log linearized, $y_t = (1 - S_G)c_t + S_G g_t$, where $S_G = G/Y$ is the steady-state government spending to GDP ratio. In deviations from the natural equilibrium,

$$\widetilde{y}_t = (1 - S_G)\widetilde{c}_t + S_G \widetilde{g}_t = \widetilde{c}_t + S_G \psi_\tau \pi_t^p \tag{B.12}$$

where we have used the VAT rule (6).

Aggregate employment is given by the sum of employment across firms, and must meet aggregate labor supply $N_t = \int_{\mathcal{I}_h} N_{i,t}\, di = \int_{\mathcal{I}_f} N_{f,t}\, df$. Using the production function (B.5) together with goods market clearing, $N_t = \int_{\mathcal{I}_f} \left(\frac{Y_{f,t}}{A_t}\right)^{\frac{1}{1-\alpha}} df = \left(\frac{Y_t}{A_t}\right)^{\frac{1}{1-\alpha}} \int_{\mathcal{I}_f} \left(\frac{P_{f,t}}{P_t}\right)^{-\frac{\epsilon}{1-\alpha}} df$. Log-linearizing the above expression yields to $n_t = \frac{1}{1-\alpha}(y_t - a_t)$. In deviations from the natural equilibrium,

$$\widetilde{n}_t = \frac{1}{1-\alpha}\widetilde{y}_t. \tag{B.13}$$

The Dynamic IS Curve Iterating forward (B.4), and aggregating across households, we can write

$$c_t = -\frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \overline{\mathbb{E}}_t^h r_{t+k} + \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \overline{\mathbb{E}}_t^h \Delta\tau_{t+1+k} + \frac{\beta(1-\rho_z)}{\sigma}\sum_{k=0}^{\infty}\beta^k \overline{\mathbb{E}}_t^h z_{t+k} + (1-\beta)\sum_{k=0}^{\infty}\beta^k \overline{\mathbb{E}}_t^h c_{t+k} \tag{B.14}$$

Let us now derive the DIS curve. Substracting the natural level of output from (B.14), I obtain

$$\widetilde{c}_t = -\frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \overline{\mathbb{E}}_t^h (r_{t+k} - r_{t+k}^n) + \frac{\beta}{\sigma}\sum_{k=0}^{\infty}\beta^k \overline{\mathbb{E}}_t^h \Delta\pi_{t+1+k}^p + (1-\beta)\sum_{k=0}^{\infty}\beta^k \overline{\mathbb{E}}_t^h \widetilde{c}_{t+k} \tag{B.15}$$

We derive an expression for the natural real interest rate. Recall that in a natural equilibrium with no nominal nor information frictions, the natural real interest rate is given by

$$\begin{aligned} r_t^n &= \sigma \mathbb{E}_t \Delta c_{t+1}^n + (1-\rho_z)z_t + \mathbb{E}_t\Delta\tau_{t+1} = \frac{\sigma}{1-S_G}\left[\psi \mathbb{E}_t \Delta a_{t+1} - S_G \mathbb{E}_t \Delta g_{t+1}^n\right] + (1-\rho_z)z_t + \mathbb{E}_t\Delta\tau_{t+1} \\ &= \sigma\left[\psi(\rho_a - 1)a_t - S_G \mathbb{E}_t\Delta\tau_{t+1}\right] + (1-\rho_z)z_t + \mathbb{E}_t\Delta\tau_{t+1} = \sigma\psi(\rho_a - 1)a_t + (1-\rho_z)z_t + (1-\sigma S_G)\mathbb{E}_t\Delta\tau_{t+1} \end{aligned} \tag{B.16}$$

Inserting (B.16) into (B.15) we obtain the aggregate output gap. Finally, notice this is implied by the beauty-contest game (2).

As in the textbook NK model, the demand curve can be summarized as a single equation; but it cannot be collapsed into a first-order expectational difference equation since the hierarchy of beliefs prevents the law of iterated expectations (LIE) from holding at the aggregate level. In this case, the individual DIS curve (B.2) can be rewritten in gap deviations from the natural level as (2).

The price Phillips curve The (log) marginal cost for firm f at time $t+k|t$ is $\psi_{f,t+k|t} = w_{t+k} - mpn_{f,t+k|t} = w_{t+k} - [a_{t+k} - \alpha n_{f,t+k|t} + \log(1-\alpha)]$, where $mpn_{f,t+k|t}$ and $n_{f,t+k|t}$ denote (log) marginal product of labor and (log) employment in period $t+k$ for a firm that last reset its price at time t, respectively. Let $\psi_t \equiv \int_{\mathcal{I}_f} \psi_{f,t}$ denote the (log) average marginal cost. I can then write $\psi_t = w_t - [a_t - \alpha n_t + \log(1-\alpha)]$. Thus, the following relation holds

$$\psi_{f,t+k|t} = \psi_{t+k} + \alpha(n_{f,t+k|t} - n_{t+k}) = \psi_{t+k} + \frac{\alpha}{1-\alpha}(y_{f,t+k|t} - y_{t+k}) = \psi_{t+k} - \frac{\alpha\epsilon}{1-\alpha}(p^*_{f,t} - p_{t+k}) \tag{B.17}$$

Introducing (B.17) into (B.7), I can rewrite the firm price-setting condition as

$$p^*_{f,t} = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k \mathbb{E}_{f,t}\left[p_{t+k} - \Theta(\widehat{\mu}^p_{t+k} - \mu^p_{t+k})\right], \tag{B.18}$$

where $\widehat{\mu} = \mu^p_t - \mu^p$ is the deviation between the average and desired markups, where $\mu^p_t = -(\psi_t - p_t)$, and $\Theta = \frac{1-\alpha}{1-\alpha+\alpha\epsilon}$. Suppose that firms observe the aggregate prices up to period $t-1$, although they do not extract information (Angeletos and Huo, 2021; Huo and Pedroni, 2023). Then we can re-state (B.18) as

$$\begin{aligned} p^*_{f,t} - p_{t-1} &= (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k \mathbb{E}_{f,t}\left[p_{t+k} - p_{t-1} - \Theta(\widehat{\mu}^p_{t+k} - \mu^p_{t+k})\right] \\ &= \sum_{k=0}^{\infty}(\beta\theta)^k \mathbb{E}_{f,t}\pi_{t+k} - (1-\beta\theta)\Theta\sum_{k=0}^{\infty}(\beta\theta)^k \mathbb{E}_{f,t}(\widehat{\mu}^p_{t+k} - \mu^p_{t+k}) \end{aligned}$$

Define the firm-specific inflation rate to be $\pi_{f,t} = (1-\theta_p)(p^*_{f,t} - p_{t-1})$. Inserting this in the previous equation, we can write

$$\begin{aligned} \pi_{f,t} &= (1-\theta_p)\sum_{k=0}^{\infty}(\beta\theta_p)^k \mathbb{E}_{f,t}\pi_{t+k} - (1-\theta_p)(1-\beta\theta_p)\Theta\sum_{k=0}^{\infty}(\beta\theta)^k \mathbb{E}_{f,t}(\widehat{\mu}^p_{t+k} - \mu^p_{t+k}) \\ &= (1-\theta_p)\mathbb{E}_{f,t}\pi_t - (1-\theta_p)(1-\beta\theta_p)\Theta\mathbb{E}_{f,t}(\widehat{\mu}^p_t - \mu^p_t) \\ &\quad + \beta\theta_p\mathbb{E}_{f,t}\left\{(1-\theta_p)\sum_{k=0}^{\infty}(\beta\theta_p)^k \mathbb{E}_{f,t+1}\pi_{t+k+1} - (1-\theta_p)(1-\beta\theta_p)\Theta\sum_{k=0}^{\infty}(\beta\theta)^k \mathbb{E}_{f,t+1}(\widehat{\mu}^p_{t+k+1} - \mu^p_{t+k+1})\right\} \\ &= (1-\theta_p)\mathbb{E}_{f,t}\pi_t - (1-\theta_p)(1-\beta\theta_p)\Theta\mathbb{E}_{f,t}\widehat{\mu}^p_t + (1-\theta_p)(1-\beta\theta_p)\Theta\mathbb{E}_{f,t}\mu^p_t + \beta\theta_p\mathbb{E}_{f,t}\pi_{f,t+1} \end{aligned} \tag{B.19}$$

Note that we can write the deviation between average and desired markups as

$$\mu^p_t = p_t - \psi_t = -\omega_t + [a_t - \alpha n_t + \log(1-\alpha)] = -\omega_t - \frac{\alpha}{1-\alpha}y_t + \frac{1}{1-\alpha}a_t + \log(1-\alpha)$$

As in the benchmark model, under flexible prices ($\theta_p = 0$) the average markup is constant and equal to the desired μ^p. Consider the natural level of output, y^n_t as the equilibrium level under flexible prices and FIRE. Rewriting the above condition under the natural equilibrium, $\mu^p = -\omega^n_t - \frac{\alpha}{1-\alpha}y^n_t + \frac{1}{1-\alpha}a_t + \log(1-\alpha)$. Therefore, we can write $\widehat{\mu}^p_t = -\widetilde{\omega}_t - \frac{\alpha}{1-\alpha}\widetilde{y}_t$, where $\widetilde{y}_t = y_t - y^n_t$ is defined as the output gap, and $\widetilde{\omega}_t = \omega_t - \omega^n_t$ is defined as the real wage gap. Using the wage markup (B.9), we can write (5), where we have used (B.12)-(B.13). Finally, plugging this expression into (B.19), we obtain (3).

Combining the goods and labor market clearing conditions, we can write the (log-linearized) firm-level Phillips curve is given by (3), where μ_t^p is a price markup shock, which follows an exogenous AR(1) process

$$\mu_t^p = \rho_p \mu_{t-1}^p + \varepsilon_t^p \tag{B.20}$$

with persistence $\rho_p \in [0, 1)$ and conditional volatility $\varepsilon_t^p \sim \mathcal{N}(0, \sigma_p^2)$. Iterating forward and aggregating across firms, the aggregate Phillips curve can be written as

$$\begin{aligned}
\pi_t^p = {} & \lambda_p \theta_p \sum_{k=0}^{\infty} (\beta\theta_p)^k \overline{\mathbb{E}}_t^f \mu_{t+k}^p + \lambda_p \kappa_{pu} \sum_{k=0}^{\infty} (\beta\theta_p)^k \overline{\mathbb{E}}_t^f \widetilde{u}_{t+k} + \theta_p \kappa_{py} \sum_{k=0}^{\infty} (\beta\theta_p)^k \overline{\mathbb{E}}_t^f \widetilde{y}_{t+k} \\
& + (1 - \theta_p - \theta_p \lambda_p \sigma S_G \psi_\tau) \sum_{k=0}^{\infty} (\beta\theta_p)^k \overline{\mathbb{E}}_t^f \pi_{t+k}^p
\end{aligned} \tag{B.21}$$

where $\overline{\mathbb{E}}_t^f(\cdot) = \int_0^1 \mathbb{E}_{j,t}(\cdot) \; dj$ is the cross-sectional average forecast across firms.

The wage Phillips curve Letting $\text{mrs}_{t+k} \equiv \sigma c_{t+k} + \varphi n_{t+k} + \log \chi$ define the economy's average marginal rate of substitution, where $n_{t+k} \equiv \log \int_0^1 \int_0^1 N_{fj,t} \; dj \; df$. We can thus write $\text{mrs}_{j,t+k|t} = \text{mrs}_{t+k} + \varphi(n_{j,t+k|t} - n_{t+k}) = -\varphi\epsilon_w(w_{j,t}^* - w_{t+k})$. Hence, we can rewrite (B.8) as

$$\begin{aligned}
w_{j,t}^* &= \frac{1-\beta\theta_w}{1+\varphi\epsilon_w} \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t}(\text{mrs}_{t+k} + \mu_t^w + \varphi\epsilon_w w_{t+k} + p_{t+k}) \\
&= \frac{1-\beta\theta_w}{1+\varphi\epsilon_w} \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t}[(1+\varphi\epsilon_w) w_{t+k} - (\widehat{\mu}_{t+k}^w - \mu_{t+k}^w)] \\
&= (1-\beta\theta_w) \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t}[w_{t+k} - \Theta_w(\widehat{\mu}_{t+k}^w - \mu_{t+k}^w)]
\end{aligned} \tag{B.22}$$

where $\widehat{\mu}_t^w = \mu_t^w - \mu^w$ denotes the deviations from the economy's (log) average wage markup $\mu_t^w = (w_t - p_t) - \text{mrs}_t$ from its steady-state level, and $\Theta_w = \frac{1}{1+\varphi\epsilon_w}$. Suppose that firms observe the aggregate (nominal) wage up to period $t-1$, w^{t-1}, but do not learn from them. Then we can restate the above condition as

$$w_{ft}^* - w_{t-1} = -(1-\beta\theta_w)\Theta_w \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t} \widehat{\mu}_{t+k}^w + (1-\beta\theta_w)\Theta_w \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t} \mu_{t+k}^w + \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t} \pi_{t+k}^w$$

Define the firm-specific inflation rate as $\pi_{j,t}^w = (1-\theta_w)(w_{j,t}^* - w_{t-1})$. Then we can write the above expression as

$$\begin{aligned}
\pi_{j,t}^w &= -(1-\theta_w)(1-\beta\theta_w)\Theta_w \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t}(\widehat{\mu}_{t+k}^w - \mu_{t+k}^w) + (1-\theta_w) \sum_{k=0}^{\infty} (\beta\theta_w)^k \mathbb{E}_{j,t} \pi_{t+k}^w \\
&= (1-\theta_w)\mathbb{E}_{j,t}[\pi_t^w - (1-\beta\theta_w)\Theta_w(\widehat{\mu}_t^w - \mu_t^w)] \\
&\quad + \beta\theta_w \mathbb{E}_{j,t} \left\{ (1-\theta_w) \sum_{k=0}^{\infty} (\beta\theta_w)^k [\pi_{t+1+k}^w - (1-\beta\theta_w)\Theta_w(\widehat{\mu}_{t+1+k}^w - \mu_{t+1+k}^w)] \right\} \\
&= -(1-\theta_w)(1-\beta\theta_w)\Theta_w \mathbb{E}_{j,t} \widehat{\mu}_t^w + (1-\theta_w)(1-\beta\theta_w)\Theta_w \mathbb{E}_{j,t} \mu_t^w + (1-\theta_w)\mathbb{E}_{j,t} \pi_t^w + \beta\theta_w \mathbb{E}_{j,t} \pi_{j,t+1}^w
\end{aligned} \tag{B.23}$$

where $\pi_t^w = \int_{\mathcal{I}_j} \pi_{j,t}^w \, dj$. Finally, the wage mark-up gap is also related to the output and real wage gaps through (B.9), $\widehat{\mu}_t^w = \varphi \widetilde{u}_t$. Combining the last two expressions, we obtain the individual wage Phillips curve (4).

The log-linearized union-level wage Phillips curve is given by (4), where μ_t^w is a wage mark-up shock, which follows an exogenous AR(1) process

$$\mu_t^w = \rho_w \mu_{t-1}^w + \varepsilon_t^w \tag{B.24}$$

with persistence $\rho_w \in [0, 1)$ and conditional volatility $\varepsilon_t^w \sim \mathcal{N}(0, \sigma_w^2)$.

C Proofs of Propositions in Main Text

Proof of Proposition 1. Combining the DIS curve (2), the Taylor rule (7), the tax policy rule (6), and the goods market clearing condition (B.12), we can write

$$\begin{aligned}\widetilde{c}_{it} = &-\frac{\beta}{\sigma}\mathbb{E}_{it}v_t + \frac{\beta(1-\rho_z)}{\sigma}\mathbb{E}_{it}z_t + \beta\psi(\rho_a - 1)\mathbb{E}_{it}a_t + \beta\left(\frac{1}{\sigma} - S_G\right)(\rho_q - 1)\mathbb{E}_{it}q_t \\ &+ (1-\beta)\,\mathbb{E}_{it}\widetilde{c}_t - \beta\left[\frac{\phi_\pi}{\sigma} + \left(\frac{1}{\sigma} - S_G\right)\psi_\tau\right]\mathbb{E}_{it}\pi_t^p - \frac{\beta\phi_u}{\sigma}\mathbb{E}_{it}\widetilde{u}_t + \beta\left[\frac{1}{\sigma} + \left(\frac{1}{\sigma} - S_G\right)\psi_\tau\right]\mathbb{E}_{it}\pi_{t+1}^p + \beta\mathbb{E}_{it}\widetilde{c}_{i,t+1}\end{aligned} \tag{C.1}$$

Combing the price Phillips curve (3) with the goods market clearing condition (B.12), we can write

$$\pi_{f,t}^p = \theta_p\lambda_p\mathbb{E}_{f,t}\mu_t^p + \theta_p\kappa_{py}\mathbb{E}_{f,t}\widetilde{c}_t + \left(1 - \theta_p + \theta_p\lambda_p S_G\psi_\tau\frac{\alpha+\varphi}{1-\alpha}\right)\mathbb{E}_{f,t}\pi_t^p + \theta_p\kappa_{pu}\mathbb{E}_{f,t}\widetilde{u}_t + \beta\theta_p\mathbb{E}_{f,t}\pi_{f,t+1}^p \tag{C.2}$$

Combining the wage gap dynamics (5) with the goods market clearing condition (B.12), and taking first differences, we can write

$$\pi_t^w = [1 + \varphi S_G\psi_\tau/(1-\alpha)]\pi_t^p - \varphi S_G\psi_\tau/(1-\alpha)\pi_{t-1}^p + \varphi(\widetilde{u}_t - \widetilde{u}_{t-1}) + \left(\sigma + \frac{\varphi}{1-\alpha}\right)(\widetilde{c}_t - \widetilde{c}_{t-1}) \tag{C.3}$$

That is, the model consists of equations (C.1), (C.2), (4), and (C.3). In general terms, we can write the first three of them as the best response of agent l in group g is specified as in (C.4)

$$a_{lgt} = \sum_{j=1}^{7}\varphi_{gj}\mathbb{E}_{lgt}\xi_{jt} + \beta_g\mathbb{E}_{lgt}a_{igt+1} + \sum_{j=1}^{4}\gamma_{gj}\mathbb{E}_{lgt}a_{j,t} + \sum_{j=1}^{4}\alpha_{gj}\mathbb{E}_{lgt}a_{j,t+1} \tag{C.4}$$

$$\sum_n h_{3n}(L)\xi_{nt} = (\kappa_3 + \kappa_4 L)\sum_n h_{2n}(L)\xi_{nt} + \kappa_1(1-L)\sum_n h_{4n}(L)\xi_{nt} + \kappa_2(1-L)\sum_n h_{1n}(L)\xi_{nt} \tag{C.5}$$

while the second equation contains the unemployment gap dynamics. Let $\boldsymbol{a}_t = (a_{gt})$ be a column vector collecting the aggregate actions of all groups, where $a_{1t} = \widetilde{c}_t$, $a_{2t} = \pi_t^p$, $a_{3t} = \pi_t^w$, and $a_{4t} = \widetilde{u}_t$; $\boldsymbol{\xi}_t = (\xi_{kt})$ be a column vector collecting the fundamental disturbances, where $\xi_{1t} = v_t$, $\xi_{2t} = z_t$, $\xi_{3t} = a_t$, $\xi_{4t} = x_t$, $\xi_{5t} = q_t$, $\xi_{6t} = \mu_t^p$, and $\xi_{7t} = \mu_t^w$, and the model parameters satisfy

$$\begin{aligned}\varphi_{11} &= -\frac{\beta}{\sigma}\\ \varphi_{12} &= \frac{\beta(1-\rho_z)}{\sigma}\\ \varphi_{13} &= \beta\psi(\rho_a - 1)\\ \varphi_{14} &= \beta\left(\frac{1}{\sigma} - S_G\right)(\rho_q - 1)\\ \varphi_{25} &= \theta_p\lambda_p\\ \varphi_{36} &= \theta_w\lambda_w\end{aligned}$$

$$\begin{aligned}\gamma_{11} &= 1-\beta\\ \gamma_{12} &= -\beta\left[\frac{\phi_\pi}{\sigma} + \left(\frac{1}{\sigma} - S_G\right)\psi_\tau\right]\\ \gamma_{14} &= -\frac{\beta\phi_u}{\sigma}\\ \gamma_{21} &= \theta_p\kappa_{py}\\ \gamma_{22} &= 1 - \theta_p + \theta_p\lambda_p S_G\psi_\tau\frac{\alpha+\varphi}{1-\alpha}\\ \gamma_{24} &= \theta_p\kappa_{pu}\\ \gamma_{33} &= 1-\theta_w\\ \gamma_{34} &= -\theta_w\lambda_w\varphi\end{aligned}$$

$$\begin{aligned}\alpha_{12} &= \beta\left[\frac{1}{\sigma} + \left(\frac{1}{\sigma} - S_G\right)\psi_\tau\right]\\ \beta_1 &= \beta\\ \beta_2 &= \beta\theta_p\\ \beta_3 &= \beta\theta_w\\ \kappa_1 &= \varphi\\ \kappa_2 &= \sigma + \frac{\varphi}{1-\alpha}\\ \kappa_3 &= 1 + \varphi S_G\psi_\tau/(1-\alpha)\\ \kappa_4 &= -\varphi S_G\psi_\tau/(1-\alpha)\end{aligned}$$

and $\varphi_{16} = \varphi_{17} = \varphi_{21} = \varphi_{22} = \varphi_{23} = \varphi_{24} = \varphi_{25} = \varphi_{27} = \gamma_{13} = \gamma_{23} = \gamma_{31} = \gamma_{32} = \alpha_{11} = \alpha_{13} = \alpha_{14} = \alpha_{21} = \alpha_{22} = \alpha_{23} = \alpha_{24} = \alpha_{31} = \alpha_{32} = \alpha_{33} = \alpha_{34} = 0$. Now we turn to solving the expectation terms. We can write the fundamental representation of the signal process as a system containing (8) and (9), which admits the following state-space representation

$$\begin{aligned} \boldsymbol{Z}_t &= \boldsymbol{F}\boldsymbol{Z}_{t-1} + \boldsymbol{\Phi}\boldsymbol{S}_{lgt} \\ \boldsymbol{X}_{lgt} &= \boldsymbol{H}\boldsymbol{Z}_t + \boldsymbol{\Psi}_g\boldsymbol{S}_{lgt} \end{aligned} \tag{C.6}$$

with

$$\begin{aligned}
\boldsymbol{Z}_t &= \begin{bmatrix} v_t & z_t & a_t & x_t & q_t & \mu_t^p & \mu_t^w \end{bmatrix}^\intercal \\
\boldsymbol{S}_{lgt} &= \begin{bmatrix} \varepsilon_t^v & \varepsilon_t^z & \varepsilon_t^a & \varepsilon_t^x & \varepsilon_t^q & \varepsilon_t^p & \varepsilon_t^w & u_{i,t}^v & u_{i,t}^z & u_{i,t}^a \\ u_{i,t}^x & u_{i,t}^q & u_{i,t}^p & u_{i,t}^w \end{bmatrix}^\intercal \\
\boldsymbol{F} &= \operatorname{diag}\begin{pmatrix} \rho_v & \rho_z & \rho_a & \rho_x & \rho_q & \rho_p & \rho_w \end{pmatrix} \\
\boldsymbol{\Phi} &= \begin{bmatrix} \operatorname{diag}\begin{pmatrix} \tau_v^{-1/2} & \tau_z^{-1/2} & \tau_a^{-1/2} & \tau_x^{-1/2} & \tau_q^{-1/2} & \tau_p^{-1/2} & \tau_w^{-1/2} \end{pmatrix} & \boldsymbol{0}_{7\times 7} \end{bmatrix} \\
\boldsymbol{\Psi}_g &= \begin{bmatrix} \boldsymbol{0}_{7\times 7} & \operatorname{diag}\begin{pmatrix} \tau_{gv}^{-1/2} & \tau_{gz}^{-1/2} & \tau_{ga}^{-1/2} & \tau_{gx}^{-1/2} & \tau_{gq}^{-1/2} & \tau_{gp}^{-1/2} & \tau_{gw}^{-1/2} \end{pmatrix} \end{bmatrix}
\end{aligned}$$

and $\boldsymbol{H} = \boldsymbol{I}_7$. The signal system can be written as

$$\boldsymbol{X}_{lgt} = \left[\operatorname{diag}\left(\left\{\tfrac{\tau_n^{-1/2}}{1-\rho_n L}\right\}_n\right) \quad \operatorname{diag}\left(\left\{\tau_{gv}^{-1/2}\right\}_n\right)\right]\boldsymbol{S}_{lgt} = \boldsymbol{M}_g(L)\boldsymbol{S}_{lgt}, \qquad \boldsymbol{S}_{lgt} \sim \mathcal{N}(0, I) \tag{C.7}$$

for $n \in \{v, z, a, q, p, w\}$. The Wold theorem states that there exists another representation of the signal process (C.7), $\boldsymbol{X}_{lgt} = \boldsymbol{B}_g(L)\boldsymbol{w}_{lgt}$, such that $\boldsymbol{B}_g(L)$ is invertible and $\boldsymbol{w}_{lgt} \sim (0, \boldsymbol{V}_g)$ is white noise. Hence, we can write the following equivalence

$$\boldsymbol{X}_{lgt} = \boldsymbol{M}_g(L)\boldsymbol{S}_{lgt} = \boldsymbol{B}_g(L)\boldsymbol{w}_{lgt} \tag{C.8}$$

In the Wold representation of $\boldsymbol{X}_{lgt}$, observing $\{\boldsymbol{X}_{lgt}\}$ is equivalent to observing $\{\boldsymbol{w}_{lgt}\}$, and $\{\boldsymbol{X}_{lg}^t\}$ and $\{\boldsymbol{w}_{lg}^t\}$ contain the same information. Furthermore, note that the Wold representation has the property that, using the equivalence (C.8), both processes share the autocovariance generating function, $\rho_{xx,g}(L) = \boldsymbol{M}_g(L)\boldsymbol{M}_g^\intercal(L^{-1}) = \boldsymbol{B}_g(L)\boldsymbol{V}_g\boldsymbol{B}_g^\intercal(L^{-1})$. Computing this last term,

$$\boldsymbol{M}_g(L)\boldsymbol{M}_g^\intercal(L^{-1}) = \left[\operatorname{diag}\left(\left\{\tau_{gn}^{-1} + \tfrac{\tau_n^{-1}L}{(L-\rho_n)(1-\rho_n L)}\right\}_n\right)\right] = \left[\operatorname{diag}\left(\left\{\tfrac{1-\lambda_{gn}L}{1-\rho_n L}\tfrac{\rho_n}{\lambda_{gn}\tau_{gn}}\tfrac{L-\lambda_{gn}}{L-\rho_n}\right\}_n\right)\right]$$

where, in the second equality, we have used the result that λ_{gn}, for $n \in \{r, z, a, \mu\}$, are the four inside roots of the determinant of $\boldsymbol{M}_g(L)\boldsymbol{M}_g^\intercal(L^{-1})$, $L^2 - \left(\frac{1}{\rho_n} + \rho_n + \frac{\tau_{gn}}{\rho_n\tau_n}\right)L + 1$, satisfying $(\rho_n - \lambda_{gn})(1 - \rho_n\lambda_{gn}) = \lambda_{gn}\frac{\tau_{gv}}{\tau_v}$. We can easily identify the unknown matrices,

$$\boldsymbol{B}_g(L) = \left[\operatorname{diag}\left(\left\{\tfrac{1-\lambda_{gn}L}{1-\rho_n L}\right\}_n\right)\right], \quad \boldsymbol{V}_g = \left[\operatorname{diag}\left(\left\{\tfrac{\rho_n}{\lambda_{gn}\tau_{gn}}\right\}_n\right)\right], \quad \boldsymbol{B}_g^\intercal(L^{-1}) = \left[\operatorname{diag}\left(\left\{\tfrac{L-\lambda_{gn}}{L-\rho_n}\right\}_n\right)\right].$$

Let us now move to the forecast of variables. Consider a variable $f_t = A(L)\boldsymbol{S}_{lgt}$. Applying the Wiener-Hopf prediction filter, we can obtain the forecast as

$$\mathbb{E}_{lgt}f_t = \left[A(L)\boldsymbol{M}_g^\intercal(L^{-1})\boldsymbol{B}_g(L^{-1})^{-1}\right]_+ \boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt},$$

where $[\cdot]_+$ denotes the annihilator operator. Recall from condition (B.2) that I am interested in obtaining $\mathbb{E}_{lgt}\xi_{k,t}$, $\mathbb{E}_{lgt}a_{j,t}$, $\mathbb{E}_{lgt}a_{j,t+1}$, and $\mathbb{E}_{lgt}a_{lg,t+1}$. We need to find the $A(z)$ polynomial for each of the forecasted variables. We start from the exogenous monetary policy shock, which can be written as $v_t = \left[\frac{\tau_v^{-1/2}}{1-\rho_v L} \quad \boldsymbol{0}_{1\times 13}\right]\boldsymbol{S}_{lgt} = A_v(L)\boldsymbol{S}_{lgt}$. Therefore, the forecasts of exogenous variables are,

$$\begin{aligned}
\mathbb{E}_{lgt}v_t &= \left[A_v(L)\boldsymbol{M}_g^\intercal(L^{-1})\boldsymbol{B}_g(L^{-1})^{-1}\right]_+ \boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt} = \left[\tfrac{L}{\tau_v(1-\rho_v L)(L-\lambda_{gv})} \quad \boldsymbol{0}_{1\times 6}\right]_+ \boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt} \\
&= \left[\left[\tfrac{\phi_v(L)}{L-\lambda_{gv}}\right]_+ \quad \boldsymbol{0}_{1\times 6}\right]\boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt}, \qquad \phi_v(z) = \frac{L}{\tau_v(1-\rho_v L)}
\end{aligned}$$

$$= \left[\tfrac{\phi_v(L)-\phi_v(\lambda_{gv})}{L-\lambda_{gv}} \quad \mathbf{0}_{1\times 6}\right] \boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt} = \left[\tfrac{1}{\tau_v(1-\rho_v L)(1-\rho_v\lambda_{gv})} \quad \mathbf{0}_{1\times 6}\right] \boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt}$$

$$= \left[\tfrac{\lambda_{gv}\tau_{gv}}{\rho_v\tau_v(1-\rho_v\lambda_{gv})}\tfrac{1}{1-\lambda_{gv}L} \quad \mathbf{0}_{1\times 6}\right] \boldsymbol{X}_{lgt} = \frac{\lambda_{gv}\tau_{gv}}{\rho_v\tau_v(1-\rho_v\lambda_{gv})}\frac{1}{1-\lambda_{gv}L}x^v_{lgt} = \left(1-\frac{\lambda_{gv}}{\rho_v}\right)\frac{1}{1-\lambda_{gv}L}x^v_{lgt}$$

$$= G_{gv}(L)x^v_{lgt}. \tag{C.9}$$

In the same manner, we can obtain

$$\mathbb{E}_{lgt}z_t = \left(1-\frac{\lambda_{gz}}{\rho_z}\right)\frac{1}{1-\lambda_{gz}L}x^z_{lgt} = G_{gz}(L)x^z_{i,t} \tag{C.10}$$

$$\mathbb{E}_{lgt}a_t = \left(1-\frac{\lambda_{ga}}{\rho_a}\right)\frac{1}{1-\lambda_{ga}L}x^a_{i,t} = G_{ga}(L)x^a_{lgt} \tag{C.11}$$

$$\mathbb{E}_{lgt}x_t = \left(1-\frac{\lambda_{gx}}{\rho_x}\right)\frac{1}{1-\lambda_{gx}L}x^x_{i,t} = G_{gx}(L)x^x_{lgt} \tag{C.12}$$

$$\mathbb{E}_{lgt}q_t = \left(1-\frac{\lambda_{gq}}{\rho_q}\right)\frac{1}{1-\lambda_{gq}L}x^q_{i,t} = G_{gq}(L)x^q_{lgt} \tag{C.13}$$

$$\mathbb{E}_{lgt}\mu^p_t = \left(1-\frac{\lambda_{gp}}{\rho_p}\right)\frac{1}{1-\lambda_{gp}L}x^p_{i,t} = G_{gp}(L)x^p_{lgt} \tag{C.14}$$

$$\mathbb{E}_{lgt}\mu^w_t = \left(1-\frac{\lambda_{gw}}{\rho_w}\right)\frac{1}{1-\lambda_{gw}L}x^w_{i,t} = G_{gw}(L)x^w_{lgt} \tag{C.15}$$

Let us now move to the endogenous variables. In this case, we need to guess (and verify) that each agent i's policy function takes the form $a_{lgt} = \sum_n h_{gn}(L)x^n_{lgt}$.[10] Aggregate action can then be expressed as

$$a_{gt} = \int_0^1 a_{lgt}\, dl \in g = \int_0^1 \left[\sum_n h_{gn}(L)x^n_{lgt}\right] dl = \sum_n h_{gn}(L)\frac{\tau_n^{-1/2}}{1-\rho_n L}\varepsilon^n_t = \left[\left(\left\{h_{gv}(L)\tfrac{\tau_v^{-1/2}}{1-\rho_v L}\right\}_{n,1\times 7} \quad \mathbf{0}_{1\times 7}\right)\right]\boldsymbol{S}_{lgt}$$
$$= A_{ag0}(L)\boldsymbol{S}_{lgt}$$
$$a_{g,t+1} = \left[\left(\left\{h_{gn}(L)\tfrac{\tau_n^{-1/2}}{L(1-\rho_n L)}\right\}_{n,1\times 7} \quad \mathbf{0}_{1\times 7}\right)\right]\boldsymbol{S}_{lgt} = A_{ag1}(L)\boldsymbol{S}_{lgt}.$$

Finally,

$$a_{lg,t+1} = \frac{1}{L}\left[\left(\{h_{gn}(L)\}_n\right)_{1\times 7}\right]\boldsymbol{X_t} = \frac{1}{L}\left[\left(\{h_{gn}(L)\}_n\right)_{1\times 7}\right]\boldsymbol{M}_g(L)\boldsymbol{S}_{lgt}$$
$$= \left[\left(\left\{\tfrac{h_{gn}(L)}{L}\tfrac{\tau_n^{-1/2}}{1-\rho_n L}\right\}_n\right)_{1\times 7} \quad \left(\left\{\tfrac{h_{gn}(L)}{L}\tau_{gn}^{-1/2}\right\}_n\right)_{1\times 7}\right]\boldsymbol{S}_{lgt} = A_{gi}(L)\boldsymbol{S}_{lgt}.$$

Looking now at the endogenous variables,

$$\mathbb{E}_{lgt}a_{kt} = \left[A_{ak0}(L)\boldsymbol{M}_g^\intercal(L^{-1})\boldsymbol{B}_g(L^{-1})^{-1}\right]_+\boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt} = \left[\left(\left\{\tfrac{Lh_{kn}(L)}{\tau_n(1-\rho_n L)(L-\lambda_{gn})}\right\}_n\right)_{1\times 7}\right]_+\boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt}$$
$$= \left[\left[\left\{\tfrac{\phi_{ak0n}(L)}{L-\lambda_{gn}}\right\}_{n,1\times 7}\right]_+\right]\boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt}, \quad \phi_{ak0n}(z) = \frac{Lh_{kn}(L)}{\tau_n(1-\rho_n L)}$$
$$= \left[\left\{\tfrac{\phi_{ak0n}(L)-\phi_{ak0n}(\lambda_{gn})}{L-\lambda_{gn}}\right\}_{n,1\times 7}\right]\boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt} = \left[\left\{\tfrac{Lh_{kn}(L)-\lambda_{gn}h_{kn}(\lambda_{gn})\frac{1-\rho_n L}{1-\rho_n\lambda_{gn}}}{\tau_n(1-\rho_n L)(L-\lambda_{gn})}\right\}_{n,1\times 7}\right]\boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt}$$
$$= \left[\left\{\tfrac{\lambda_{gn}\tau_{gn}\left[Lh_{kn}(L)-\lambda_{gn}h_{kn}(\lambda_{gn})\frac{1-\rho_n L}{1-\rho_n\lambda_{gn}}\right]}{\rho_n\tau_n(1-\lambda_{gn}L)(L-\lambda_{gn})}\right\}\right]\boldsymbol{X}_{lgt}$$

[10] In this framework agents only observe signals, and the policy function can only depend on current and past signals.

$$
\begin{aligned}
&= \sum_n \frac{\lambda_{gn}\tau_{gn}\left[Lh_{kn}(L) - \lambda_{gn}h_{kn}(\lambda_{gn})\frac{1-\rho_n L}{1-\rho_n\lambda_{gn}}\right]}{\rho_n\tau_n}\frac{1}{(1-\lambda_{gn}L)(L-\lambda_{gn})}x_{lgt}^n \\
&= \sum_n \left(1-\frac{\lambda_{gn}}{\rho_n}\right)\left[Lh_{kn}(L)(1-\rho_n\lambda_{gn}) - \lambda_{gn}h_{kn}(\lambda_{gn})(1-\rho_n L)\right]\frac{1}{(1-\lambda_{gn}L)(L-\lambda_{gn})}x_{lgt}^n = \sum_n G_{0gkn}(L)x_{lg}^n
\end{aligned}
\tag{C.16}
$$

$$
\mathbb{E}_{lgt}a_{k,t+1} = \sum_n \left(1-\frac{\lambda_{gn}}{\rho_n}\right)\left[h_{kn}(L)(1-\rho_n\lambda_{gn}) - h_{kn}(\lambda_{gn})(1-\rho_n L)\right]\frac{1}{(1-\lambda_{gn}L)(L-\lambda_{gn})}x_{lgt}^n = \sum_n G_{1gkn}(L)x_{lgt}^n
\tag{C.17}
$$

$$
\begin{aligned}
\mathbb{E}_{lgt}a_{lg,t+1} &= \left[A_{gi}(L)\boldsymbol{M}_g^{\intercal}(L^{-1})\boldsymbol{B}_g(L^{-1})^{-1}\right]_+ \boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt} = \left[\left\{\frac{h_{gn}(L)}{L-\lambda_{gn}}\left(\frac{1}{\tau_n(1-\rho_n L)} + \frac{L-\rho_n}{L\tau_{gn}}\right)\right\}_{n,1\times 7}\right]_+ \boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X} \\
&= \left[\left\{\left[\frac{\phi_{igv1}(L)}{L-\lambda_{gv}}\right]_+ + \left[\frac{\phi_{igv2}(L)}{L(L-\lambda_{gv})}\right]_+\right\}_{n,1\times 7}\right]\boldsymbol{V}_g^{-1}\boldsymbol{B}_g(L)^{-1}\boldsymbol{X}_{lgt} \\
&= \sum_n \left(\frac{h_{gn}(L)}{L-\lambda_{gn}}\left(\left(1-\frac{\lambda_{gn}}{\rho_n}\right)\frac{1-\rho_n\lambda_{gn}}{1-\rho_n L} + \frac{\lambda_{gn}(L-\rho_n)}{\rho_n L}\right) - \frac{h_{gn}(0)}{L}\right)\frac{1-\rho_n L}{1-\lambda_{gn}L}x_{i,t}^n = \sum_n G_{ign}(L)x_{lgt}^n
\end{aligned}
\tag{C.18}
$$

where $\phi_{ign1}(L) = \frac{h_{gn}(L)}{\tau_n(1-\rho_n L)}$ and $\phi_{ign2}(L) = \frac{h_{gn}(L)(L-\rho_n)}{\tau_{gn}}$. Inserting our obtained expressions into (C.4), and removing the x_{lgt}^n terms, and rearranging terms on the LHS and RHS

$$
\begin{aligned}
&h_{gn}(L)\left\{1-\beta_g\left[\left(1-\frac{\lambda_{gn}}{\rho_n}\right)\frac{1-\rho_n\lambda_{gn}}{1-\rho_n L} + \frac{\lambda_{gn}(L-\rho_n)}{\rho_n L}\right]\frac{1-\rho_n L}{(1-\lambda_{gn}L)(L-\lambda_{gn})}\right\} \\
&-\sum_{k=1}^4 h_{kn}(L)\frac{(\rho_n-\lambda_{gn})(1-\rho_n\lambda_{gn})}{\rho_n}\frac{\gamma_{gk}L+\alpha_{gk}}{(1-\lambda_{gn}L)(L-\lambda_{gn})} \\
&= \varphi_{gn}\left(1-\frac{\lambda_{gn}}{\rho_n}\right)\frac{1}{1-\lambda_{gn}L} - \beta_g\frac{1-\rho_n L}{L(1-\lambda_{gn}L)}h_{gn}(0) - \sum_{k=1}^4 h_{kn}(\lambda_{gn})\left(1-\frac{\lambda_{gn}}{\rho_n}\right)\frac{\gamma_{gk}\lambda_{gn}+\alpha_{gk}}{(1-\lambda_{gn}L)(L-\lambda_{gn})}(1-\rho_n L)
\end{aligned}
$$

Multiplying both sides by $L(L-\lambda_{gn})(1-\lambda_{gn}L)$,

$$
\begin{aligned}
&h_{gn}(L)\left[L(L-\lambda_{gn})(1-\lambda_{gn}L) - \beta_g(L-\lambda_{gn})(1-\lambda_{gn}L)\right] - \sum_{k=1}^4 h_{kn}(L)\left(1-\frac{\lambda_{gn}}{\rho_n}\right)(1-\rho_n\lambda_{gn})L(\gamma_{gk}L+\alpha_{gk}) \\
&= \varphi_{gn}\left(1-\frac{\lambda_{gn}}{\rho_n}\right)L(L-\lambda_{gn}) - \beta_g(1-\rho_n L)(L-\lambda_{gn})h_{gn}(0) - \sum_{k=1}^4 h_{kn}(\lambda_{gn})\left(1-\frac{\lambda_{gn}}{\rho_n}\right)(\gamma_{gk}\lambda_{gn}+\alpha_{gk})L(1-\rho_n L)
\end{aligned}
$$

We can write the above system of equations in terms of $\boldsymbol{h}(L)$ in matrix form

$$
\boldsymbol{C}_n(L)\boldsymbol{h}_n(L) = \boldsymbol{d}_n(L)
\tag{C.19}
$$

where $\boldsymbol{C}_n(L) = \begin{bmatrix} C_{n11}(L) & C_{n12}(L) & C_{n13}(L) & C_{n14}(L) \\ C_{n21}(L) & C_{n22}(L) & C_{n23}(L) & C_{n24}(L) \\ C_{n31}(L) & C_{n32}(L) & C_{n33}(L) & C_{n34}(L) \\ C_{n41}(L) & C_{n42}(L) & C_{n43}(L) & C_{n44}(L) \end{bmatrix}$, where

$$
\begin{aligned}
&C_{nkk}(L) = \lambda_{kn}\left[(\beta_k - L)\left(L-\frac{1}{\rho_n}\right)(L-\rho_n) + \frac{\tau_{kn}}{\rho_n\tau_n}L\left[L(1-\gamma_{kk})-\delta_{kk}\right]\right], \quad k\in\{1,2,3\} \\
&C_{njk}(L) = -\lambda_{jn}L\frac{\tau_{jn}}{\rho_n\tau_n}(L\gamma_{jk}+\delta_{jk}), \quad j\neq k, \quad j\in\{1,2,3\}, \quad k\in\{1,2,3,4\} \\
&C_{n41}(L) = \kappa_2(1-L), \quad C_{n42}(L) = \kappa_3+\kappa_4 L, \quad C_{n43}(L) = -1, \quad C_{n44} = \kappa_1(1-L)
\end{aligned}
$$

I can also write $\boldsymbol{d}_n(z) = \begin{bmatrix} d_{1n}[L; h_{1n}(\cdot)] & d_{2n}[L; h_{2n}(\cdot)] & d_{3n}[L; h_{3n}(\cdot)] & d_{4n}[L; h_{4n}(\cdot)] \end{bmatrix}^\intercal$, where

$$d_{gn}(L) = \varphi_{gn}\left(1 - \frac{\lambda_{gn}}{\rho_n}\right) L(L - \lambda_{gn}) - \beta_g(1 - \rho_n L)(L - \lambda_{gn}) h_{gn}(0) - \sum_{k=1}^{4} h_{kn}(\lambda_{gn}) \left(1 - \frac{\lambda_{gn}}{\rho_n}\right) (\gamma_{gk}\lambda_{gn} + \alpha_{gk}) L(1 - \rho_n$$

for $g = \{1, 2, 3\}$ and $d_{4n}(L) = 0$

From (C.19), the solution to the policy function is given by $\boldsymbol{h}_n(L) = \boldsymbol{C}_n(L)^{-1}\boldsymbol{d}_n(L) = \frac{\operatorname{adj} \boldsymbol{C}_n(L)}{\det \boldsymbol{C}_n(L)}\boldsymbol{d}(L)$. Hence, we need to obtain $\det \boldsymbol{C}_n(L)$. Note that the degree of $\det \boldsymbol{C}_n(L)$ is a polynomial of degree 10 on L. Denote the inside roots of $\det \boldsymbol{C}_n(L)$ as $\{\zeta_{1n}, \zeta_{2n}, \zeta_{3n}, \zeta_{4n}, \zeta_{5n}, \zeta_{6n}\}$, and the outside roots as $\left\{\vartheta_{1n}^{-1}, \vartheta_{2n}^{-1}, \vartheta_{3n}^{-1}, \vartheta_{4n}^{-1}\right\}$. Because agents cannot use future signals, the inside roots have to be removed. Note that the number of free constants in $\boldsymbol{d}_n(L)$ is 6: $\{h_{gn}(0)\}$ and $\left\{\widetilde{h}_n(\lambda_{gn}) = \sum_{k=1}^{4} h_{kn}(\lambda_{gn}) \left(1 - \frac{\lambda_{gn}}{\rho_n}\right)(\gamma_{gk}\lambda_{gn} + \alpha_{gk})\right\}$ for each $g \in \{1, 2, 3\}$. With a unique solution, it has to be the case that the number of outside roots is 4. By Cramer's rule, $h_{gn}(L)$ is given by

$$h_{1n}(z) = \frac{\det \begin{bmatrix} d_{1n}(z) & C_{n12}(z) & C_{n13}(z) & C_{n14}(z) \\ d_{2n}(z) & C_{n22}(z) & C_{n13}(z) & C_{n14}(z) \\ d_{3n}(z) & C_{n32}(z) & C_{n33}(z) & C_{n34}(z) \\ d_{4n} & C_{n42}(z) & C_{n43}(z) & C_{n44}(z) \end{bmatrix}}{\det \boldsymbol{C}(z)}, \quad h_{2n}(z) = \frac{\det \begin{bmatrix} C_{n11}(z) & d_{1n}(z) & C_{n13}(z) & C_{n14}(z) \\ C_{n21}(z) & d_{2n}(z) & C_{n13}(z) & C_{n14}(z) \\ C_{n31}(z) & d_{3n}(z) & C_{n33}(z) & C_{n34}(z) \\ C_{n41}(z) & d_{4n} & C_{n43}(z) & C_{n44}(z) \end{bmatrix}}{\det \boldsymbol{C}(z)}$$

$$h_{3n}(z) = \frac{\det \begin{bmatrix} C_{n11}(z) & C_{n12}(z) & d_{1n}(z) & C_{n14}(z) \\ C_{n21}(z) & C_{n22}(z) & d_{2n}(z) & C_{n24}(z) \\ C_{n31}(z) & C_{n32}(z) & d_{3n}(z) & C_{n34}(z) \\ C_{n41}(z) & C_{n42}(z) & d_{4n} & C_{n44}(z) \end{bmatrix}}{\det \boldsymbol{C}(z)}, \quad h_{4n}(z) = \frac{\det \begin{bmatrix} C_{n11}(z) & C_{n12}(z) & C_{n13}(z) & d_{1n}(z) \\ C_{n21}(z) & C_{n22}(z) & C_{n13}(z) & d_{2n}(z) \\ C_{n31}(z) & C_{n32}(z) & C_{n33}(z) & d_{3n}(z) \\ C_{n41}(z) & C_{n42}(z) & C_{n43}(z) & d_{4n} \end{bmatrix}}{\det \boldsymbol{C}(z)}$$

Which are the policy function for the different groups. The degree of the numerator is 8, as the highest degree of $d_{gn}(L)$ is 1 degree less than that of $\boldsymbol{C}_n(L)$. By choosing the appropriate constants

$$\left\{h_{1n}(0), \widetilde{h}_{1n}(\lambda_{1n}), h_{2n}(0), \widetilde{h}_{2n}(\lambda_{2n}), h_{3n}(0), \widetilde{h}_{3n}(\lambda_{3n})\right\},$$

the 6 inside roots will be removed. Therefore, the 6 constants are solutions to the following system of linear equations

$$\det \begin{bmatrix} d_{1n}(\zeta_{in}) & C_{n12}(\zeta_{in}) & C_{n13}(\zeta_{in}) & C_{n14}(\zeta_{in}) \\ d_{2n}(\zeta_{in}) & C_{n22}(\zeta_{in}) & C_{n23}(\zeta_{in}) & C_{n24}(\zeta_{in}) \\ d_{3n}(\zeta_{in}) & C_{n32}(\zeta_{in}) & C_{n33}(\zeta_{in}) & C_{n34}(\zeta_{in}) \\ d_{4n} & C_{n42}(\zeta_{in}) & C_{n43}(\zeta_{in}) & C_{n44}(\zeta_{in}) \end{bmatrix} = 0$$

After removing the inside roots in the denominator, the degree of the numerator is 2 and the degree of the denominator is 3. The above determinants can be written as a system of 6 equations and 6 unknowns (our free constants). Once we have set the appropriate free constants the policy functions for $g \in \{1, 2, 3, 4\}$ will be

$$\begin{aligned} h_{gn}(z) &= \frac{\widetilde{\psi}_{gn1} + \widetilde{\psi}_{gn2}z + \widetilde{\psi}_{gn3}z^2 + \widetilde{\psi}_{gn4}z^3}{(1 - \vartheta_{1n}z)(1 - \vartheta_{2n}z)(1 - \vartheta_{3n}z)(1 - \vartheta_{4n}z)} = \frac{\widetilde{\psi}_{gn4}(z - \mu_{gn1})(z - \mu_{gn2})(z - \mu_{gn3})}{(1 - \vartheta_{1n}z)(1 - \vartheta_{2n}z)(1 - \vartheta_{3n}z)(1 - \vartheta_{4n}z)} \\ &= -\frac{\widetilde{\psi}_{gn4}\mu_{gn1}\mu_{gn2}\mu_{gn3}(1 - \mu_{gn1}^{-1}z)(1 - \mu_{gn2}^{-1}z)(1 - \mu_{gn3}^{-1}z)}{(1 - \vartheta_{1n}z)(1 - \vartheta_{2n}z)(1 - \vartheta_{3n}z)(1 - \vartheta_{4n}z)} = \frac{\widetilde{\psi}_{gn1}(1 - \mu_{gn1}^{-1}z)(1 - \mu_{gn2}^{-1}z)(1 - \mu_{gn3}^{-1}z)}{(1 - \vartheta_{1n}z)(1 - \vartheta_{2n}z)(1 - \vartheta_{3n}z)(1 - \vartheta_{4n}z)} \\ &= \widetilde{\psi}_{gn1}\left\{\frac{(\vartheta_{1n} - \mu_{gn1}^{-1})(\vartheta_{3n} - \mu_{g2}^{-1})}{(\vartheta_{1n} - \vartheta_{2n})(\vartheta_{3n} - \vartheta_{4n})} \frac{1 - \mu_{gn3}^{-1}z}{(1 - \vartheta_{1n}z)(1 - \vartheta_{3n}z)} - \frac{(\vartheta_{1n} - \mu_{g1}^{-1})(\vartheta_{4n} - \mu_{gn2}^{-1})}{(\vartheta_{1n} - \vartheta_{2n})(\vartheta_{3n} - \vartheta_{4n})} \frac{1 - \mu_{gn3}^{-1}z}{(1 - \vartheta_{1n}z)(1 - \vartheta_{4n}z)}\right. \\ &\qquad \left. - \frac{(\vartheta_{2n} - \mu_{g1}^{-1})(\vartheta_{3n} - \mu_{gn2}^{-1})}{(\vartheta_{1n} - \vartheta_{2n})(\vartheta_{3n} - \vartheta_{4n})} \frac{1 - \mu_{gn3}^{-1}z}{(1 - \vartheta_{2n}z)(1 - \vartheta_{3n}z)} + \frac{(\vartheta_{2n} - \mu_{g1}^{-1})(\vartheta_{4n} - \mu_{gn2}^{-1})}{(\vartheta_{1n} - \vartheta_{2n})(\vartheta_{3n} - \vartheta_{4n})} \frac{1 - \mu_{gn3}^{-1}z}{(1 - \vartheta_{2n}z)(1 - \vartheta_{4n}z)}\right\} \end{aligned}$$

$$
\begin{aligned}
&= \beta_{gn1}\frac{1-\mu_{gn3}^{-1}z}{(1-\vartheta_{1n}z)(1-\vartheta_{3n}z)} + \beta_{gn2}\frac{1-\mu_{gn3}^{-1}z}{(1-\vartheta_{1n}z)(1-\vartheta_{4n}z)} + \beta_{gn3}\frac{1-\mu_{gn3}^{-1}z}{(1-\vartheta_{2n}z)(1-\vartheta_{3n}z)} + \beta_{gn4}\frac{1-\mu_{gn3}^{-1}z}{(1-\vartheta_{2n}z)(1-\vartheta_{4n}z)} \\
&= \left[\beta_{gn1}\frac{\vartheta_{1n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{3n}} + \beta_{gn2}\frac{\vartheta_{1n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{4n}}\right]\frac{1}{1-\vartheta_{1n}z} + \left[\beta_{gn3}\frac{\vartheta_{2n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{3n}} + \beta_{gn4}\frac{\vartheta_{2n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{4n}}\right]\frac{1}{1-\vartheta_{2n}z} \\
&\quad - \left[\beta_{gn1}\frac{\vartheta_{3n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{3n}} + \beta_{gn3}\frac{\vartheta_{3n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{3n}}\right]\frac{1}{1-\vartheta_{3n}z} - \left[\beta_{gn2}\frac{\vartheta_{4n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{4n}} + \beta_{gn4}\frac{\vartheta_{4n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{4n}}\right]\frac{1}{1-\vartheta_{4n}z} \\
&= \kappa_{gn1}\frac{1}{1-\vartheta_{1n}z} + \kappa_{gn2}\frac{1}{1-\vartheta_{2n}z} + \kappa_{gn3}\frac{1}{1-\vartheta_{3n}z} + \kappa_{gn4}\frac{1}{1-\vartheta_{4n}z} \\
&= \psi_{gn1}\left(1-\frac{\vartheta_{1n}}{\rho_n}\right)\frac{1}{1-\vartheta_{1n}z} + \psi_{gn2}\left(1-\frac{\vartheta_{2n}}{\rho_n}\right)\frac{1}{1-\vartheta_{2n}z} + \psi_{gn3}\left(1-\frac{\vartheta_{3n}}{\rho_n}\right)\frac{1}{1-\vartheta_{3n}z} + \psi_{gn4}\left(1-\frac{\vartheta_{4n}}{\rho_n}\right)\frac{1}{1-\vartheta_{4n}z}
\end{aligned}
$$

where $\{\mu_{gn1}, \mu_{gn2}, \mu_{gn3}\}$ are the roots of the cubic polynomial $\widetilde{\psi}_{gn1} + \widetilde{\psi}_{gn2}z + \widetilde{\psi}_{gn3}z^2 + \widetilde{\psi}_{gn4}z^3$, $\widetilde{\psi}_{gn1} = -\widetilde{\psi}_{gn4}\mu_{gn1}\mu_{gn2}\mu_{gn3}$ follows from the Vieta properties,

$$
\begin{aligned}
\beta_{gn1} &= \frac{\widetilde{\psi}_{gn1}(\vartheta_{1n}-\mu_{gn1}^{-1})(\vartheta_{3n}-\mu_{gn2}^{-1})}{(\vartheta_{1n}-\vartheta_{2n})(\vartheta_{3n}-\vartheta_{4n})} & \beta_{gn3} &= -\frac{\widetilde{\psi}_{gn1}(\vartheta_{2n}-\mu_{gn1}^{-1})(\vartheta_{3n}-\mu_{gn2}^{-1})}{(\vartheta_{1n}-\vartheta_{2n})(\vartheta_{3n}-\vartheta_{4n})} \\
\beta_{gn2} &= -\frac{\widetilde{\psi}_{gn1}(\vartheta_{1n}-\mu_{gn1}^{-1})(\vartheta_{4n}-\mu_{gn2}^{-1})}{(\vartheta_{1n}-\vartheta_{2n})(\vartheta_{3n}-\vartheta_{4n})} & \beta_{gn4} &= \frac{\widetilde{\psi}_{gn1}(\vartheta_{2n}-\mu_{gn1}^{-1})(\vartheta_{4n}-\mu_{gn2}^{-1})}{(\vartheta_{1n}-\vartheta_{2n})(\vartheta_{3n}-\vartheta_{4n})} \\
\kappa_{gn1} &= \beta_{gn1}\frac{\vartheta_{1n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{3n}} + \beta_{gn2}\frac{\vartheta_{1n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{4n}} & \kappa_{gn3} &= -\beta_{gn1}\frac{\vartheta_{3n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{3n}} - \beta_{gn3}\frac{\vartheta_{3n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{3n}} \\
\kappa_{gn2} &= \beta_{gn3}\frac{\vartheta_{2n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{3n}} + \beta_{gn4}\frac{\vartheta_{2n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{4n}} & \kappa_{gn4} &= -\beta_{gn2}\frac{\vartheta_{4n}-\mu_{gn3}^{-1}}{\vartheta_{1n}-\vartheta_{4n}} - \beta_{gn4}\frac{\vartheta_{4n}-\mu_{gn3}^{-1}}{\vartheta_{2n}-\vartheta_{4n}}
\end{aligned}
$$

and $\psi_{gnl} = \kappa_{gnl}\left(1-\vartheta_{nl}/\rho_n\right)^{-1}$. Hence, we have

$$
a_{g,t} = \sum_n h_{gn}(L)\xi_{nt} = \sum_n \sum_{j=1}^{4} \psi_{ngj}\left(1-\frac{\vartheta_{jn}}{\rho_n}\right)\frac{1}{1-\vartheta_{jn}L}\xi_{nt} = \sum_n \sum_{j=1}^{4} \psi_{ngj}\widetilde{\vartheta}_{ngj,t}
$$

We can write

$$
\boldsymbol{a}_{nt} = \begin{bmatrix} a_{1nt} \\ a_{2nt} \\ a_{3nt} \\ a_{4nt} \end{bmatrix} = \Psi_n \widetilde{\vartheta}_t = \begin{bmatrix} \psi_{11,n} & \psi_{12,n} & \psi_{13,n} & \psi_{14,n} \\ \psi_{21,n} & \psi_{22,n} & \psi_{23,n} & \psi_{24,n} \\ \psi_{31,n} & \psi_{32,n} & \psi_{33,n} & \psi_{34,n} \\ \psi_{41,n} & \psi_{42,n} & \psi_{43,n} & \psi_{44,n} \end{bmatrix} \begin{bmatrix} \widetilde{\vartheta}_{1nt} \\ \widetilde{\vartheta}_{2nt} \\ \widetilde{\vartheta}_{3nt} \\ \widetilde{\vartheta}_{4nt} \end{bmatrix}
$$

Notice that we can write $\widetilde{\vartheta}_{jn,t}(1-\vartheta_{jn}L) = \left(1-\frac{\vartheta_{jn}}{\rho_n}\right)n_t \implies \widetilde{\vartheta}_{jn,t} = \vartheta_{jn}\widetilde{\vartheta}_{jn,t-1} + \left(1-\frac{\vartheta_{jn}}{\rho_n}\right)n_t$, which I can write as a system as $\widetilde{\vartheta}_{nt} = \Lambda_n\widetilde{\vartheta}_{n,t-1} + \Gamma_n n_t$, where $\Lambda_n = \text{diag}\left[\{\vartheta_{jn}\}_j\right]$, $\Gamma_n = \left[1-\frac{\vartheta_{1n}}{\rho_n} \quad 1-\frac{\vartheta_{2n}}{\rho_n} \quad 1-\frac{\vartheta_{3n}}{\rho_n} \quad 1-\frac{\vartheta_{4n}}{\rho_n}\right]^{\intercal}$. Hence, I can write $\boldsymbol{a}_{nt} = Q_n\widetilde{\theta}_{nt} = \Psi_n(\Lambda_n\widetilde{\theta}_{n,t-1} + \Gamma_n n_t) = \Psi_n\Lambda_n\widetilde{\theta}_{n,t-1} + \Psi_n\Gamma_n n_t = \Psi_n\Lambda_n\Psi_n^{-1}\boldsymbol{a}_{n,t-1} + \Psi_n\Gamma_n n_t = A_n\boldsymbol{a}_{n,t-1} + B_n n_t$. Finally, $\boldsymbol{a}_t = \sum_n \boldsymbol{a}_{nt}$. □

Proposition C.1. *(i) The reaction of the backcast of price inflation and the unemployment rate to an announced VAT change, $s_{t,0}^{\tau}$, is given by the OLS coefficient $\beta_g^{backcast} = \mathbb{C}\left[\mathbb{E}_t^l a_{g,t-1}, s_{t,0}^{\tau}\right]/\mathbb{V}\left[s_{t,0}^{\tau}\right]$ for a variable $a_g \in \{\pi^p, \widetilde{u}\}$, where*

$$
\mathbb{C}\left[\mathbb{E}_t^l a_{g,t-1}, s_{t,0}^{\tau}\right] = \sum_n \left\{\sum_{j=1}^{4}\frac{\widetilde{\alpha}_{nlgj}\chi_{nl}}{1-\vartheta_{jn}\lambda_{ln}} + \sum_{j=1}^{4}\sum_{m=1}^{4}\frac{\widetilde{\alpha}_{nlgj}\mu_{nlm}}{1-\vartheta_{jn}\vartheta_{mn}} + \frac{\widetilde{\delta}_{nlg}\chi_{nl}}{1-\lambda_{ln}^2} + \sum_{j=1}^{4}\frac{\widetilde{\delta}_{nlg}\mu_{nlj}}{1-\vartheta_{jn}\lambda_{ln}}\right.
$$

$$
+\frac{\widetilde{\kappa}_{ng}\chi_{nl}}{1-\rho_n\lambda_{ln}}+\sum_{j=1}^{4}\frac{\widetilde{\kappa}_{ng}\mu_{nlj}}{1-\vartheta_{jn}\rho_n}\Bigg\}\sigma_n^2
$$

$$
\mathbb{V}\left[s_{t,0}^{\tau}\right]=\sum_n\left\{\frac{\chi_{nl}^2}{1-\lambda_{ln}^2}+2\sum_{j=1}^{4}\frac{\chi_{nl}\mu_{nlj}}{1-\lambda_{nl}\vartheta_{jn}}+\sum_{j=1}^{4}\sum_{m=1}^{4}\frac{\mu_{nlj}\mu_{nlm}}{1-\vartheta_{jn}\vartheta_{mn}}\right\}\sigma_n^2
$$

where $\widetilde{\alpha}_{nlgj},\widetilde{\delta}_{nlg},\widetilde{\kappa}_{ng},\chi_{nl},\mu_{nlm},\lambda_{ln}$ are all coefficients that depend on the degree of information frictions, derived in Appendix C.

(ii) The reaction of the forecast of price inflation and the unemployment rate to an announced VAT change, $s_{t,0}^{\tau}$, is given by the OLS coefficient $\beta_g^{forecast}=\mathbb{C}\left[\overline{\mathbb{E}}_t^c a_{g,t+4},s_{t,0}^{\tau}\right]/\mathbb{V}\left[s_{t,0}^{\tau}\right]$ for a variable $a_g\in\{\pi^p,\widetilde{u}\}$, where

$$
\begin{aligned}
\mathbb{C}\left[\overline{\mathbb{E}}_t^l a_{g,t+4},s_{t,0}^{\tau}\right]=\sum_n\Bigg\{&\sum_{s=1}^{4}\sum_{j=1}^{4}\frac{\alpha_{nlgj,s}\chi_{nl}}{1-\vartheta_{jn}\lambda_{ln}}\vartheta_{jn}^{4-s}+\sum_{s=1}^{4}\sum_{j=1}^{4}\sum_{m=1}^{4}\frac{\alpha_{nlgj,s}\mu_{nlm}}{1-\vartheta_{jn}\lambda_{m\pi}}\vartheta_{jn}^{4-s}+\\
&+\sum_{s=1}^{4}\frac{\delta_{nlg,s}\chi_{nl}}{1-\lambda_{ln}^2}\lambda_{ln}^{4-s}+\sum_{s=1}^{4}\sum_{j=1}^{4}\frac{\delta_{nlg,s}\mu_{nlj}}{1-\vartheta_{jn}\lambda_{ln}}\lambda_{ln}^{4-s}+\\
&+\sum_{s=1}^{4}\frac{\kappa_{ng,s}\chi_{nl}}{1-\rho_n\lambda_{ln}}\rho_n^{4-s}+\sum_{s=1}^{4}\sum_{j=1}^{4}\frac{\kappa_{ng,s}\mu_{nlj}}{1-\vartheta_{jn}\rho_n}\rho_n^{4-s}\Bigg\}\sigma_n^2
\end{aligned}
$$

where $\alpha_{nlgj},\delta_{nlg},\kappa_{ng}$ are all coefficients that depend on the degree of information frictions.

Proof of Proposition C.1. Following the results in the proof of Proposition 1, we have that

$$
\overline{\mathbb{E}}_t^c a_{g,t+k}=\sum_n\left(1-\frac{\lambda_{ln}}{\rho_n}\right)\frac{L^{1-k}h_{gn}(L)(1-\rho_n\lambda_{ln})-\lambda_{ln}^{1-k}h_{gn}(\lambda_{ln})(1-\rho_nL)}{(1-\lambda_{ln}L)(L-\lambda_{ln})}n_t
$$

for $k\geq 0$ and $n\in\{v,z,a,q,p,w\}$. We can compute

$$
\begin{aligned}
\overline{\mathbb{E}}_t^l a_{g,t-1}&=\sum_n\left(1-\frac{\lambda_{ln}}{\rho_n}\right)\frac{L^2h_{gn}(L)(1-\rho_n\lambda_{ln})-\lambda_{ln}^2h_{gn}(\lambda_{ln})(1-\rho_nL)}{(1-\lambda_{ln}L)(L-\lambda_{ln})}n_t\\
&=\sum_n\left(1-\frac{\lambda_{ln}}{\rho_n}\right)\frac{L^2\sum_{j=1}^4\psi_{ngj}\left(1-\frac{\vartheta_{jn}}{\rho_n}\right)\frac{1}{1-\vartheta_{jn}L}(1-\rho_n\lambda_{ln})-\lambda_{ln}^2\sum_{j=1}^4\psi_{ngj}\left(1-\frac{\vartheta_{jn}}{\rho_n}\right)\frac{1}{1-\vartheta_{jn}\lambda_{ln}}(1-\rho_nL)}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_nL)}\varepsilon_t^n\\
&=\sum_n\sum_{j=1}^{4}\left(1-\frac{\lambda_{ln}}{\rho_n}\right)\psi_{ngj}\left(1-\frac{\vartheta_{jn}}{\rho_n}\right)\frac{\frac{L^2(1-\rho_n\lambda_{ln})}{1-\vartheta_{jn}L}-\frac{\lambda_{ln}^2(1-\rho_nL)}{1-\vartheta_{jn}\lambda_{ln}}}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_nL)}\varepsilon_t^n\\
&=\sum_n\sum_{j=1}^{4}\left(1-\frac{\lambda_{ln}}{\rho_n}\right)\psi_{ngj}\left(1-\frac{\vartheta_{jn}}{\rho_n}\right)\frac{(L-\lambda_{ln})\lambda_{ln}\left(1-\frac{\rho_n\lambda_{ln}+\vartheta_{jn}\lambda_{ln}-1}{\lambda_{ln}}L\right)}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_nL)(1-\vartheta_{jn}L)(1-\vartheta_{jn}\lambda_{ln})}\varepsilon_t^n\\
&=\sum_n\sum_{j=1}^{4}\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})\lambda_{ln}}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})}\frac{1-\frac{\rho_n\lambda_{ln}+\vartheta_{jn}\lambda_{ln}-1}{\lambda_{ln}}L}{(1-\lambda_{ln}L)(1-\vartheta_{jn}L)(1-\rho_nL)}\varepsilon_t^n\\
&=\sum_n\sum_{j=1}^{4}\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})\lambda_{ln}}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})}\left[\frac{1-\rho_n\lambda_{ln}}{\lambda_{ln}(\vartheta_{jn}-\lambda_{ln})}\frac{1}{1-\vartheta_{jn}L}+\left(1-\frac{1-\rho_n\lambda_{ln}}{\lambda_{ln}(\vartheta_{jn}-\lambda_{ln})}\right)\frac{1}{1-\lambda_{ln}L}\right]\frac{1}{1-\rho_nL}\varepsilon_t^n\\
&=\sum_n\sum_{j=1}^{4}\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})\lambda_{ln}}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})}\left[\frac{\vartheta_{jn}(1-\rho_n\lambda_{ln})}{\lambda_{ln}(\lambda_{ln}-\vartheta_{jn})(\rho_n-\vartheta_{jn})}\frac{1}{1-\vartheta_{jn}L}-\left(1+\frac{1-\rho_n\lambda_{ln}}{\lambda_{ln}(\lambda_{ln}-\vartheta_{jn})}\right)\frac{\lambda_{ln}}{\rho_n-\lambda_{ln}}\frac{1}{1-\lambda_{ln}L}\right.\\
&\qquad\left.+\frac{\rho_n(1-\lambda_{ln}\vartheta_{jn})}{\lambda_{ln}(\rho_n-\vartheta_{jn})(\rho_n-\lambda_{ln})}\frac{1}{1-\rho_nL}\right]\varepsilon_t^n\\
&=\sum_n\sum_{j=1}^{4}\frac{(\rho_n-\lambda_{ln})\psi_{ngj}\vartheta_{jn}(1-\rho_n\lambda_{ln})}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^{\infty}\vartheta_{jn}^k\varepsilon_{t-k}^n-\sum_n\sum_{j=1}^{4}\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})\lambda_{ln}[\lambda_{ln}(\lambda_{ln}-\rho_n)+1-\lambda_{ln}\vartheta_{jn}]}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^{\infty}\lambda_{ln}^k\varepsilon_{t-k}^n\\
&\qquad+\sum_n\sum_{j=1}^{4}\frac{\psi_{ngj}}{\rho_n}\sum_{k=0}^{\infty}\rho_n^k\varepsilon_{t-k}^n
\end{aligned}
$$

$$
\begin{aligned}
&= \sum_n \left[\sum_{j=1}^{4} \widetilde{\alpha}_{nlgj} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n + \widetilde{\delta}_{nlg} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \widetilde{\kappa}_{ng} \sum_{k=0}^{\infty} \rho_n^k \varepsilon_{t-k}^n \right] \\
\overline{\mathbb{E}}_t^l a_{g,t} &= \sum_n \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \frac{L h_{gn}(L)(1-\rho_n\lambda_{ln}) - \lambda_{ln} h_{gn}(\lambda_{ln})(1-\rho_n L)}{(1-\lambda_{ln}L)(L-\lambda_{ln})} n_t \\
&= \sum_n \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \frac{L \sum_{j=1}^4 \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{1}{1-\vartheta_{jn}L}(1-\rho_n\lambda_{ln}) - \lambda_{ln} \sum_{j=1}^4 \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{1}{1-\vartheta_{jn}\lambda_{ln}}(1-\rho_n L)}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_n L)} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{\frac{L(1-\rho_n\lambda_{ln})}{1-\vartheta_{jn}L} - \frac{\lambda_{ln}(1-\rho_n L)}{1-\vartheta_{jn}\lambda_{ln}}}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_n L)} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{(L-\lambda_{ln})(1-\rho_n\vartheta_{jn}\lambda_{ln}L)}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_n L)(1-\vartheta_{jn}L)(1-\vartheta_{jn}\lambda_{ln})} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})} \frac{1-\rho_n\vartheta_{jn}\lambda_{ln}L}{(1-\lambda_{ln}L)(1-\vartheta_{jn}L)(1-\rho_n L)} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})} \left[\frac{\vartheta_{jn}(1-\rho_n\lambda_{ln})}{\vartheta_{jn}-\lambda_{ln}} \frac{1}{1-\vartheta_{jn}L} - \frac{\lambda_{ln}(1-\rho_n\vartheta_{jn})}{\vartheta_{jn}-\lambda_{ln}} \frac{1}{1-\lambda_{ln}L} \right] \frac{1}{1-\rho_n L} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})} \left[\frac{\vartheta_{jn}^2(1-\rho_n\lambda_{ln})}{(\vartheta_{jn}-\lambda_{ln})(\vartheta_{jn}-\rho_n)} \frac{1}{1-\vartheta_{jn}L} - \frac{\vartheta_{jn}\rho_n(1-\rho_n\lambda_{ln})}{(\vartheta_{jn}-\lambda_{ln})(\vartheta_{jn}-\rho_n)} \frac{1}{1-\rho_n L} \right. \\
&\qquad \left. - \frac{\lambda_{ln}^2(1-\rho_n\vartheta_{jn})}{(\vartheta_{jn}-\lambda_{ln})(\lambda_{ln}-\rho_n)} \frac{1}{1-\lambda_{ln}L} + \frac{\lambda_{ln}\rho_n(1-\rho_n\vartheta_{jn})}{(\vartheta_{jn}-\lambda_{ln})(\lambda_{ln}-\rho_n)} \frac{1}{1-\rho_n L} \right] \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}\vartheta_{jn}^2(1-\rho_n\lambda_{ln})}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n - \sum_n \sum_{j=1}^4 \frac{\psi_{ngj}(\rho_n-\vartheta_{jn})\lambda_{ln}^2(1-\rho_n\vartheta_{jn})}{\rho_n^2(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n \\
&\qquad + \sum_n \sum_{j=1}^4 \psi_{ngj} \sum_{k=0}^{\infty} \rho_n^k \varepsilon_{t-k}^n \\
&= \sum_n \left[\sum_{j=1}^{4} \alpha_{nlgj} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n + \delta_{nlg} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \kappa_{ng} \sum_{k=0}^{\infty} \rho_n^k \varepsilon_{t-k}^n \right]
\end{aligned}
$$

$$
\begin{aligned}
\overline{\mathbb{E}}_t^l a_{g,t+4} &= \sum_n \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \frac{L^{-3} h_{gn}(L)(1-\rho_n\lambda_{ln}) - \lambda_{ln}^{-3} h_{gn}(\lambda_{ln})(1-\rho_n L)}{(1-\lambda_{ln}L)(L-\lambda_{ln})} n_t \\
&= \sum_n \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \frac{L^{-3} \sum_{j=1}^4 \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{1}{1-\vartheta_{jn}L}(1-\rho_n\lambda_{ln}) - \lambda_{ln}^{-3} \sum_{j=1}^4 \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{1}{1-\vartheta_{jn}\lambda_{ln}}(1-\rho_n L)}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_n L)} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{\frac{1-\rho_n\lambda_{ln}}{L^3(1-\vartheta_{jn}L)} - \frac{1-\rho_n L}{\lambda_{ln}^3(1-\vartheta_{jn}\lambda_{ln})}}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_n L)} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^4 \left(1 - \frac{\lambda_{ln}}{\rho_n}\right) \psi_{ngj} \left(1 - \frac{\vartheta_{jn}}{\rho_n}\right) \frac{1}{(1-\lambda_{ln}L)(L-\lambda_{ln})(1-\rho_n L)} \times \\
&\qquad \times \frac{-(L-\lambda_{ln}) \left[(1-\rho_n\lambda_{ln})(1-\lambda_{ln}\vartheta_{jn})(\lambda_{ln}^2 + \lambda_{ln}L + L^2 + \lambda_{ln}^{-1}L^3) - \frac{L^3}{\lambda_{ln}}(1-\rho_n\lambda_{ln}\vartheta_{jn}L) \right]}{L^3\lambda_{ln}^3(1-\vartheta_{jn}L)(1-\vartheta_{jn}\lambda_{ln})} \varepsilon_t^n \\
&= -\sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})}{\rho_n^2\lambda_{ln}^3(1-\vartheta_{jn}\lambda_{ln})} \frac{\left[(1-\rho_n\lambda_{ln})(1-\lambda_{ln}\vartheta_{jn})(\lambda_{ln}^2 + \lambda_{ln}L + L^2 + \lambda_{ln}^{-1}L^3) - \frac{L^3}{\lambda_{ln}}(1-\rho_n\lambda_{ln}\vartheta_{jn}L) \right]}{L^3(1-\lambda_{ln}L)(1-\rho_n L)(1-\vartheta_{jn}L)} \varepsilon_t^n \\
&= -\sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}^3} \frac{\lambda_{ln}^2 + \lambda_{ln}L + L^2 + \lambda_{ln}^{-1}L^3}{L^3} \times \\
&\qquad \times \frac{1}{(1-\vartheta_{jn}L)(1-\lambda_{ln}L)(1-\rho_n L)} \varepsilon_t^n \\
&\qquad + \sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})}{\rho_n^2\lambda_{ln}^4(1-\vartheta_{jn}\lambda_{ln})} \frac{1-\rho_n\lambda_{ln}\vartheta_{jn}L}{(1-\lambda_{ln}L)(1-\rho_n L)(1-\vartheta_{jn}L)} \varepsilon_t^n \\
&= -\sum_n \sum_{j=1}^4 \frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}^3} \frac{\lambda_{ln}^2 + \lambda_{ln}L + L^2 + \lambda_{ln}^{-1}L^3}{L^3} \times
\end{aligned}
$$

$$\times\left[\frac{\vartheta_{jn}^2}{(\lambda_{ln}-\vartheta_{jn})(\rho_n-\vartheta_{jn})}\frac{1}{1-\vartheta_{jn}L}-\frac{\lambda_{ln}^2}{(\lambda_{ln}-\vartheta_{jn})(\rho_n-\lambda_{ln})}\frac{1}{1-\lambda_{ln}L}+\frac{\rho_n^2}{(\rho_n-\lambda_{ln})(\rho_n-\vartheta_{jn})}\frac{1}{1-\rho_n L}\right]\varepsilon_t^n$$

$$+\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(\rho_n-\vartheta_{jn})}{\rho_n^2\lambda_{ln}^4(1-\vartheta_{jn}\lambda_{ln})}\times$$

$$\times\left[\frac{\vartheta_{jn}^2(1-\rho_n\lambda_{ln})}{(\lambda_{ln}-\vartheta_{jn})(\rho_n-\vartheta_{jn})}\frac{1}{1-\vartheta_{jn}L}-\frac{\lambda_{ln}^2(1-\rho_n\vartheta_{jn})}{(\lambda_{ln}-\vartheta_{jn})(\rho_n-\lambda_{ln})}\frac{1}{1-\lambda_{ln}L}+\frac{\rho_n^2(1-\lambda_{ln}\vartheta_{jn})}{(\rho_n-\lambda_{ln})(\rho_n-\vartheta_{jn})}\frac{1}{1-\rho_n L}\right]\varepsilon_t^n$$

$$=-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}^3(\lambda_{ln}-\vartheta_{jn})}\frac{\lambda_{ln}^2+\lambda_{ln}L+L^2+\lambda_{ln}^{-1}L^3}{L^3}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}(\lambda_{ln}-\vartheta_{jn})}\frac{\lambda_{ln}^2+\lambda_{ln}L+L^2+\lambda_{ln}^{-1}L^3}{L^3}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}^3}\frac{\lambda_{ln}^2+\lambda_{ln}L+L^2+\lambda_{ln}^{-1}L^3}{L^3}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}\vartheta_{jn}^2(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}^4(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\vartheta_{jn})}{\rho_n^2\lambda_{ln}^2(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}}{\lambda_{ln}^4}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t-k}^n$$

$$=-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+3-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}^2(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+2-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}^3(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+1-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}^4(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})\lambda_{ln}}{\rho_n^2(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+3-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+2-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+1-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}^2(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+3-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}^2}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+2-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}^3}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+1-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}^4}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t-k}^n$$

$$+\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}\vartheta_{jn}^2(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}^4(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t-k}^n$$

$$-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\vartheta_{jn})}{\rho_n^2\lambda_{ln}^2(1-\vartheta_{jn}\lambda_{ln})(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t-k}^n$$

$$
\begin{aligned}
&+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}}{\lambda_{ln}^4}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t-k}^n\\
=&-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+3-k}^n\\
&-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}^2(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+2-k}^n\\
&-\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^2}{\rho_n^2\lambda_{ln}^3(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+1-k}^n\\
&+\sum_n\sum_{j=1}^4\frac{(\rho_n-\lambda_{ln})\psi_{ngj}(1-\rho_n\lambda_{ln})\vartheta_{jn}^3}{\rho_n^2\lambda_{ln}^3(\lambda_{ln}-\vartheta_{jn})(1-\lambda_{ln}\vartheta_{jn})}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t-k}^n\\
&+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})\lambda_{ln}}{\rho_n^2(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+3-k}^n\\
&+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+2-k}^n\\
&+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})(1-\rho_n\lambda_{ln})}{\rho_n^2\lambda_{ln}(\lambda_{ln}-\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+1-k}^n\\
&+\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(\rho_n-\vartheta_{jn})[\vartheta_{jn}(\rho_n-\lambda_{ln})-\rho_n\lambda_{ln}(1-\lambda_{ln}\vartheta_{jn})]}{\rho_n^2\lambda_{ln}^2(\lambda_{ln}-\vartheta_{jn})(1-\lambda_{ln}\vartheta_{jn})}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t-k}^n\\
&-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+3-k}^n\\
&-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}^2}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+2-k}^n\\
&-\sum_n\sum_{j=1}^4\frac{\psi_{ngj}(1-\rho_n\lambda_{ln})}{\lambda_{ln}^3}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+1-k}^n\\
&+\sum_n\sum_{j=1}^4\frac{\rho_n\psi_{ngj}}{\lambda_{ln}^3}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t-k}^n\\
=&\sum_n\sum_{j=1}^4\alpha_{nlgj,1}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+3-k}^n+\sum_n\sum_{j=1}^4\alpha_{nlgj,2}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+2-k}^n+\sum_n\sum_{j=1}^4\alpha_{nlgj,3}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t+1-k}^n\\
&+\sum_n\sum_{j=1}^4\alpha_{nlgj,4}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t-k}^n+\sum_n\delta_{nlg,1}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+3-k}^n+\sum_n\delta_{nlg,2}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+2-k}^n\\
&+\sum_n\delta_{nlg,3}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t+1-k}^n+\sum_n\delta_{nlg,4}\sum_{k=0}^\infty\lambda_{ln}^k\varepsilon_{t-k}^n+\sum_n\kappa_{ng,1}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+3-k}^n\\
&+\sum_n\kappa_{ng,2}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+2-k}^n+\sum_n\kappa_{ng,3}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t+1-k}^n+\sum_n\kappa_{ng,4}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t-k}^n
\end{aligned}
$$

The tax policy surprise is given by

$$
\text{shock}_t^l=\tau_t-\overline{\mathbb{E}}_t^l\tau_t=\psi_\tau(\pi_t^p-\overline{\mathbb{E}}_t^l\pi_t^p)+q_t-\overline{\mathbb{E}}_t^lq_t
$$

We know aggregate endogenous variables evolve according to

$$
\begin{aligned}
a_{g,t}&=\sum_n\sum_{j=1}^4\psi_{ngj}\left(1-\frac{\vartheta_{jn}}{\rho_n}\right)\frac{1}{(1-\vartheta_{jn}L)(1-\rho_nL)}\varepsilon_t^n=\sum_n\frac{\psi_{ngj}}{\rho_n}\sum_{k=0}^\infty\left(\rho_n^{k+1}-\vartheta_{jn}^{k+1}\right)\varepsilon_{t-k}^n\\
&=\sum_n\left[\beta_{ng}\sum_{k=0}^\infty\rho_n^k\varepsilon_{t-k}^n+\sum_{j=1}^4\nu_{ngj}\sum_{k=0}^\infty\vartheta_{jn}^k\varepsilon_{t-k}^n\right]
\end{aligned}
$$

where $\beta_{ng} = \sum_{j=1}^{4} \psi_{ngj}$ and $\nu_{ngj} = -\frac{\psi_{ngj}\vartheta_{jn}}{\rho_n}$. Hence, we can write,

$$
\begin{aligned}
a_{g,t} - \overline{\mathbb{E}}_t^l a_{g,t} &= \sum_n \left\{ h_{gn}(L) \left[1 - \frac{(\rho_n - \lambda_{ln}) L (1 - \rho_n \lambda_{ln})}{\rho_n (1 - \lambda_{ln} L)(L - \lambda_{ln})} \right] + h_{gn}(\lambda_{ln}) \frac{(\rho_n - \lambda_{ln}) \lambda_{ln} (1 - \rho_n L)}{\rho_n (1 - \lambda_{ln} L)(L - \lambda_{ln})} \right\} n_t \\
&= \sum_n \frac{\lambda_{ln}(1 - \rho_n L)}{\rho_n (1 - \lambda_{ln} L)(L - \lambda_{ln})} \left[h_{gn}(L)(L - \rho_n) + h_{gn}(\lambda_{ln})(\rho_n - \lambda_{ln}) \right] n_t \\
&= \sum_n \frac{\lambda_{ln}}{\rho_n (1 - \lambda_{ln} L)(L - \lambda_{ln})} \left[h_{gn}(L)(L - \rho_n) + h_{gn}(\lambda_{ln})(\rho_n - \lambda_{ln}) \right] \varepsilon_t^n \\
&= \sum_n \frac{\lambda_{ln}}{\rho_n (1 - \lambda_{ln} L)(L - \lambda_{ln})} \sum_{j=1}^{4} \left[\frac{\psi_{ngj}(\rho_n - \vartheta_{jn})(L - \rho_n)}{\rho_n (1 - \vartheta_{jn} L)} + \frac{\psi_{ngj}(\rho_n - \vartheta_{jn})(\rho_n - \lambda_{ln})}{\rho_n (1 - \vartheta_{jn} \lambda_{ln})} \right] \varepsilon_t^n \\
&= \sum_n \frac{\lambda_{ln}}{\rho_n (1 - \lambda_{ln} L)(L - \lambda_{ln})} \sum_{j=1}^{4} \frac{\psi_{ngj}(\rho_n - \vartheta_{jn})}{\rho_n} \left[\frac{(L - \rho_n)}{1 - \vartheta_{jn} L} + \frac{\rho_n - \lambda_{ln}}{1 - \vartheta_{jn} \lambda_{ln}} \right] \varepsilon_t^n \\
&= \sum_n \frac{\lambda_{ln}}{\rho_n (1 - \lambda_{ln} L)(L - \lambda_{ln})} \sum_{j=1}^{4} \frac{\psi_{ngj}(\rho_n - \vartheta_{jn})}{\rho_n} \frac{(L - \lambda_{ln})(1 - \rho_n \vartheta_{jn})}{(1 - \vartheta_{jn} L)(1 - \lambda_{ln} \vartheta_{jn})} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^{4} \frac{\lambda_{ln} \psi_{ngj}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})} \frac{1}{(1 - \vartheta_{jn} L)(1 - \lambda_{ln} L)} \varepsilon_t^n \\
&= \sum_n \sum_{j=1}^{4} \frac{\lambda_{ln} \psi_{ngj}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})} \left(\frac{\lambda_{ln}}{\lambda_{ln} - \vartheta_{jn}} \frac{1}{1 - \lambda_{ln} L} - \frac{\vartheta_{jn}}{\lambda_{ln} - \vartheta_{jn}} \frac{1}{1 - \vartheta_{jn} L} \right) \varepsilon_t^n \\
&= \sum_n \left[\sum_{j=1}^{4} \frac{\lambda_{ln}^2 \psi_{ngj}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})} \sum_{l=0}^{\infty} \lambda_{ln}^l \varepsilon_{t-l}^n - \sum_{j=1}^{4} \frac{\lambda_{ln} \vartheta_{jn} \psi_{ngj}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})} \sum_{l=0}^{\infty} \vartheta_{jn}^l \varepsilon_{t-l}^n \right] \\
&= \sum_n \gamma_{ngl} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \sum_n \sum_{j=1}^{4} \xi_{ngjl} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n
\end{aligned}
$$

where $\gamma_{ngl} = \sum_{j=1}^{4} \frac{\lambda_{ln}^2 \psi_{ngj}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})}$ and $\xi_{ngjl} = -\frac{\lambda_{ln} \vartheta_{jn} \psi_{ngj}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{kn} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})}$. Therefore,

$$
\begin{aligned}
\pi_t^p - \overline{\mathbb{E}}_t^l \pi_t^p &= \sum_n \left[\sum_{j=1}^{4} \frac{\lambda_{ln}^2 \psi_{n2j}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})} \sum_{l=0}^{\infty} \lambda_{ln}^l \varepsilon_{t-l}^n - \sum_{j=1}^{4} \frac{\lambda_{ln} \vartheta_{jn} \psi_{n2j}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})} \sum_{l=0}^{\infty} \vartheta_{jn}^l \varepsilon_{t-l}^n \right] \\
&= \sum_n \gamma_{n2l} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \sum_n \sum_{j=1}^{4} \xi_{n2jl} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n
\end{aligned}
$$

where $\gamma_{n2l} = \sum_{j=1}^{4} \frac{\lambda_{ln}^2 \psi_{n2j}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{ln} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})}$ and $\xi_{n2jl} = -\frac{\lambda_{ln} \vartheta_{jn} \psi_{n2j}(\rho_n - \vartheta_{jn})(1 - \rho_n \vartheta_{jn})}{\rho_n^2 (1 - \lambda_{kn} \vartheta_{jn})(\lambda_{ln} - \vartheta_{jn})}$.

We also have

$$
\begin{aligned}
q_t - \overline{\mathbb{E}}_t^l q_t &= \left[\frac{1}{1 - \rho_q L} - \left(1 - \frac{\lambda_{lq}}{\rho_q} \right) \frac{1}{(1 - \lambda_{lq} L)(1 - \rho_q L)} \right] \varepsilon_t^q \\
&= \left\{ \frac{1}{1 - \rho_q L} - \left(1 - \frac{\lambda_{lq}}{\rho_q} \right) \left[\frac{\lambda_{lq}}{\lambda_{lq} - \rho_q} \frac{1}{1 - \lambda_{lq} L} - \frac{\rho_q}{\lambda_{lq} - \rho_q} \frac{1}{1 - \rho_q L} \right] \right\} \varepsilon_t^q = \frac{\lambda_{lq}}{\rho_q} \sum_{k=0}^{\infty} \lambda_{lq}^k \varepsilon_{t-k}^q
\end{aligned}
$$

we can therefore finally write the monetary policy surprise as

$$
\begin{aligned}
\text{shock}_t^l &= \psi_\tau \left[\sum_n \gamma_{n2l} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \sum_n \sum_{j=1}^{4} \xi_{n2jl} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n \right] + \frac{\lambda_{lq}}{\rho_q} \sum_{k=0}^{\infty} \lambda_{lq}^k \varepsilon_{t-k}^q \\
&= \sum_n \left[\chi_{nl} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \sum_{j=1}^{4} \mu_{nlj} \sum_{l=0}^{\infty} \vartheta_{jn}^l \varepsilon_{t-l}^n \right]
\end{aligned}
$$

where $\chi_{ql} = \psi_\tau \gamma_{q2l} + \frac{\lambda_{ln}}{\rho_q}$, $\chi_{nl} = \psi_\tau \gamma_{n2l}$ for $n \neq q$, and $\mu_{njl} = \psi_\tau \gamma_{n2lj}$. We can thus write

$$
\begin{aligned}
&\mathbb{C}\left[\overline{\mathbb{E}}_t^l a_{g,t-1}, \text{shock}_t^l\right] = \\
&= \sum_n \mathbb{E}\left[\left(\sum_{j=1}^{4} \widetilde{\alpha}_{nlgj} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n + \widetilde{\delta}_{nlg} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \widetilde{\kappa}_{ng} \sum_{k=0}^{\infty} \rho_n^k \varepsilon_{t-k}^n \right) \left(\chi_{nl} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \sum_{j=1}^{4} \mu_{nlj} \sum_{k=0}^{\infty} \vartheta_{jn}^k \varepsilon_{t-k}^n \right) \right] \\
&= \sum_n \left\{ \sum_{j=1}^{4} \frac{\widetilde{\alpha}_{nlgj} \chi_{nl}}{1 - \vartheta_{jn} \lambda_{ln}} + \sum_{j=1}^{4} \sum_{m=1}^{4} \frac{\widetilde{\alpha}_{nlgj} \mu_{nlm}}{1 - \vartheta_{jn} \vartheta_{mn}} + \frac{\widetilde{\delta}_{nlg} \chi_{nl}}{1 - \lambda_{ln}^2} + \sum_{j=1}^{4} \frac{\widetilde{\delta}_{nlg} \mu_{nlj}}{1 - \vartheta_{jn} \lambda_{ln}} + \frac{\widetilde{\kappa}_{ng} \chi_{nl}}{1 - \rho_n \lambda_{ln}} + \sum_{j=1}^{4} \frac{\widetilde{\kappa}_{ng} \mu_{nlj}}{1 - \vartheta_{jn} \rho_n} \right\} \sigma_n^2 \\
&\mathbb{V}\left[\text{shock}_t^l\right] = \sum_n \mathbb{E}\left[\left(\chi_{nl} \sum_{k=0}^{\infty} \lambda_{ln}^k \varepsilon_{t-k}^n + \sum_{j=1}^{4} \mu_{nlj} \sum_{l=0}^{\infty} \vartheta_{jn}^l \varepsilon_{t-l}^n \right)^2 \right] \\
&= \sum_n \left\{ \frac{\chi_{nl}^2}{1 - \lambda_{ln}^2} + 2 \sum_{j=1}^{4} \frac{\chi_{nl} \mu_{nlj}}{1 - \lambda_{nl} \vartheta_{jn}} + \sum_{j=1}^{4} \sum_{m=1}^{4} \frac{\mu_{nlj} \mu_{nlm}}{1 - \vartheta_{jn} \vartheta_{mn}} \right\} \sigma_n^2
\end{aligned}
$$

We can also write

$$
\begin{aligned}
&\mathbb{C}\left[\overline{\mathbb{E}}_t^l a_{g,t+4}, \text{shock}_t^l\right] = \\
&= \sum_n \left\{ \sum_{s=1}^{4} \sum_{j=1}^{4} \frac{\alpha_{nlgj,s} \chi_{nl}}{1 - \vartheta_{jn} \lambda_{ln}} \vartheta_{jn}^{4-s} + \sum_{s=1}^{4} \sum_{j=1}^{4} \sum_{m=1}^{4} \frac{\alpha_{nlgj,s} \mu_{nlm}}{1 - \vartheta_{jn} \lambda_{m\pi}} \vartheta_{jn}^{4-s} + \sum_{s=1}^{4} \frac{\delta_{nlg,s} \chi_{nl}}{1 - \lambda_{ln}^2} \lambda_{ln}^{4-s} \right. \\
&\qquad \left. + \sum_{s=1}^{4} \sum_{j=1}^{4} \frac{\delta_{nlg,s} \mu_{nlj}}{1 - \vartheta_{jn} \lambda_{ln}} \lambda_{ln}^{4-s} + \sum_{s=1}^{4} \frac{\kappa_{ng,s} \chi_{nl}}{1 - \rho_n \lambda_{ln}} \rho_n^{4-s} + \sum_{s=1}^{4} \sum_{j=1}^{4} \frac{\kappa_{ng,s} \mu_{nlj}}{1 - \vartheta_{jn} \rho_n} \rho_n^{4-s} \right\} \sigma_n^2
\end{aligned}
$$

$\square$

D Fiscal Response to the Cost-of-Living Crisis in Spain

This appendix presents a narrative analysis of the price-related fiscal measures implemented by the Spanish government in response to the surge of inflation in the second part of 2021, and acceleration after the Russian invasion of Ukraine in February 2022.

Table A.3 summarizes the 15 price-related fiscal measures we identify for Spain, which were presented in 8 distinct fiscal announcements. We focus on three instruments: indirect taxes, subsidies to firms, and price discounts to households. The estimated total fiscal impulse was about 14 billion euros at prices of 2022 or 1% of GDP. A third of the price-related fiscal measures were targeted to a specific group, and 47% of the fiscal announcements extended previously enacted measures.

Table A.3 also includes the keywords used to verify the dating with Google searches related to the fiscal measures. When multiple measures were announced together in a single package, we made a judgment call to select the most prominent one. This ensures that we are likely capturing the exact moment when households updated their information set. The choice reflects our personal experiences during the historical period, the media coverage at the time of the different measures, and conversations with several national experts.

The narrative analysis is organized around the official communications. Most sections refer to Cabinet meetings, and the laws legislating the agreements reached. Occasionally, we include other extraordinary announcements such as a radio interview or unscheduled speeches at the Parliament.

The fiscal measures are quantified in million euros and calculated as the average present value of the annual charges to government budgets. We use the average 10-year government debt yield for the period when the measures are in effect for the calculations. The fiscal cost is also calculated as a percentage of GDP.

Table A.3: Fiscal Measures in Spain

	Description	Official Dating	Google Spike	Key words	Instrument	Beneficiary	Targeted	Extension	% GDP
ES1	Temporary suspension of tax on value of energy production	24/06/2021	20/06/2021		Indirect taxes	Households	Broad-based		0.08
	Temporary reduction of VAT tax rates on electricity	24/06/2021	20/06/2021	IVA electricidad	Indirect taxes	Households	Broad-based		0.06
ES2	Temporary reduction in tax on electricity	14/09/2021	13/09/2021	rebaja impuesto	Indirect taxes	Households	Broad-based		0.03
ES3	Fuel subsidy to households	29/03/2022	29/03/2022	descuento gasolina	Discount	Households	Broad-based		0.22
	Fuel subsidy to firms	29/03/2022	29/03/2022		Subsidies	Firms	Targeted		0.17
	Temporary suspension of tax on value of energy production	29/03/2022	29/03/2022		Indirect taxes	Households	Broad-based	Yes	0.09
	Temporary reduction of VAT tax rates on electricity	29/03/2022	29/03/2022		Indirect taxes	Households	Broad-based	Yes	0.08
	Temporary reduction in tax on electricity	29/03/2022	29/03/2022		Indirect taxes	Households	Broad-based	Yes	0.03
ES4	Reduction in public transport fares	25/06/2022	25/06/2022	rebaja transporte	Discount	Households	Broad-based		0.05
ES5	Temporary reduction of VAT tax rates on gas	01/09/2022	01/09/2022	IVA gas	Indirect taxes	Households	Broad-based	Yes	0.03
ES6	Government subsidy to gas consumption by households	13/10/2022	12/10/2022		Discount	Households	Targeted		0.11
	Extension of subsidies to low-income households for heating ("bono térmico")	13/10/2022	12/10/2022	bono social	Discount	Households	Targeted	Yes	0.02
ES7	Temporary reduction of VAT rates on food staples	27/12/2022	27/12/2022	IVA alimentos	Indirect taxes	Households	Broad-based		0.05
	Fuel subsidy to firms in transport sector	27/12/2022	27/12/2022		Subsidies	Firms	Targeted	Yes	0.02
	Fuel subsidy to firms in transport sector (new recipients)	27/12/2022	27/12/2022		Subsidies	Firms	Targeted	Yes	0.02

D.1 Cabinet meeting of 24th June 2021 and Royal Decree-Law 12/2021, of June 24, adopting urgent measures in the field of energy taxation and energy generation, and on the management of the regulatory fee and the water use tariff

In the extraordinary Cabinet meeting of 24th June of 2021, the Spanish government[11] adopted a fiscal package intended to, as described by the government, "adopt immediate tax measures to lower consumers' electricity bills".[12] The fiscal package was legislated in the Royal Decree-Law 12/2021.

Regarding the communication of the fiscal package, an ordinary press conference was held after the Cabinet meeting, and the agreements were presented by the Finance Minister and former Spokesperson of the Spanish Government (Spanish Socialist Party), Environment Minister (Spanish Socialist Party) and Labour Minister (Spanish Communist Party).

Among the measures intended to lower electricity bills, the Government approved the suspension of the 7% Tax on the Value of the Electricity Production. This tax is paid by electricity producers and is ultimately passed on to the consumers. Consumers saw the reduction directly in the utility bills in the month of the official fiscal announcement. This measure had an allocated budget of 1091,11 million euros. The measure was extended several times in 2022.

As it is described in the Royal Decree Law 12/2021, the suspension of the tax implies that facilities that produce electricity and incorporate it into the electricity system will be compensated by the lost revenue for the value of electricity production. The compensation to firms equals the discount applied to households. Therefore, we only record the price measure for households to avoid double counting.

Moreover, it was also announced a temporary reduction of the VAT rates on electricity. This measure entails the reduction of the VAT rate from a 21% to a 10% on electricity. Consumers saw the VAT reduction directly in their utility bills in the month of the official fiscal announcement. This measure had an allocated budget of 757,17 million euros. This measure was also extended several times in 2022.

[11] Legislatures in Spain last generally four years. The Spanish Government at the time was a coalition government formed by the Spanish Socialist Party and the leftist party 'Unidas Podemos', in office since the 13th January 2020. The President of the Government was the socialist Pedro Sánchez. The coalition government was formed after early elections, which shortened the previous legislature. The previous government was also left wing, but with members being only from the Spanish Socialist Party. The previous government was conformed the 7th June 2018 after a vote of no confidence against the right wing government of Mariano Rajoy (the People's Party) resulted in the appointment of Pedro Sánchez as the President of the Government.

[12] For all the references in Spanish our translation.

The total budget allocated to the official announcements on June 24 was 1848,24 million euros.

Sources:

https://www.lamoncloa.gob.es/lang/en/gobierno/councilministers/Paginas/2022/20220329_council.aspx

https://www.boe.es/buscar/act.php?id=BOE-A-2022-4972

D.2 Cabinet meeting of 14th September 2021, and Royal Decree-Law 17/2021, of September 14, on urgent measures to mitigate the impact of the escalation of natural gas prices in the retail gas and electricity markets

In the ordinary Cabinet meeting of 14th September of 2021, the Spanish government adopted a fiscal package intended to, as described by the government, reduce a 22% the consumers' bill until the end of the year ("*El Ejecutivo prevé una reducción del 22% de media en la factura mensual hasta diciembre*").

Regarding the communication of the fiscal package, an ordinary press conference was held after the Cabinet meeting, and the agreements were presented by the spokesperson of the government and Territorial Policy Minister (Spanish Socialist Party) and Environment Minister (Spanish Socialist Party).

At this Cabinet meeting it was announced the reduction of the Special Tax on Electricity at the minimum rate allowed by the EU, from 5,1% to 0,5%. Consumers saw the reduction directly in the utility bills in the month of the official fiscal announcement.

This measure had an allocated budget of 352,36 million euros.

Sources:

https://www.lamoncloa.gob.es/consejodeministros/resumenes/Paginas/2021/140721-cministros.aspx

https://www.boe.es/buscar/act.php?id=BOE-A-2021-14974

D.3 Cabinet meeting of 29th March 2022 and Royal Decree-Law 6/2022, of March 29, 2022 adopting urgent measures as part of the National Plan in response to the economic and social consequences of the war in Ukraine

In the ordinary Cabinet meeting of 29th March of 2022, the Spanish government adopted a fiscal package intended to, as described by the government, 'mitigate the effects of the war in Ukraine, support the most vulnerable groups and the most affected productive sectors, guarantee supplies and lower fuel and electricity prices'. The fiscal package was legislated in the Royal Decree-Law 6/2022.

Regarding the communication of the fiscal package, an ordinary press conference was held after the Cabinet meeting, and the agreements were presented by the Economy Minister (independent, linked to the Spanish Socialist Party), Environment Minister (Spanish Socialist Party) and Labour Minister (Spanish Communist Party).

The measures with a significant budgetary impact of interest included a fuel subsidy to households and firms, direct transfers to firms, extension to the June 2021 temporary suspension of taxes on value of energy production, subsidies to the electricity sector linked to the tax on value of energy production, a temporary reduction of the VAT rates on electricity, and a temporary reduction in the tax on electricity. We cover all these measures in turn.

First, the fuel subsidy to households and firms consisted of a temporary €0.20 discount on the retail price per unit of different types of carburant ("*la bonificación tendrá un importe de 0,20 euros y se aplicará sobre el precio de venta al público por cada una de las siguientes unidades de medida*"). In order to take advantage of this measure, consumers did not need to undergo any additional procedure. The discount, although not displayed at the gas station signs, was directly applied and noticed by consumers in the purchase tickets. Moreover, this measure was both for households and firms. Households' discount was broad-based, while for firms the subsidy was targeted to the transport sector. The discount for households amounted to 2,900 million euros and the subsidy for transport firms 2,200 million euros.

Second, the package included temporary subsidies targeted to the agriculture, breeding, fishing sectors as well as to gas and electricity intensive industries. In order to benefit from the subsidy, firms had to fill in a special form of the Tax Administration (in Spanish, *Agencia Estatal de Administración Tributaria*). Thus, this measure has a delayed payment and it is costly for the beneficiaries. A total of 2,160 million euros is allocated to finance this measure.

Third, the package included a set of measures with the objective of reducing electricity consumer bills through the suspension or reduction of several indirect taxes:

- Extension of the temporary suspension of taxes on value of energy production enacted in June 2021 with the Royal Decree Law 12/2021. This measure includes both a discount for households' electricity bills and a compensatory subsidy to electricity producers. Households notice their bills directly reduced. The measure is broad-based and the discount is immediately applied to the bills of all consumers. The Royal Decree Law also legislated subsidies to the electricity sector linked to the tax on value of energy production in compensation to the electricity suppliers for the foregone revenues ("*obligación de la compensación por el importe equivalente a la reducción de recaudación consecuencia de esta medida al Sistema eléctrico*"). This compensation is applied by the Spanish National Markets and Competition Commission (CNMC). The discount for households costed 1131,60 million euros while the compensation to firms was 1631,75 million euros.

- Extension of the temporary reduction of the VAT rates on electricity from 21% to 10%, enacted in the Royal Decree Law 12/2021 of 24$^{\text{th}}$ June. This reduction is directly applied to the consumers' electricity bills. This measure costed 1124,09 million euros.

- Temporary reduction in the tax on electricity (in Spanish, *impuesto especial sobre la electricidad*). The tax rate is reduced to 0.5% for all consumers, being the measure broad-based. Additionally, no procedure is necessary to benefit from the reduction. Consumers noticed their electricity bills directly reduced within a month of the official announcement. To finance this measure, it was allocated a total of 428,15 million euros.

The above described tax measures implemented by the Royal Decree Law approved in the Cabinet meeting held the 19$^{\text{th}}$ March 2022 had a total allocated budget of 12,941 million euros.
Sources:
https://www.lamoncloa.gob.es/lang/en/gobierno/councilministers/Paginas/2022/20220329_council.aspx
https://www.boe.es/buscar/act.php?id=BOE-A-2022-4972
https://www.ico.es/l%C3%ADnea-de-avales-real-decreto-ley-6-2022-de-29-de-marzo
https://www.boe.es/diario_boe/txt.php?id=BOE-A-2022-7639#:~:text=La%20fecha%20l%C3%ADmite%20para%20la,financiaci%C3%B3n%20las%20empresas%20y%20aut%C3%B3nomos.
https://www.elperiodico.com/es/politica/20220328/pedro-sanchez-anuncio-medidas-plan-nacional-respuesta-guerra-ucrania-consejo-europeo-gas-13439059

D.4 Cabinet meeting of 25th June 2022 and Royal Decree Law 11/2022, of 25 June adopting and extending certain measures to respond to the economic and social consequences of the war in Ukraine, to deal with situations of social and economic vulnerability and for the economic and social recovery of the Island of La Palma

The Spanish Government held an extraordinary Cabinet meeting on the 25th June 2022 to approve several measures in response to cost of living crisis, including price measures. The agreement reached by the Cabinet meeting was announced and explained by the President of the Government at a press conference, and it was legislated in the Royal Decree Law 11/2022 of 25 June.

As part of the package the President announced a reduction in the public transport fares applying from the 1st September until 31st December. This is a broad-based measure representing a 50% reduction of the price of monthly tickets and multi-trip public transport tickets. The Spanish Government subsidised 30% of the discount in the public transport fares, while the rest was covered by the regional level governments. Citizens noticed the discount immediately when purchasing the tickets. The measure was effortless without requiring additional procedures, but delayed as it was implemented more than 30 days after the announcement. This measure had an estimated cost of 637,82 million euros (about 40% of the total funding allocated to this package of measures).

Sources:
https://www.lamoncloa.gob.es/lang/en/gobierno/councilministers/Paginas/2022/20220625_council-extr.aspx
https://www.boe.es/buscar/act.php?id=BOE-A-2022-10557#:~:text=Ayuda-,Real%20Decreto%2Dley%2011%2F2022%2C%20de%2025%20de%20junio,la%20isla%20de%20La%20Palma
https://sede.agenciatributaria.gob.es/Sede/procedimientoini/GC51.shtml

D.5 Cabinet meeting of 1st August 2022 and Royal Decree-Law 14/2022 on economic sustainability measures in the field of transport, in terms of scholarships and study aid, as well as measures for saving, energy efficiency and reducing the energy dependence of the natural gas

At the ordinary Cabinet meeting of the 1st August 2022 the government extended some of the measures in response to the cost of living crisis. The agreement reached by the Cabinet was announced and explained by the Spokesperson of the Government (Spanish Socialist Party), the Environment Minister (Spanish Socialist Party) and the Presidency Minister (Spanish Socialist Party) at a press conference; it was legislated in the Royal Decree Law 14/2022, of 1 August.

The RDL 14/2022 introduced a subsidy for electricity producers. The government compensates the loss of revenue for energy firms due to the temporal suspension of the Tax on Value of Electric Energy Production (IVPEE for its acronym in Spanish). These revenues partly finance the regulated costs of the system and are particularly used to promote renewable energy. This compensation was applied by the Spanish National Markets and Competition Commission (CNMC).

The Spanish government allocated a total of 3,360 million euros to finance this measure.

Sources:

https://www.boe.es/buscar/doc.php?id=BOE-A-2022-12925

D.6 Radio interview of the Spanish President at Cadena Ser - 1st September 2022

The 1st September 2022, the President of the Government was interviewed in the Spanish radio station *Cadena Ser*.

The President took advantage of the interview to make an announcement: that the government would cut the VAT rate on gas from 21% to 5% from October 2022 to December 2023. This is a broad-based fiscal measure, noticed immediately by consumers in their gas bills.

The Spanish government allocated a total of 373.86 million euros to finance this measure.

Sources:

https://elpais.com/espana/2022-09-01/pedro-sanchez-anuncia-una-bajada-del-iva-del-gas-del-21-al-5.html

D.7 Cabinet meeting of 4th October presenting the draft General Budget for 2023

The ordinary Cabinet meeting held the 4th October approved the draft General Budget for 2023. The draft was presented in a press conference by the Finance Minister (Spanish Socialist Party) and the Economy Minister (independent, linked to the Spanish Socialist Party).

Among the measures in the draft Budget we find a subsidy to compensate energy firms for additional flexibility in customers' contracts is also included in the Draft General Budget for 2023. This measure is intended to allow consumers to change their electricity contracts without being penalized by their companies, with this additional cost being assumed by the Spanish Government. Firms needed to justify the "flexibility costs" to the public administration and ask for the reimbursement. According to the fiscal experts, the measure is implemented in January 2023. This subsidy costed 182,35 million euros.

Sources:

https://www.lamoncloa.gob.es/lang/en/gobierno/councilministers/Paginas/2022/20221004_council.aspx

D.8 Speech of the Spanish President at the Parliament of 13th October 2022

The President of the Government conducted a speech at the Parliament the 13th October 2022. The President reported on the European Council session of the 7th October and on the adopted measures to tackle the cost of living crisis.

Regarding measures aimed at the reduction of the heating and gas prices, it was announced an extension of the subsidies to low-income households for heating (in Spanish known as the *bono térmico*). The *bono térmico* was introduced in Article 5 of the Royal Decree-Law 15/2018, of 5 October, in order to complement the energy social benefits (in Spanish Bono Social Eléctrico) for vulnerable consumers to purchase energy for heating, domestic hot water or cooking, regardless of the sources used ("*El Bono Social Térmico ha sido creado en el art. 5 del Real Decreto-ley 15/2018, de 5 de octubre [...] con el fin de complementar la ayuda percibida en concepto de Bono Social Eléctrico por los consumidores vulnerables, para la energía destinada a calefacción, agua caliente sanitaria o cocina, independientemente de cual sea la fuente utilizada*"). The *bono térmico* is directly granted to low-income households that already receive the *bono social eléctrico*. Thus, receiving the aid is effortless for the recipients of the *bono social eléctrico* and costly for those that did not received previously the aid. The bonus is transfer wired in a single annual payment and the amount received depends on the degree of vulnerability and the climate zone in which the residence of the consumer is located ("*La ayuda por beneficiario se abonará en un pago único anual, en su cuenta corriente, en la que tienen domiciliada la factura eléctrica, y la cuantía de la misma depende de su grado de vulnerabilidad y de la zona climática en la que se ubique su vivienda habitual*"). The government spent 225 million euros to finance this measure.

The President also announced a subsidy for the gas consumption of households from October 2022 to December 2023. It implies the creation of a new regulated gas tariff (*TUR 4)* for collective heating systems and a gas consumption higher than 50.000 kWh. The new tariff adds to the existent regulated last resort gas tariffs: i) TUR 1 for consumers with less than 5,000 kWh/h per year without heating; ii) TUR 2 for 5,001-15,000 kWh per year; and iii) TUR 3 for 15,000-50,000 kWh per year with heating and high consumption. The potential beneficiaries need to fill an application and the collective heating systems must satisfy environmental standards that might require installing new parts, but it is perceived immediately in the first bill. 1,500 million euros were allocated to finance this measure.

These measures were included in the agreement of the Cabinet meeting of the 18$^{\text{th}}$ October and in the Royal Decree Law 18/2022, of October 18, approving measures to reinforce the protection of energy consumers and to contribute to the reduction of natural gas consumption and application of the *Plan + seguridad para tu energía (Plan +SE),* as well as measures regarding the remuneration of public sector personnel and the protection of temporary agricultural workers affected by the drought.

The total budget amount allocated for the announced measures is 1,725 million euros.

Sources:

https://www.lamoncloa.gob.es/presidente/actividades/Paginas/2022/131022-sanchez-congreso.aspx

https://www.bonotermico.gob.es/

https://www.boe.es/eli/es/rdl/2022/10/18/18

D.9 Cabinet meeting of 27$^{\text{th}}$ December 2022 and Royal Decree-Law 20/2022, of 27 December, on measures to respond to the economic and social consequences of the war in Ukraine and to support the reconstruction of the island of La Palma and other situations of vulnerability.

The Spanish Government held an extraordinary Cabinet meeting on the 27$^{\text{th}}$ December 2022 to approve several measures in response to the cost of ling crisis. The agreement reached by the Cabinet was announced and explained by the President of the Government at a press conference. It was legislated in the Royal Decree Law 20/2022 of 27 December, on measures to respond to the economic and social consequence of the war in Ukraine and to support the reconstruction of the island of La Palma and other situations of vulnerability. The fiscal package included relevant measures. We cover each of them in turn:

First, VAT rates on food necessities are temporarily reduced. This entails the reduction of the VAT rate from 4% to 0% for all staple foods and from 10% to 5 % for olive and seed oils and pasta. This measure is non-targeted, effortless and immediate as it is directly noticed in the final price shown at the grocery shops. The government spent 630,46 million euros to finance this measure.

Second, subsidies to firms targeted to gas-intensive industries most affected by the high gas costs. These industries have a high consumption of natural gas in their production processes. The complete list of beneficiary sectors is detailed in the Royal Decree Law 20/2022 and some examples are the industries dedicated to the manufacturing of ceramics, glass, paper or cardboard, among other items. Moreover, new subsidies for the agricultural sector to compensate for the rise in the price of fertilisers are announced. It was necessary to fill an application at the Spanish Tax Administration (in Spanish, *Agencia Estatal de Administración Tributaria)*, but payments started within 30 days after the announcement. A total of 1076,62 million euros were allocated to finance this measure.

Finally, it was announced the extension of the fuel subsidy to firms in the transport sector.The measure extends the 20 cents discount per litre of fuel for the production sectors more affected by the rise in fuel prices. This measure replaces the general fuel subsidy of 20 cents per litre that was adopted in March with the RDL 6/2022 with a targeted measure covering only the professional users of fuel. In the case of companies benefiting from the professional diesel refund, the bonus would be paid at the end of the month, together with the partial refund of the hydrocarbon tax. They perceived it immediately. However, for companies that do not benefit from the refund of professional diesel, potential beneficiaries must fill an application form at the Spanish Tax Administration. This measure costed in total 436,47 million euros. However, without further information on the number of beneficiaries, the quantification of the measure is divided in half (218,23 million euros), between the beneficiaries that need to fill an application to obtain the subsidy and those that notice it automatically along with the refund of the hydrocarbon tax.

The total budget amount allocated for the announced measures is 3,307.47 million euros.

Sources:

https://www.lamoncloa.gob.es/lang/en/gobierno/councilministers/Paginas/2022/20221227_council.aspx

https://www.boe.es/buscar/act.php?id=BOE-A-2022-22685

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Acknowledgements

We would like to thank the Working Group of Public Finances of the ESCB for producing and sharing with us the data of the fiscal questionnaires, and Celia Martín García for her help in producing the narrative of fiscal measures. We are grateful for comments of and discussions with the Working Group of Public Finances of the ESCB, Evi Pappa, Pablo Burriel, Anna Rogantini and Leonardo Melosi. The views expressed in this manuscript are those of the authors and do not necessarily represent those of the Bank of Spain or the European Central Bank.

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PDF ISBN 978-92-899-7497-4 ISSN 1725-2806 doi:10.2866/7739308 QB-01-25-246-EN-N