Federal Reserve Bank of Cleveland Working Paper Series

The Geographic Effects of Monetary Policy

Juan Herreño and Mathieu Pedemonte

Working Paper No. 22-15

May 2022

Suggested citation: Herreño, Juan, and Mathieu Pedemonte. 2022. "The Geographic Effects of Monetary Policy." Working Paper No. 22-15. Federal Reserve Bank of Cleveland. https://doi.org/10.26509/frbc-wp-202215.

Federal Reserve Bank of Cleveland Working Paper Series
ISSN: 2573-7953

The Geographic Effects of Monetary Policy*

Juan Herreño
UC San Diego

Mathieu Pedemonte
Federal Reserve Bank of Cleveland†

Abstract

We study the differential regional effects of monetary policy exploiting geographical heterogeneity in income across cities in the United States. We find that prices and employment in poorer cities react more to monetary policy shocks. The results for prices hold for a wide range of narrow consumer expenditure categories. The results are consistent with New Keynesian models that allow for a differential share of hand-to-mouth consumers across regions, but not with models in which regions have different slopes of the Phillips curve. We show that an increase in heterogeneity across cities amplifies the effect of monetary policy on prices and employment.

Keywords: Heterogeneous Effects of Monetary Policy, Monetary Union, TANK

JEL: E31, E24, E52, E58, F45

*We thank Corina Boar, Yuriy Gorodnichenko, Joe Hazell, Ed Knotek, Christina Patterson, David Romer, Sanjay Singh, Johannes Wieland, Ines Xavier, and seminar participants at various institutions for useful comments and discussions. We thank Michael McMain for excellent research assistance.

†The views expressed here are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Cleveland or the Federal Reserve System.

1 Introduction

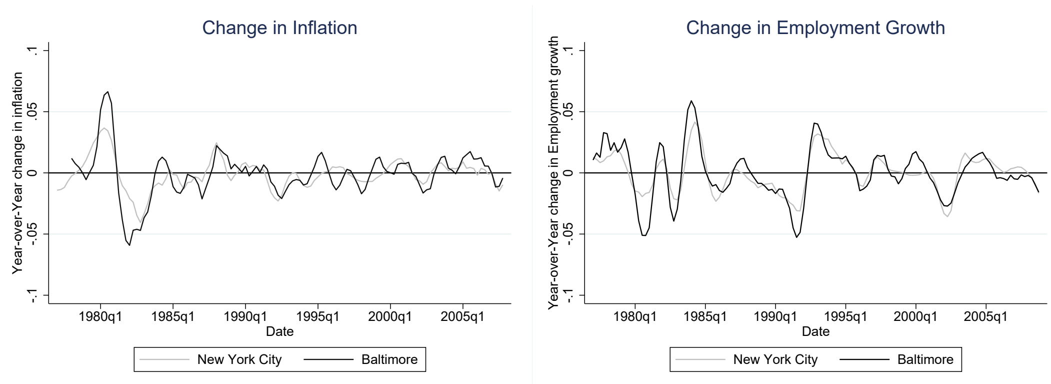
In the textbook New Keynesian model of a monetary union, regions are equally affected by exogenous shifts in monetary policy. In that framework, a rising tide lifts all boats. However, micro-level evidence shows that individuals in the economy are differently affected by national policies as a function of their earnings or balance-sheet positions.[1] In addition, some key markets clear locally, such as local labor markets or markets for non-tradable goods. Local characteristics in specific local markets may create unequal adjustment after an aggregate shock.

This paper estimates whether the transmission of monetary policy shocks in the US is different across regions and evaluates plausible drivers of economic heterogeneity that can explain our findings. As an illustration of the issues we aim to tackle in this paper, Figure 1 compares the change in inflation and employment in two US cities, New York City and Baltimore, and shows that inflation and employment are more cyclical in Baltimore than in New York City.

The patterns in Figure 1 could be explained by differential volatility of regional shocks, differential industrial composition across regions, or differential transmission of macroeconomic policy. We use exogenous variation in the stance of monetary policy since 1969 to document that monetary policy shocks induce differential responses across cities in line with this simple figure. Employment and prices react more in lower-income cities of the US after the Federal Reserve tightens rates nationally.

[1] In the case of monetary policy, see Coibion et al. (2017) for differences in income inequality; Beraja et al. (2019) and Wong (2021) provide evidence related to balance-sheet positions. See also Doepke and Schneider (2006).

Figure 1: Inflation and Employment across Space and Time



Note: The figure shows the year-over-year change in smoothed quarterly overall CPI inflation and private employment percentage change for New York City and Baltimore. The smoothing is the four-quarter (backward-looking) moving average of the overall variable.

We use consumer price index (CPI) data for 28 city areas in the US at a quarterly frequency. We estimate the effects of a monetary policy shock using local projections and a decomposition into an average effect and a heterogeneous effect depending on the base city's level of income, in line with Cloyne, Jorda, and Taylor (2020). We find that the effect of monetary policy shocks, as measured originally by Romer and Romer (2004) and extended to 2008 by Coibion et al. (2017), varies systematically with the level of relative income of the cities. After a contractionary monetary policy shock, inflation in richer cities in the US declines by less than in poorer cities.

We use more disaggregated data to understand the reaction of prices of different categories of consumer expenditures after a monetary policy shock. We find that the prices of goods and services of a wide range of narrow categories (for example, food at home, regular gas) react differently in rich and poor areas, following the same pattern we estimate for overall consumer prices.

We also estimate the effects of monetary policy shifts on employment, on average, and across the geographical income distribution. Using quarterly data on employment from the Quarterly Census of Employment and Wages (QCEW), we generate private employment counts for the same geographical areas as in the price data. We estimate that after a contractionary monetary policy shock of 1 percent, average city employment goes down by 1 percent after two years. Beyond these average effects, we show that contractionary monetary policy shocks reduce employment by more in poorer cities. A city in the bottom 10th percentile of the geographical income distribution faces a peak employment loss of 2.5 percent, while a city in the richest 10th percentile suffers negligible effects. The effects on employment are persistent and occur faster than for prices. Employment declines after the first year of the shock and stays depressed for four years after its occurrence.

A model with variation in the fraction of hand-to-mouth households across regions can replicate our results. We build a New Keynesian model of a monetary union where regions are heterogeneous in their share of hand-to-mouth households, a monetary union extension of the two-agent New Keynesian (TANK) model in Bilbiie (2008). In regions with higher shares of hand-to-mouth households, a larger share of the population is outside their Euler equation and may only smooth consumption via their labor supply decisions. The share of hand-to-mouth households then changes the "effective" sensitivity of regional consumption to real interest rates.

The model can reproduce the qualitative regional patterns we estimate in the data. Hand-to-mouth households exacerbate the effects of monetary policy shocks, as they cannot smooth consumption after aggregate shocks, affecting local demand. Changes in labor supply affect marginal costs and pass-through the price of local varieties, creating differences in regional CPI inflation rates whenever there is home bias or non-tradable goods.

In the model, monetary policy has relevant distributional effects in the short run. Contractionary monetary policy shocks induce larger price decreases in poorer regions. However, it also induces larger declines in employment, driven by the reduced labor supply of Ricardian households in regions with higher shares of hand-to-mouth households. In our calibration, after a contractionary monetary policy shock, hand-to-mouth households increase their labor supply. The empirical reaction of local employment rates we estimate comes from larger cross-regional employment responses between Ricardian agents across regions, not from the employment differences across hand-to-mouth consumers.

We then evaluate whether other sources of heterogeneity in a standard New Keynesian model without hand-to-mouth consumers can induce regional differences in the response to monetary policy shocks in line with our empirical findings. We allow for regional variation in nominal rigidities, elasticities of labor supply, and the intertemporal elasticity of substitution, the three key parameters in New Keynesian models.

We find that two of these margins of heterogeneity cannot, on their own, capture the effects we estimate. Introducing variation in the frequency of price changes and the labor supply elasticity would imply that regions with higher price responses would exhibit lower employment responses. This result is driven by a lower degree of monetary non-neutrality in regions with more flexible prices. A model with reduced-form geographic variation in the elasticity of intertemporal substitution can also rationalize our results, as it changes the sensitivity of consumption to real interest rates, as the TANK model does.

Finally, we use the TANK model to evaluate the aggregate effects of having cities with different shares of hand-to-mouth households. We find that heterogeneity in hand-to-mouth households exacerbates the effects of monetary policy shocks. This effect is explained by the accelerator effect of hand-to-mouth share explained in Bilbiie (2020). This result implies that an increase in the polarization of inequality across cities in the US makes the impact of monetary policy on both prices and employment larger.

This paper is part of a growing literature that attempts to understand the distributional effects of monetary policy and its implications. Auclert (2019) and Kaplan, Moll, and Violante (2018) focus on how heterogeneity may change the average effects of monetary policy. Bilbiie (2008) presents a two-agent New-Keynesian model in which hand-to-mouth consumers introduce frictions in the determination of aggregate quantities. We use a framework similar to that in Bilbiie (2008), extending it to a monetary union with heterogeneity in the presence of hand-to-mouth consumers, and we show that this class of models can rationalize the cross-regional heterogeneous responses of monetary policy shocks in the US.

On the empirical front, Coibion et al. (2017) show that monetary policy affects nominal income distribution in the US, Furceri, Loungani, and Zdzienicka (2018) find similar effects for a panel of countries. Cloyne, Ferreira, and Surico (2020) find heterogeneous results depending on the financial position of households. Cravino, Lan, and Levchenko (2018) focus on the heterogeneity of price adjustment. Andersen et al. (2021) document the effects of monetary policy on several sub-components of income triggered by monetary policy shocks that induce increases in inequality after expansionary shocks. While they explore differences in the price stickiness of goods consumed by rich and poor households, we focus on a different mechanism, highlighting that even for the same degree of price rigidity, heterogeneity in real rigidities will induce different inflation dynamics across regions.

Along those lines, Bergman, Matsa, and Weber (2022) look at different demographics affected by a monetary policy shock. They find that groups with lower labor market attachment have higher employment growth after expansionary monetary policy shocks when the market is tighter. Using a New Keynesian model with heterogeneous workers, they show that this effect is plausible when there are differences in workers' productivity. In this paper, we focus on the spatial income heterogeneity of the US. This heterogeneity allows us to evaluate not only the effect on employment but also on price indexes. Having employment and prices allows us to have a complete picture of the effects in terms of real income.

The rest of the paper is organized in the following way: Section 2 presents the data. Section 3 shows the empirical results. Section 4 discusses the distributional effect with different versions of a monetary union New Keynesian model. Section 5 shows the implications of monetary policy for geographic inequality according to the model. Finally, Section 6 concludes.

2 Data

Our main empirical exercise consists of estimating impulse response functions of inflation and employment at the regional level via local projections after a monetary policy shock. We focus our analysis on 28 metropolitan areas.

We construct a balanced panel for 28 metropolitan areas containing inflation rates and indicators of real economic activity. Our data start in 1969 and end in 2008, a restriction of using the Romer and Romer (2004) monetary policy shocks.[2] We use CPI inflation as our benchmark and present results for various sub-indexes, including CPI for food, food at home, food away from home, gas, and housing.

Price index data come directly from the Bureau of Labor Statistics (BLS). For our study, the granularity of observations is essential. For that reason, we choose to use city-wide indexes instead of state-wide indexes, such as those produced by Hazell et al. (2022) in order to have more variation in average economic conditions across units of observation. In addition, we will use price indexes for specific consumer categories to illustrate whether our results are driven by changes in degrees of tradability, product differentiation, or the degree of nominal rigidities.

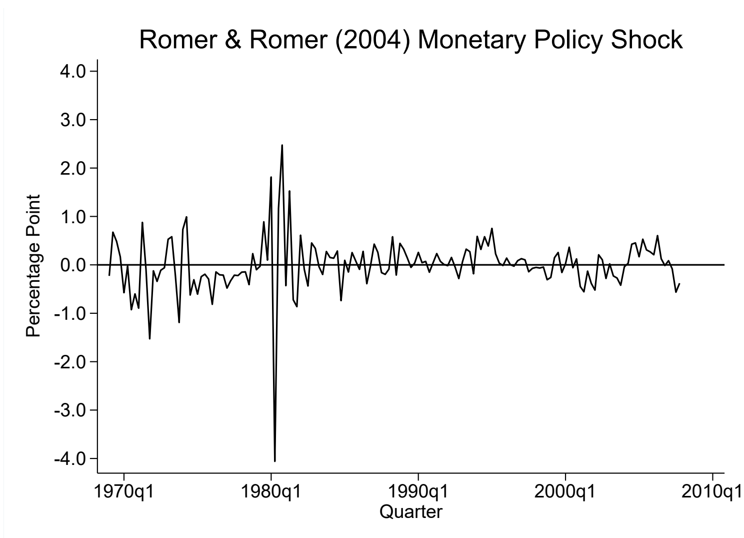
The employment data come from the Quarterly Census of Employment and Wages (QCEW). We use county-level data at the quarterly frequency covering private employment since 1975. Thus, we create a correspondence between counties and the statistical sampling units created by the BLS (called PSUs). The main advantage of the QCEW is

[2] The metropolitan areas we consider are Boston-Cambridge-Newton (MA-NH), New York-Newark-Jersey City (NY-NJ-PA), Philadelphia-Camden-Wilmington (PA-NJ-DE-MD), Chicago-Naperville-Elgin (IL-IN-WI), Detroit-Warren-Dearborn (MI), Minneapolis-St.Paul-Bloomington (MN-WI), St. Louis (MO-IL), Washington-Arlington-Alexandria (DC-MD-VA-WV), Baltimore-Columbia-Towson (MD), Miami-Fort Lauderdale-West Palm Beach (FL), Atlanta-Sandy Springs-Roswell (GA), Tampa-St. Petersburg-Clearwater (FL), Dallas-Fort Worth-Arlington (TX), Houston-The Woodlands-Sugar Land (TX), Phoenix-Mesa-Scottsdale (AZ), Denver-Aurora-Lakewood (CO), Los Angeles-Long Beach-Anaheim (CA), San Francisco-Oakland-Hayward (CA), Seattle-Tacoma-Bellevue (WA), San Diego-Carlsbad (CA), Urban Hawaii, Urban Alaska, Pittsburgh (PA), Cincinnati-Hamilton (OH-KY-IN), Cleveland-Akron (OH), Milwaukee-Racine (WI), Portland-Salem (OR-WA) and Kansas City (MO-KS).

its broad geographical coverage.

We use the Romer and Romer (2004) shocks, extended to 2008 by Coibion et al. (2017), as our measure of monetary policy shocks. We aggregate monthly shocks at the quarterly frequency. These shocks capture monetary policy changes that are free of the anticipatory movements inherent to monetary policy decisions. Figure 2 shows the shock over the sample time.

Figure 2: Romer and Romer (2004) Monetary Policy Shock



Note: The figure shows the Romer and Romer (2004) monetary policy shock added at the quarterly level.

Most of the variation in the Romer and Romer (2004) measure of monetary policy shocks comes from the Volcker disinflation.[3] There is variation after that decade. Still, it is small compared with the experience of the 1980s. Since the Great Recession, the US policy rule has been limited by the zero lower bound; so we stopped our analysis in 2008. In order to rank regions according to their income, we use data on personal income per capita from the BEA. The empirical estimation and results are presented in the next section.

[3]For a discussion, see Coibion (2012).

3 Empirical Strategy and Results

In this section, we present our empirical strategy to estimate the causal effect on prices and employment of a monetary policy shock in US metropolitan areas and our estimation results.

For a given price index in location i we compute the cumulative inflation rate between a reference period t and h periods in the future as

$$\pi_{i,t+h,t} = \frac{P_{i,t+h} - P_{i,t}}{P_{i,t}}.$$

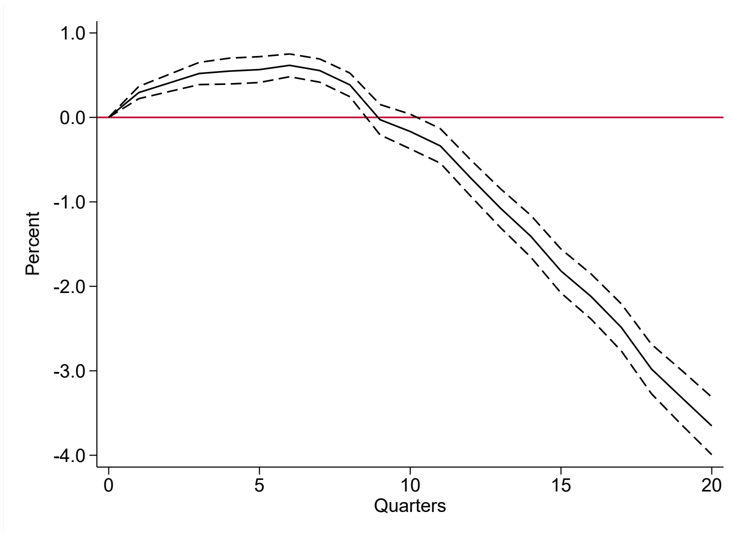
To estimate the effect of a monetary policy shock on prices in the average city, we use a panel version of the Jorda (2005) local projection method with city fixed effects,

$$\pi_{i,t+h,t} = \alpha_i^h + \sum_{j=0}^{J} \beta^{h,j} RR_{t-j} + \sum_{k=0}^{K} \gamma^{h,k} \pi_{i,t,t-k} + \varepsilon_{i,t+h}^h \;\; \forall h \in [0, H], \tag{1}$$

where i is a city, t is the current period, and h denotes the number of quarters after the shock. The coefficient $\beta^{h,j}$ accounts for the cumulative effect of a monetary policy shock j periods ago RR_{t-j}, on inflation $\pi_{i,t+h}$ h periods in the future. α_i^h is a city fixed effect and $\varepsilon_{i,t+h}^h$ is the error term. We cluster standard errors at the city level. This specification is a panel version of the lag-augmented local projections as in Montiel Olea and Plagborg-Møller (2021).

The terms $\beta^{h,0}$ trace the cumulative impulse response function on prices at horizon h after a monetary policy shock, controlling for city-specific inflation trends, past shocks, and the inflation dynamics prior to the shock. Figure 3 shows the estimated cumulative impulse response function of overall CPI inflation or, equivalently, the impulse response of prices, after a monetary policy shock that tightens rates by 1 percentage point, after estimating equation 1.

Figure 3: Effect of Monetary Policy Shock on Prices - CPI



Note: The figure shows the results of equation (1) for the panel of cities. We use $H = 20$, $J = 8$, and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level.

Our results are very similar to the original Romer and Romer (2004) results obtained by running a regression of national inflation on the monetary policy shock and controls at the aggregate level. The effect of a monetary policy shock on prices is positive and close to zero for the first two years, followed by a sharp decline, reaching a value of -6 percentage points after 20 quarters. Both the point estimate and the standard errors are similar to those obtained using aggregate data. Figure A.1 in Appendix A.1 shows the same results, clustering the standard errors in the time dimension.

We turn our attention to testing whether monetary policy shocks induce differential effects across local economic areas in the US In order to rank local areas, we use the real personal income per capita of all of the metropolitan areas. Next, we deflate nominal income per capita using the national CPI to avoid a mechanical correlation between real income per capita and regional inflation. Finally, we regress real personal income per capita on time fixed effects and use the residual as our normalized measure of income. The interpretation of this residual is the difference in income between a specific city with respect to the average income across cities in our sample for a given year.[4]

We extend equation 1 to account for regional heterogeneity in terms of real income per capita, which we estimate by running a regression of local inflation rates on the monetary policy shocks, interactions between the monetary policy shock and real relative income per capita, and local area controls that are in the information set at time t. Our specification uses the Blinder-Oaxaca decomposition on local projections as in Cloyne, Jorda, and Taylor (2020), applied to a panel setting.

$$\pi_{i,t+h,t} = \alpha_i^h + \sum_{j=0}^{J} \beta^{h,j} RR_{t-j} + \sum_{j=0}^{J} \gamma^{h,j} RR_{t-j} \times RPIPC_{i,t-j-1} + \sum_{j=0}^{J} X'_{t-j} \theta^{h,j} + \varepsilon_{i,t+h}^h \;\; \forall h \in [0, H], \quad (2)$$

with

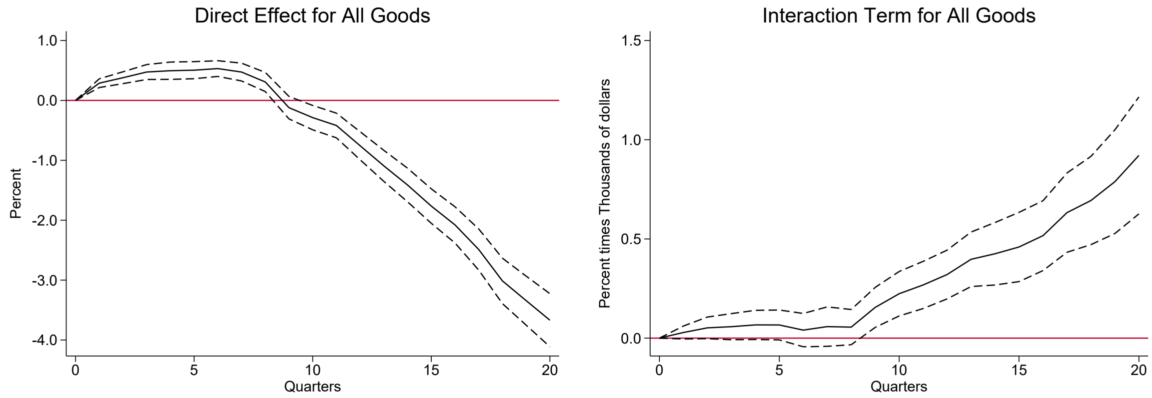
$$X_{t-j} = [RPIPC_{i,t-j-1} \;\; \pi_{i,t,t-j}],$$

where $RPIPC_{i,t}$ is the relative personal income per capita in city i at time t.

The marginal effect of a monetary policy shock that occurs in period t on inflation in city i, h periods after the shock is given by $\beta^{h,0} + \gamma^{h,0} PIPC_{i,t-1}$. Since our income control does not vary with h, we do not use any variation in real income per capita caused by the monetary policy shock. Instead, we use pre-existing differences across metropolitan areas at the onset of the shock.

[4]The decision to deflate income by the CPI avoids introducing additional heteroskedasticity in the data as the dispersion measured in current values increases along the time dimension.

Figure 4: Effect of Monetary Policy and Income Heterogeneity



Note: The figure shows the coefficient β^h of equation (2). We use $H = 20$, $J = 8$, and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level.

The left panel of Figure 4 shows the impulse response for a city of average income. The interpration of the left panel is the same as that in Figure 3; it shows effects for an average city, where here average takes the meaning of a city with mean income at the onset of the shock.

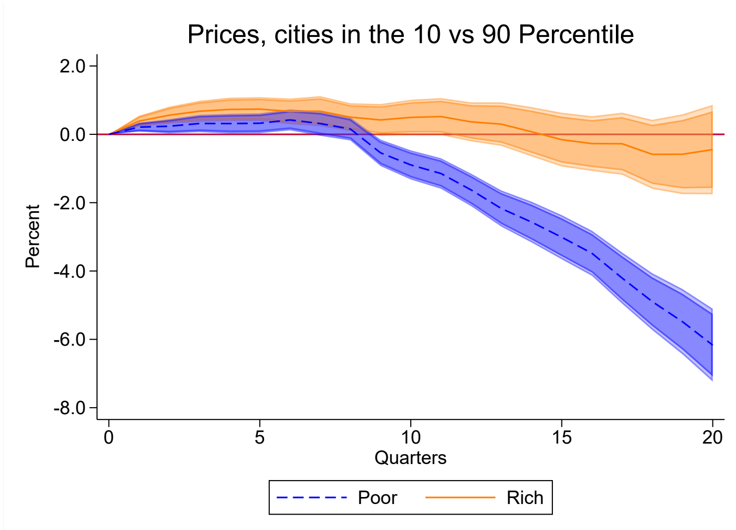
The interpretation of the interaction term in the right panel is the additional effect on prices experienced by a city with real income that is \$1000 (in the year 2000) higher than average after a monetary policy shock of 1 percentage point. The main takeaway of the right panel is that a contractionary monetary policy shock causes a smaller decline in prices in richer cities compared to that in poorer areas. The differential effects are economically sizable; a city with an income per capita that is \$1000 higher than the average gets 1.0 percentage point less cumulative inflation after a monetary policy shock of 1 percent, after 20 quarters.[5]

To illustrate further the economic relevance of our estimated heterogeneous effects, Figure 5 shows the effect for cities in the 10th percentile of the income distribution versus cities in the 90th percentile, giving a sense of the quantitative importance of our

[5]In Appendix A.1, Figure A.2 shows that the results hold when we cluster at the time level.

result throughout the geographical distribution of income. The result implies that a monetary policy shock of the same size causes an effect on prices almost 50 percent larger for cities in the 10th percentile of the distribution compared to the average, and 50 percent milder in the richer 90th percentile compared to the average. Among cities as rich as those in the 90th percentile of the income distribution, we fail to detect negative effects of monetary policy shocks on prices.

Figure 5: Effect of Monetary Policy for Poor and Rich Cities

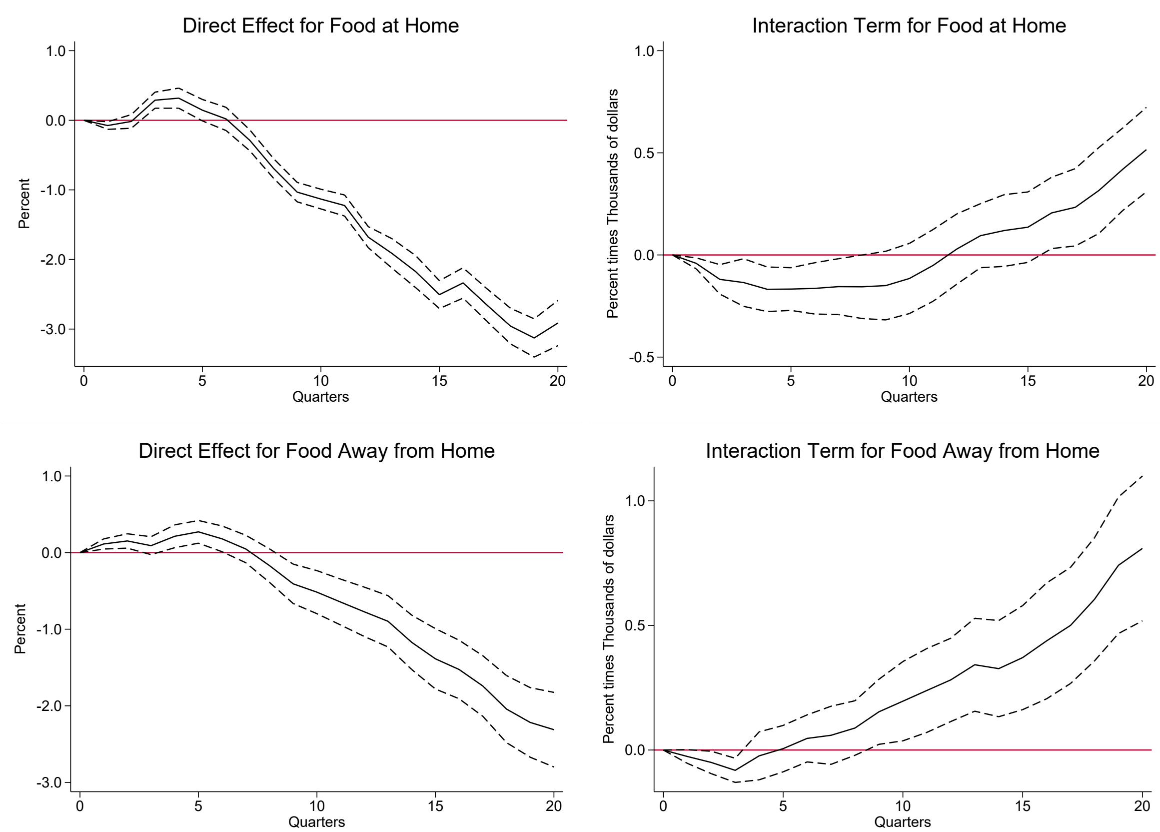


Note: The figure shows the coefficient $\beta^h + \gamma^h PIPC_{i,t+h}$ of equation (2) for cities in the 90th percentile of the distribution and cities in the 10th percentile. The 90th percentile of the distribution has 3,060 USD in 2000 more than the average annual income and the 10th percentile represents 2,105 USD in 2000 less than the average annual income. We use $H = 20$, $J = 8$ and $K = 8$. The darker area around the line represents 90 percent intervals and the lighter area 95 percent. Standard errors are clustered at the city level.

Although the effects for headline CPI are appealing, overall prices are not free of shortcomings due to the level of generality they imply. It could be the case that a subset of consumer expenditures drives our results. Since the components of the CPI vary in terms of their tradability, price stickiness, durability, and cyclicality, and since rich and poor areas potentially differ in their consumption baskets, the comparison of subcomponents of the CPI allows us to dig deeper into the mechanism behind our main results.

Our results hold across goods with a differential degree of tradability. Figure 6 shows our estimated impulse responses for "food at home,", a category with a substantial tradable component, and "food away from home," a category with a large non-tradable component. In Appendix A.1, Figure A.3 shows similar results for "housing," which also has a large non-tradable component due to the relevance of shelter in that consumption category.

Figure 6: Monetary Policy Shocks and Income Heterogeneity - By Tradability



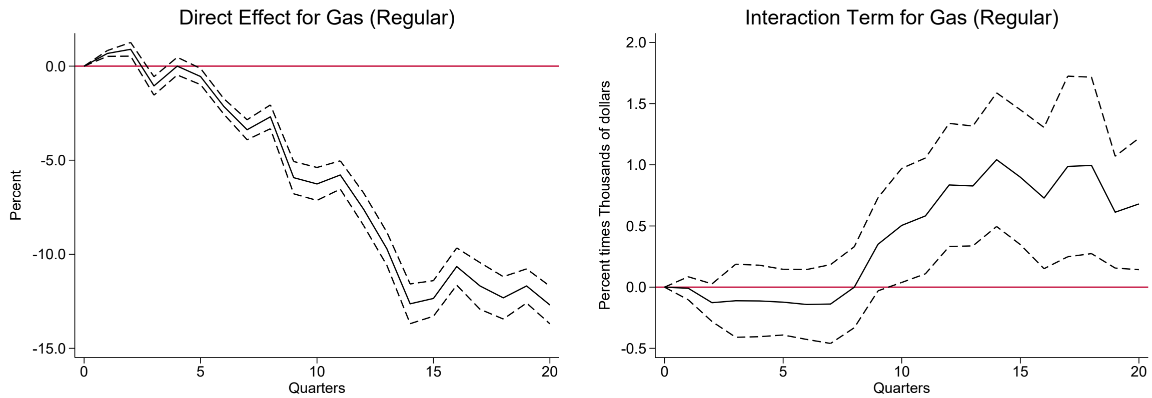
Note: The left panel shows the β^h coefficient and the right panel shows the γ^h coefficient of equation (2) for Food Away From Home. We use $H = 20$, $J = 8$, and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level.

Both the average and differential income effects across these tradable and non-tradable components move in the same direction. Richer areas experience lower declines in prices after a contractionary monetary policy shock. At first glance, the interaction term for Food Away From Home is larger, but the direct effect is also larger in a similar proportion. Therefore, the differential effect in percentage terms is roughly the same across these tradable and non-tradable categories of food consumption.

Price stickiness and homogeneity of goods are other dimensions in which our results may change. Our results may be driven by the fact that even within specific product categories, goods and services consumed in different areas are not comparable. Therefore, differential price behavior is not indicative of differences in consumer and firm behavior but rather of different economic structures across locations. Similarly, it could be the case that an economically meaningful differential response is only present for sticky-price products, where the average price response is likely to be smaller.

We find consistent results for gasoline, a highly tradable, homogeneous, flexible-price good, which we show in Figure 7. Gasoline has very flexible prices (see Nakamura and Steinsson (2008)), with a frequency of price change of once every month. Moreover, the interaction term for gasoline is proportionally smaller than that for overall consumer prices, as the average response to monetary policy shocks is larger. We take these results as indicative that our findings are not driven by particular regional differences in technology, quality of goods, or the extent of nominal rigidities in a subset of goods.

Figure 7: Effect of Monetary Policy Shock and Income Heterogeneity for Gas



Note: The left panel shows the β^h coefficient and the right panel shows the γ^h coefficient of equation (2) for gasoline (regular).We use $H = 20$, $J = 8$, and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level.

3.1 Economic Activity

Although the effects on prices are interesting on their own, to connect the evidence with economic mechanisms, it is important to discuss the differential effects of monetary policy on quantities. For example, a model in which regions are characterized by Phillips curves with slopes that are decreasing with income would create differential price responses in line with those we discussed in the previous section. However, that model would predict that quantities in rich regions would react more, contrary to the evidence we will show in this section.

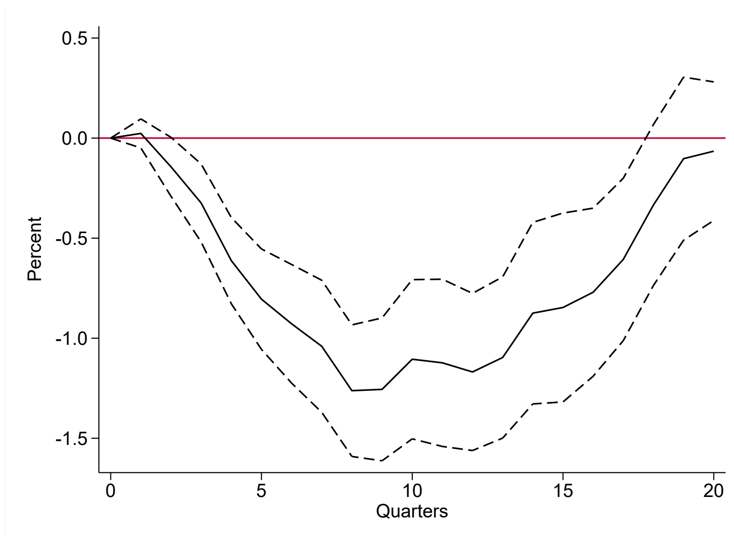
We estimate the effect of the Romer and Romer (2004) monetary policy shock on private employment. We run a specification similar in spirit to equation (1), but with the percentage change of private employment as the dependent variable, given by

$$g^e_{i,t+h,t} = \alpha^h_i + \sum_{j=0}^{J} \beta^{h,j} RR_{t-j} + \sum_{k=0}^{K} \gamma^{h,k} g^e_{i,t,t-k} + \varepsilon^h_{i,t+h} \;\; \forall h \in [0, H], \tag{3}$$

where $g^e_{i,t+h,t}$ is the employment growth in state i between time t and $t+h$.

By estimating $\beta^{h,0}$ in equation 3 we will trace the average cumulative impulse response function of private city employment at different horizons after a monetary policy shock that tightens rates by 1 percent.

Figure 8: Effect of Monetary Policy Shock on Employment



Note: The figure shows the results of equation (3) for the panel of cities. We use $H = 20$, $J = 8$ and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level.

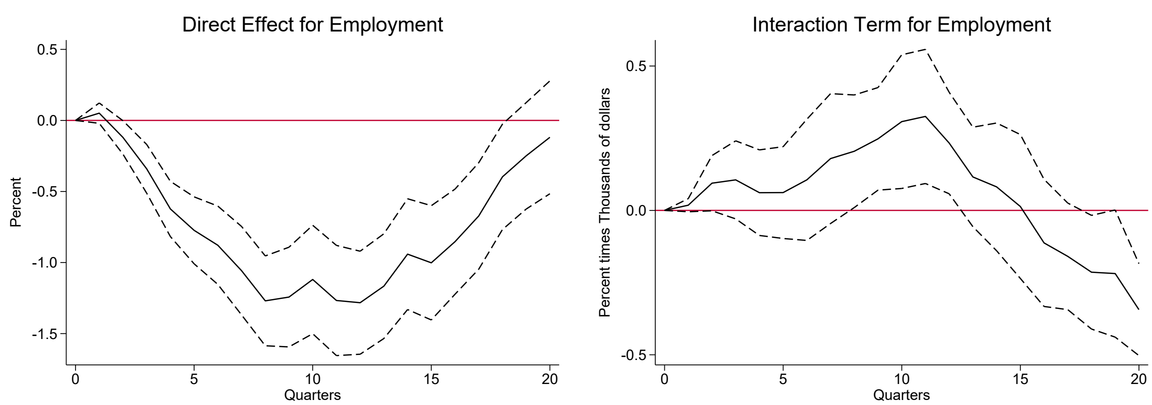
The figure shows that there is a negative effect on employment after a contractionary monetary policy shock. This effect occurs faster than the effect on prices: After five quarters, there is a decrease in employment that lasts 10 quarters. This effect is significant; the maximum cumulative effect reaches a 1 percent decrease in private employment.

In a fashion similar to what we did for prices, we estimate relative effects by income by interacting the Romer and Romer (2004) shock with our measure of pre-existing city-level real personal income per capita. Figure 9 presents the direct and interaction effects.

We estimate a significant effect of the interaction term that dampens the negative effects for richer cities. The interaction term goes in the opposite direction of the direct effect; richer cities have smaller relative employment declines when the direct effect is negative. When employment starts to recover on average, richer cities experience smaller improvements. These results imply slight variation in rich cities' employment compared with the effect in poor cities.

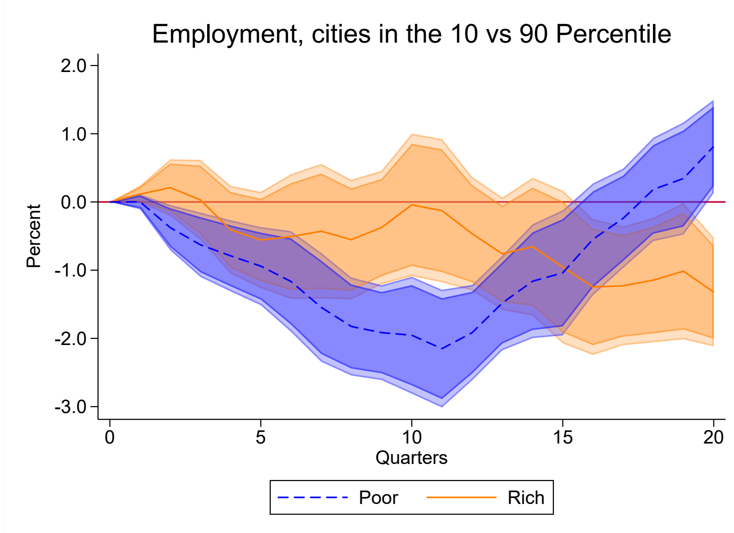
In order to illustrate the economic relevance of this result, Figure 10 shows the effect for a city in the 10th percentile of real relative income versus a city in the 90th percentile. Our results indicate that poor cities shape the national profile of employment effects. In fact, we are unable to find significant employment effects for cities as rich as those in the 90th percentile of the geographic income distribution. On the other side, cities as poor as those in the 10th percentile of the distribution have employment losses that are two times as large as those observed on average.

Figure 9: Effect of Monetary Policy Shock and Income Heterogeneity for Employment



Note: The left panel shows the β^h coefficient and the right panel shows the γ^h coefficient of equation (2) for private employment. We use $H = 20$, $J = 8$ and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level

Figure 10: Effect of Monetary Policy Shock on Employment for Poor and Rich Cities



Note: The figure shows the coefficient $\beta^h + \gamma^h PIPC_{i,t+h}$ of equation (2) for cities in the 90th percentile of the distribution and cities in the 10th percentile. The 90th percentile of the distribution has 4,755 USD (in 2000 dollars) more than the average annual income and the 10th has 3,596 USD (in 2000) less than the average annual income. We use $H = 20$, $J = 8$, and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level.

The figure shows that the richer city is not affected by the monetary policy shock during the first 15 quarters after the shock, while the poorer city has an effect of almost 2 percent at the peak, which is then compensated by an increase in employment after 15 quarters.

In the first year, we see an effect in terms of employment, while the effect of a monetary policy shock on prices is smaller at that horizon. Also, the effect lasts fewer periods. After three years, employment starts to recover. Poor cities drive national effects.

4 Discussion

Our results show that poorer cities see larger declines in prices after a contractionary monetary policy shock and larger declines in employment. This section discusses explanations behind these results and insights for the distributive effects within and across regions using our model.

4.1 Inequality Within and Across Borders

We first present a model of a monetary union in which monetary policy shocks induce differential regional responses. The model we will present has a large tradition in macroeconomics and is an extension of TANK models as in Bilbiie (2008) in a monetary union.

The model has two regions: Home and Foreign. Each region has two types of households: Ricardian and hand-to-mouth households Hand-to-mouth households are over-represented in regions with lower income per capita, as they have on average less income compared with Ricardian agents (Kaplan, Violante, and Weidner (2014); Aguiar, Bils, and Boar (2020)).

In this class of models, differential effects across regions after a monetary policy shock is induced via differences in the intertemporal IS curve; therefore, regional consumption has differential sensitivity to changes in real interest rates.

On the other side, the Phillips curve with real marginal costs as the driving variable has the same slope across regions. This is because every region faces the same degree of nominal rigidities, so there will not be any action coming directly from prices being more or less sticky. However, marginal costs will differ across firms due to assumptions of labor immobility across regions, home bias in consumer preferences, and variation in the share of hand-to-mouth households.

Home and Foreign regions are equal in population. A unit mass of Ricardian households populates the Foreign region. The Home region (H) is populated by both Ricardian (HR) and hand-to-mouth households (HH). The share of hand-to-mouth agents is denoted by λ and will be a key parameter in the model. Ricardian and hand-to-mouth households have the same preferences and supply homogeneous labor. Ricardian households save and own firms, and hand-to-mouth households consume their labor income at every point in time. Thus, labor markets are perfectly integrated within a region, and there is no labor mobility across regions.

Households have separable preferences for consumption and leisure that take a standard form,

$$U(C_{j,t}, L_{j,t}) = \frac{C_{j,t}^{1-\gamma}}{1-\gamma} - \psi \frac{L_{j,t}^{1+\alpha}}{1+\alpha},$$

with $j = \{HH, HR, F\}$.

Home Ricardian households maximize their discounted sum of expected utility

$$\max \sum_{t=0}^{\infty} E_0 \beta^t U(C_{HR,t}, L_{HR,t}),$$

subject to a sequence of budget constraints, given by

$$B_{HR,t+1}(1+i_t) + P_{H,t} C_{HR,t} \leq W_{H,t} L_{HR,t} + B_{HR,t} + \Pi_{H,t},$$

where $B_{HR,t}$ are the holdings of nominal bonds. i_t is the national nominal interest rate, common to Home and Foreign regions, and set by the monetary authority. $P_{H,t}$ is the consumer price index in the Home region, $C_{HR,t}$ is the consumption of the Ricardian agent, and $W_{H,t}$ is the nominal wage of the H region. $L_{HR,t}$ is the labor supply of the Ricardian agent. $\Pi_{H,t}$ are the profits of the firms in region H.

Hand-to-mouth households maximize the same utility function, but they do so subject to a static budget constraint that relates labor income to consumption expenditures,

$$P_{H,t} C_{HH,t} \leq W_{H,t} L_{HH,t}.$$

Regional consumption in the home region $C_{H,t}$ is the average of the consumption of both types of households, weighted by their population shares.

$$C_{H,t} = \lambda C_{HH,t} + (1-\lambda) C_{HR,t}.$$

Households have CES preferences over varieties produced in the Home and Foreign region with elasticity of substitution ν and potential home bias $\phi \geq 1/2$. Specifically

$$C_{j,t} = \left[\phi^{\frac{1}{\nu}} C_{j,H,t}^{\frac{\nu-1}{\nu}} + (1-\phi)^{\frac{1}{\nu}} C_{j,F,t}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}},$$

with $j = \{HH, HR\}$ and,

$$C_{F,t} = \left[\phi^{\frac{1}{\nu}} C_{F,F,t}^{\frac{\nu-1}{\nu}} + (1-\phi)^{\frac{1}{\nu}} C_{F,H,t}^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}.$$

In the last expression $C_{i,k,t}$ is the consumption of agent i of goods produced in region k, which is a CES aggregate of a continuum of varieties with an elasticity of substitution η,

$$C_{i,k,t} = \left(\int_0^1 C_{i,k,t}(z)^{\frac{\eta-1}{\eta}} dz \right)^{\frac{\eta}{\eta-1}}.$$

There is a continuum of firms in each region producing tradable varieties. Each firm faces demand coming from the three types of consumers,

$$Y_{j,t}(z) = \lambda C_{HH,j,t}(z) + (1-\lambda) C_{HR,j,t}(z) + C_{F,j,t}(z),$$

with $j = \{H, F\}$.

Firms produce using a linear production function in labor and are subject to regional productivity shocks, $Y_t(z) = A_t L_t(z)$. Real marginal costs, denoted MC, expressed in terms of domestic prices are common across firms within a region, and equal to $MC_t = \frac{W_t}{P_{Ht}} \frac{1}{A_t}$.

The price-setting problem of these firms is very standard. Firms can set their prices freely with probability $(1-\theta)$, and must keep their prices unchanged with probability θ, as in Calvo (1983). Firms set prices equal to a markup over the weighted discounted sum of nominal marginal costs. Up to first-order approximation, the optimal price-setting rule, consists of a price $\bar{p}_{Ht}$ that depends on regional prices, real marginal costs, the discount factor β, and the probability that firms may not adjust their prices θ, according to

$$\bar{p}_{Ht} = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k \, \mathbb{E}_t \left[mc_{t+k} + p_{H,t+k} \right]. \tag{4}$$

The Phillips curve in Home and Foreign regions has the same slope, κ,

$$\pi_{Ht} = \beta \mathbb{E}_t \pi_{H,t+1} + \kappa mc_{Ht} \tag{5}$$

$$\pi_{Ft} = \beta \mathbb{E}_t \pi_{F,t+1} + \kappa mc_{Ft} \tag{6}$$

with $j = \{H, F\}$, where $mc_{j,t}$ is the average marginal cost in region j and $\kappa = \frac{(1-\theta\beta)(1-\theta)}{\theta}$ is a coefficient that captures the extent of nominal rigidities.

The risk-sharing condition states that consumption of the Ricardian household in the Home region and consumption of households in the Foreign region obey the following relationship,

$$\left(\frac{C_{HR,t}}{C_{F,t}} \right)^{\gamma} \vartheta_0 = \frac{P_{F,t}}{P_{H,t}}$$

where ϑ_0 is constant and equal to 1 when Home and Foreign regions have the same productivity in the long run. ϑ_0 captures the current expectations of price and quantity differentials in the infinite future.

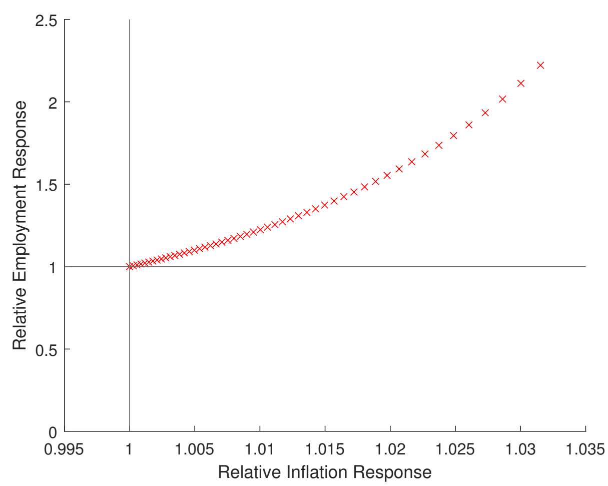
There is a single monetary authority for the monetary union that sets an interest rate i_t according to a monetary policy rule that takes into account national inflation and output in both economies, and a monetary policy shock ε_t,

$$i_t = \phi_\pi (\pi_{Ht} + \pi_{Ft}) + \phi_y (y_{Ht} + y_{Ft}) + \varepsilon_t.$$

This model generates heterogeneous regional responses after a monetary policy innovation. Regions with a higher proportion of hand-to-mouth consumers will suffer a higher drop in employment and prices after a contractionary monetary policy shock, in line with our estimated responses in US data.

Figure 11 shows the relative effect of a monetary policy shock on prices and employment between the Home and Foreign regions. We will present the result of these alternative models using a series of scatterplots. The x-axis of each scatterplot will show the present value of the impulse response function of prices in the Home region relative to the present value of the impulse response of prices in the Foreign region. The y-axis will be analogous but for the employment responses rather than for prices. Each point in the scatterplot will correspond to a model with a different value for the parameter of interest in the Home region. The calibration for the Foreign region is kept fixed.

Figure 11: Relative Price and Employment Responses - Fraction of Hand-to-Mouth Consumers



Note: This figure shows the relative behavior of regional prices, on the x-axis, and employment, on the y-axis, after a national monetary policy shock. The source of regional heterogeneity is the share of hand-to-mouth households (λ). Relative inflation and employment are computed as the ratio between the discounted cumulative impulse response functions of each variable in the Home region divided by the analogous object in the Foreign region. A value of 1 means that the Home and Foreign regions have responses of the same magnitude in present value. Each point of the scatterplot represents the solution of a model with a different value of λ. The calibrations that underlie the figure are presented in Appendix A.2.

Our results do not arise due to lower labor supply after a monetary policy shock from hand-to-mouth households. The labor supply decisions in the Home region are given by

$$\psi L^{\alpha}_{Hj,t} C^{\gamma}_{Hj,t} = \frac{W_{Ht}}{P_{Ht}}, \text{ for } j \in [H, R]. \tag{7}$$

For the case of hand-to-mouth households, plugging in the budget constraint, and solving for the labor supply yields

$$L_{HHt} = \left(\frac{1}{\psi}\right)^{\frac{1}{\gamma+\alpha}} \left(\frac{W_{Ht}}{P_{Ht}}\right)^{\frac{1-\gamma}{\gamma+\alpha}}. \tag{8}$$

Equation 8 makes clear that the co-movement of labor supply decisions of hand-to-mouth households and the real wage depends on whether the intertemporal elasticity of substitution is smaller, equal, or greater than 1. For the case of log-utility, hand-to-mouth households' labor supply is acyclical. However, for the standard case where $\gamma > 1$ the amount of labor supplied by hand-to-mouth households is countercyclical. In this case, hand-to-mouth households compensate for lower real wages by supplying more hours, the only available means they have to smooth consumption.

Due to labor immobility across regions, monetary policy in the model induces changes in labor supply decisions across household types within regions, not only across regions. This model implies that the differences in employment found in the empirical part are not necessarily due to poor households reducing their employment more. In this case, the drop in employment in the poorer region comes from Ricardian agents. The model predicts that the regional employment differences are even bigger if we compare Ricardian agents across borders.

4.2 Alternative Interpretation of Empirical Results

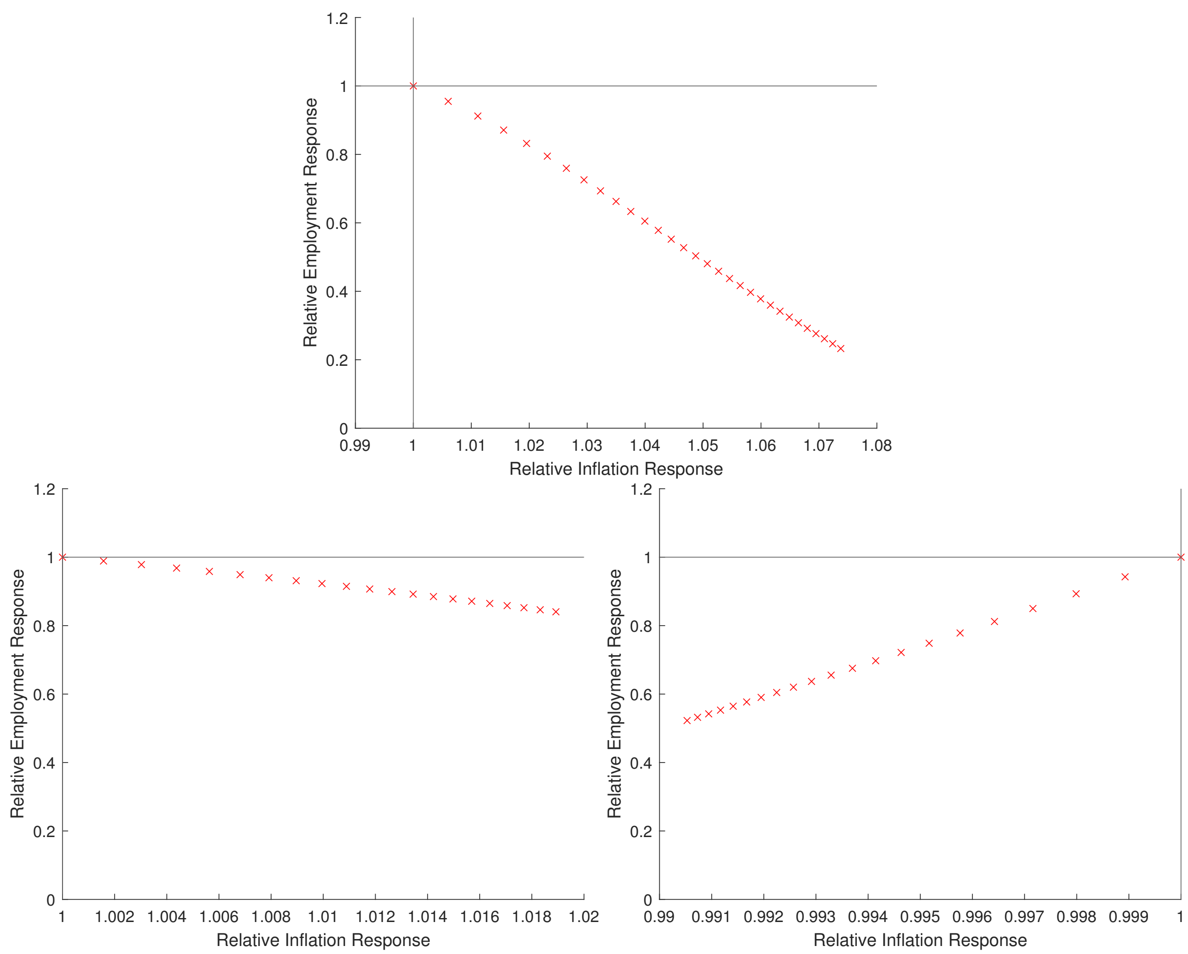
We evaluate whether other margins of variation across regions can produce results like the one found in the empirical section of this paper.

We present results from two-region New Keynesian models of an open economy in which geographical heterogeneity arises from different alternative mechanisms, the extent of nominal rigidities, the elasticity of labor supply, and the intertemporal elasticity of substitution. We set the fraction of hand-to-mouth households λ to zero. We will present the main takeaways of these exercises in this section. The details on the calibration of the models are in Appendix A.3.

The exercise we will perform will be analogous to our main exercise in the previous section. For each economic mechanism highlighted above, we will compare the impulse response of inflation and employment of Home and Foreign economies to a monetary policy shock. Home and Foreign economies are symmetric except for the one particular dimension (nominal rigidities, elasticity of labor supply, elasticity of intertemporal substitution) that we will vary. Each of these margins of heterogeneity will induce differential impulse responses across regions.

The first alternative explanation for our facts is that high-income local economies have a flatter Phillips curve than low-income ones. This alternative explanation is unsatisfactory. Intuitively, if all the action was coming from heterogeneity in the sensitivity of inflation to marginal costs, regions with larger price responses would be closer to monetary neutrality. This finding is the opposite of what we find in the empirical section; regions with larger price responses have larger real responses as well.

Figure 12: Relative Price and Employment Responses



Note: These figures show the relative behavior of regional prices, on the x-axis, and employment, on the y-axis, after a national monetary policy shock. The source of regional heterogeneity is variation in the extent of nominal rigidities (upper panel), elasticity of labor supply (lower left panel) and the intertemporal elasticity of substitution (lower right panel). Relative inflation and employment are computed as the ratio between the discounted cumulative impulse response functions of each variable in the Home region divided by the analogous object in the Foreign region. A value of 1 means that Home and Foreign regions have responses of the same magnitude in present value. Each point of the scatterplot represents the solution of a model with different variations in the extent of nominal rigidities, labor supply or intertemporal elasticity of substitution. The calibrations that underlie the figure are in Appendix A.3.

The equilibrium response of the model confirms this intuition. Figure 12, upper panel shows the relative behavior of inflation versus the relative behavior of employment. The scatterplot traces a downward sloping curve, and every point is in the second and fourth quadrant of the figure. The interpretation is that when regional heterogeneity is induced by variation in nominal rigidities, regions with relatively high inflation responses have relatively low employment responses. This result is the opposite of what we document empirically; regions with relatively high inflation responses have relatively high employment responses.

The second alternative we consider is that the driver of heterogeneity is differences in labor supply elasticity. Variation in the elasticity of labor supply across regions induces changes in marginal costs. So although the sensitivity of inflation to real marginal costs is the same across regions with different elasticities of labor supply, the reaction of inflation to demand shifts will be different across regions.

This intuition explains why Figure 12, upper panel, is qualitatively similar to the lower left panel. The frequency of price changes and the elasticity of labor supply affect the slope of the Phillips curve. So models in which these margins drive regional heterogeneity imply that economies in which inflation is more sensitive to monetary policy shocks should be closer to monetary neutrality.

A final alternative is that regional heterogeneity is driven by differences in the intertemporal elasticity of substitution. The case of the intertemporal elasticity of substitution is a priori less evident, since variation in this margin will introduce cross-sectional changes in the intertemporal IS curve and in the Phillips curve via changes in the behavior of real marginal costs.

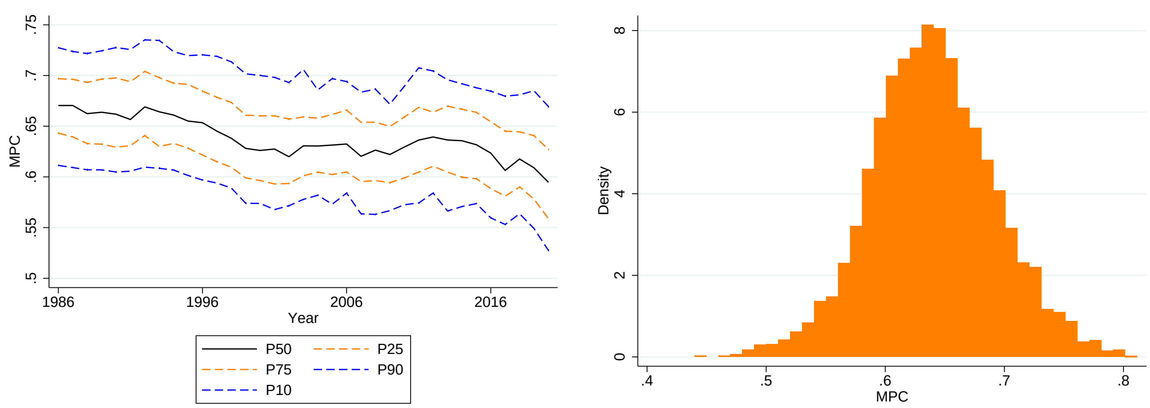
Figure 12, lower right panel, shows that cross-sectional variation in the intertemporal elasticity of substitution creates a pattern counter to the ones we have presented before and in line with those in the data. In fact, the monetary union TANK model we presented before aims to introduce the same variation as reduced-form heterogeneity in intertemporal elasticity of substitution across regions. By placing a fraction of the population out of their Euler equation, the TANK model changes the effective intertemporal elasticity of substitution.

5 Aggregate Implications

In Section 3, we showed that the average relative income of a city is a relevant margin of heterogeneity for the local effects of monetary policy shocks on employment and prices. We showed our results are consistent with a model of a monetary union where regions differ in their share of hand-to-mouth (HtM) households. Aguiar, Bils, and Boar (2020) and Patterson (2019) show a large negative correlation of HtM (or high MPC consumers) with income at the individual level.

We use estimates of the relationship between income and MPCs produced by Patterson (2019) to characterize the average MPCs across cities in the US. Figure 13 shows the evolution of MPCs for US cities since 1986 and their distribution.

Figure 13: Distribution of MPCs in the US over Time



Note: These figures show the distribution of the marginal propensity to consume across US metropolitan areas and over time. We use the estimates from Patterson (2019) and compute them for each metropolitan area at every period of time. The left panel shows the evolution over time for the mean (solid black), 25th and 75th percentile (orange dashed) and 10th and 90th percentile (blue dashed) between 1986 and 2020. The right panel is a histogram that shows the complete distribution of values and their density for all periods of time and year.

The median of the distribution has been relatively stable over time, with a slight decrease in recent years, but there is substantial heterogeneity across US cities. This section explores whether the heterogeneity of regional MPCs and the different shares of hand-to-mouth consumers that heterogeneity implies affect the aggregate effect of monetary policy shocks. We will run counterfactuals that vary the dispersion in the share of HtM households across locations keeping the national share of HtM households constant. We will use the model presented in Section 4.1 to back out the relevance of geographical heterogeneity in determining aggregate outcomes.

We impute the relationship between MPCs and income to individual earnings data from the CPS using estimates by Patterson (2019). We have a panel of MPCs for 177 metropolitan areas from 1986 to 2020.[6] We use our model to obtain the share of hand-to-mouth households in each metropolitan area (λ_i), and compute the 90th and 10th percentiles of the distribution, using that the MPC out of transitory income from HtM consumers is equal to 1 and that of Ricardians consumers is $(1 - \beta)$, effectively backing out the value for λ.

We use a labor supply elasticity α equal to 0.5, close to micro estimates, summarized by Chetty et al. (2011), a home bias parameter (ϕ) of 0.8, an intertemporal elasticity of substitution γ of 1, a Calvo parameter θ of 0.75, a discount factor β of 0.995, an elasticity of substitution between goods produced locally and in the other region ν of 1.5, and policy parameters for the Taylor rule of $\phi_y = 0.5$ and $\phi_\pi = 1.5$.

We simulate the model using two regions keeping the national average λ constant, but varying its geographical dispersion. Table 1 shows the results of the simulations.

[6] The start date is determined by changes in the geographical sampling of the CPS and our intention to have a balanced panel of metropolitan areas.

Table 1: Simulation of Heterogeneous and Homogeneous Monetary Union

	Heterogeneity			Homogeneity		
	Region 1	Region 2	Aggregate	Region 1	Region 2	Aggregate
Share of HtM	0.702	0.579	0.640	0.640	0.640	0.640
Employment	-0.898	-0.554	-0.726	-0.671	-0.671	-0.671
Inflation	-0.105	-0.078	-0.091	-0.085	-0.085	-0.085

Note: This table shows the effect on impact (first period, in percentages) on employment and prices of a 1 percent monetary policy shock. Both simulations have an average share of HtM of 0.64. Columns 2 to 4 (heterogeneity) show the effect of the shock in an economy with heterogeneous values of HtM across regions. Results are shown for each individual region (columns 2 and 3) and the aggregate effect (column 4). Columns 5 to 7 show the same effects, but for an economy where regions have the same share of HtM.

The main message of Table 1 is that heterogeneity amplifies the effect of monetary policy shocks. Amplification arises due to the non-linear effects of the share of hand-to-mouth consumers described in Bilbiie (2020). After a contractionary monetary policy shock, Ricardian agents reduce consumption and labor supply, reducing real wages in the local region. The effect on real wages makes hand-to-mouth (HtM) consumers reduce their spending as they consume exclusively from their labor income. The reduction in local wages, common for a given region by our assumption of integrated local labor markets, produces an additional decrease in demand in the local economy that depends on the share of hand-to-mouth households. This additional effect reduces marginal costs, increasing profits and producing an income effect.[7]

This effect depends critically on the labor supply elasticity (α in our model), and it is non-linear in the share of hand-to-mouth. The higher the share of HtM, the higher the effect in absolute value and at an increasing rate. Because of this non-linearity, the average effect is also larger in absolute value when there is a region with a higher share of HtM compared to the average. Therefore, the higher the dispersion of HtM, the higher the effect will be. Heterogeneity across regions amplifies the effect of monetary policy on both employment and prices.

[7] See Bilbiie (2008) for details on the conditions for this equilibrium.

6 Conclusions

This paper documents the differential regional effects on real and nominal variables of monetary policy shocks in the US. We estimate that monetary policy shocks induce larger effects on both prices and employment in poorer cities. The results for prices hold for overall prices and for a wide range of inflation categories.

We evaluate which economic mechanisms driving regional heterogeneity can rationalize our results. We propose a model in which regions are characterized by a different fraction of hand-to-mouth consumers. By affecting the sensitivity of consumption to real interest rates, the model rationalizes the larger employment and price responses we estimate in the data. On the contrary, models in which regions are characterized by differential slopes of the Phillips curve fail to rationalize our findings, since they would imply lower employment responses in regions with higher price responses.

The effects we estimate are economically large and suggest an important challenge for the monetary authority, since the power of its main tool varies across regions. This challenge is compounded for the case in which regions have differential exposure to the underlying shocks, as in trade shocks (Autor, Dorn, and Hanson (2016)), or government spending shocks (Nakamura and Steinsson (2014)).

Our results highlight the potential role of fiscal policy in generating the same aggregate effects as those induced by monetary policy, but with different local effects, as studied in the literature of equivalence results between monetary and fiscal policies (Wolf (2021)). Along that same line, the results of this paper highlight the potential complementary role of fiscal policy in correcting undesirable distributional effects of monetary policy.

References

Aguiar, Mark A., Mark Bils, and Corina Boar. 2020. "Who are the Hand-to-Mouth?" Working paper 26643, National Bureau of Economic Research. https://doi.org/10.3386/w26643.

Andersen, Asger Lau, Niels Johannesen, Mia Jorgensen, and Jose-Luos Peydro. 2021. "Monetary Policy and Inequality." Working Paper 1761, Department of Economics and Business, Universitat Pompeu Fabra. https://ideas.repec.org/p/upf/upfgen/1761.html.

Auclert, Adrien. 2019. "Monetary Policy and the Redistribution Channel." *American Economic Review* 109 (6):2333–67. https://doi.org/10.1257/aer.20160137.

Autor, David H., David Dorn, and Gordon H. Hanson. 2016. "The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade." *Annual Review of Economics* 8:205–240. https://doi.org/10.1146/annurev-economics-080315-015041.

Beraja, Martin, Andreas Fuster, Erik Hurst, and Joseph Vavra. 2019. "Regional Heterogeneity and the Refinancing Channel of Monetary Policy." *The Quarterly Journal of Economics* 134 (1):109–183. https://doi.org/10.1093/qje/qjy021.

Bergman, Nittai, David A. Matsa, and Michael Weber. 2022. "Inclusive Monetary Policy: How Tight Labor Markets Facilitate Broad-Based Employment Growth." Working Paper 29651, National Bureau of Economic Research. https://doi.org/10.3386/w29651.

Bilbiie, Florin O. 2008. "Limited asset markets participation, monetary policy and (inverted) aggregate demand logic." *Journal of Economic Theory* 140 (1):162–196. https://doi.org/10.1016/j.jet.2007.07.008.

———. 2020. "The New Keynesian cross." *Journal of Monetary Economics* 114:90–108. https://doi.org/10.1016/j.jmoneco.2019.03.003.

Calvo, Guillermo A. 1983. "Staggered prices in a utility-maximizing framework." *Journal of Monetary Economics* 12 (3):383–398. https://doi.org/10.1016/0304-3932(83)90060-0.

Chetty, Raj, Adam Guren, Day Manoli, and Andrea Weber. 2011. "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins." *American Economic Review* 101 (3):471–75. https://doi.org/10.1257/aer.101.3.471.

Cloyne, James, Clodomiro Ferreira, and Paolo Surico. 2020. "Monetary Policy when Households have Debt: New Evidence on the Transmission Mechanism." *The Review of Economic Studies* 87 (1):102–129. https://doi.org/10.1093/restud/rdy074.

Cloyne, James, Oscar Jorda, and Alan Taylor. 2020. "Decomposing the Fiscal Multiplier." *Federal Reserve Bank of San Francisco Working Paper, 2020-12* https://doi.org/10.24148/wp2020-12.

Coibion, Olivier. 2012. "Are the Effects of Monetary Policy Shocks Big or Small?" *American Economic Journal: Macroeconomics* 4 (2):1–32. https://www.aeaweb.org/articles?id=10.1257/mac.4.2.1.

Coibion, Olivier, Yuriy Gorodnichenko, Lorenz Kueng, and John Silvia. 2017. "Innocent Bystanders? Monetary policy and inequality." *Journal of Monetary Economics* 88:70–89. https://doi.org/10.1016/j.jmoneco.2017.05.005.

Cravino, Javier, Ting Lan, and Andrei A. Levchenko. 2018. "Price stickiness along the income distribution and the effects of monetary policy." *Journal of Monetary Economics* 110:19–32. https://doi.org/10.1016/j.jmoneco.2018.12.001.

Doepke, Matthias and Martin Schneider. 2006. "Inflation and the Redistribution of Nominal Wealth." *Journal of Political Economy* 114 (6):1069–1097. https://doi.org/10.1086/508379.

Furceri, Davide, Prakash Loungani, and Aleksandra Zdzienicka. 2018. "The effects of monetary policy shocks on inequality." *Journal of International Money and Finance* 85:168–186. https://doi.org/10.1016/j.jimonfin.2017.11.004.

Hazell, Jonathon, Juan Herreño, Emi Nakamura, and Jón Steinsson. 2022. "The Slope of the Phillips Curve: Evidence from US States." *The Quarterly Journal of Economics* https://doi.org/10.1093/qje/qjac010.

Jorda, Oscar. 2005. "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95 (1):161–182. http://www.aeaweb.org/articles?id=10.1257/0002828053828518.

Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante. 2018. "Monetary Policy According to HANK." *American Economic Review* 108 (3):697–743. https://doi.org/110.1257/aer.20160042.

Kaplan, Greg, Giovanni L. Violante, and Justin Weidner. 2014. "The Wealthy Hand-to-Mouth." Working Paper 20073, National Bureau of Economic Research. https://doi.org/10.3386/w20073.

Montiel Olea, José Luis and Mikkel Plagborg-Møller. 2021. "Local projection inference is simpler and more robust than you think." *Econometrica* 89 (4):1789–1823. https://doi.org/10.3982/ECTA18756.

Nakamura, Emi and Jón Steinsson. 2008. "Five Facts about Prices: A Reevaluation of Menu Cost Models." *The Quarterly Journal of Economics* 123 (4):1415–1464. https://doi.org/10.1162/qjec.2008.123.4.1415.

———. 2014. "Fiscal stimulus in a monetary union: Evidence from U.S. regions." *American Economic Review* 104 (3):753–92. https://10.1257/aer.104.3.753.

Patterson, Christina. 2019. "The Matching Multiplier and the Amplification of Recessions." Unpublished Manuscript, Northwestern University.

Romer, Christina D. and David H. Romer. 2004. "A New Measure of Monetary Shocks: Derivation and Implications." *American Economic Review* 94 (4):1055–1084. http://www.aeaweb.org/articles?id=10.1257/0002828042002651.

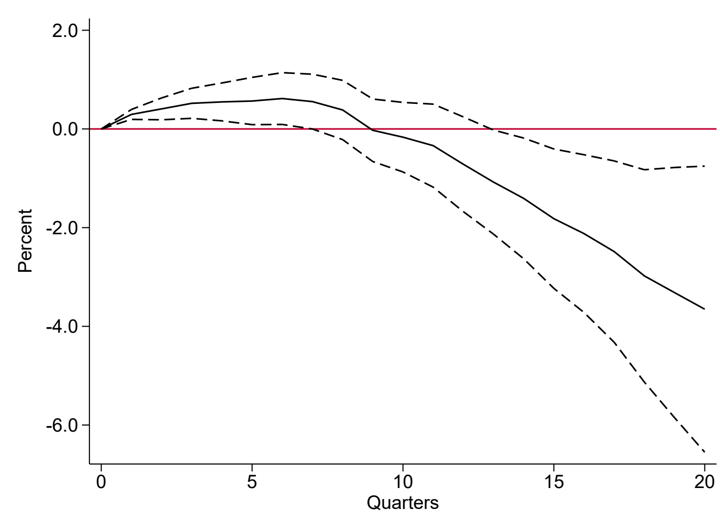
Wolf, Christian. 2021. "Interest rate cuts vs. stimulus payments: An equivalence result." Working paper 29193, National Bureau of Economic Research. https://doi.org/10.3386/w29193.

Wong, Arlene. 2021. "Refinancing and the Transmission of Monetary Policy to Consumption." Working paper 2021-57, Princeton University. https://ideas.repec.org/p/pri/econom/2021-57.html.

A Appendix

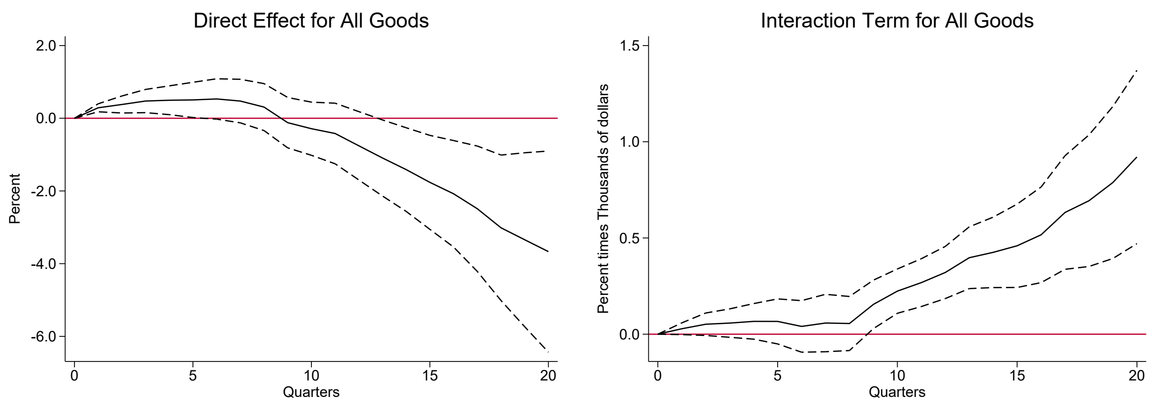
A.1 Additional Figures

Figure A.1: Effect of a Monetary Policy Shock with time cluster



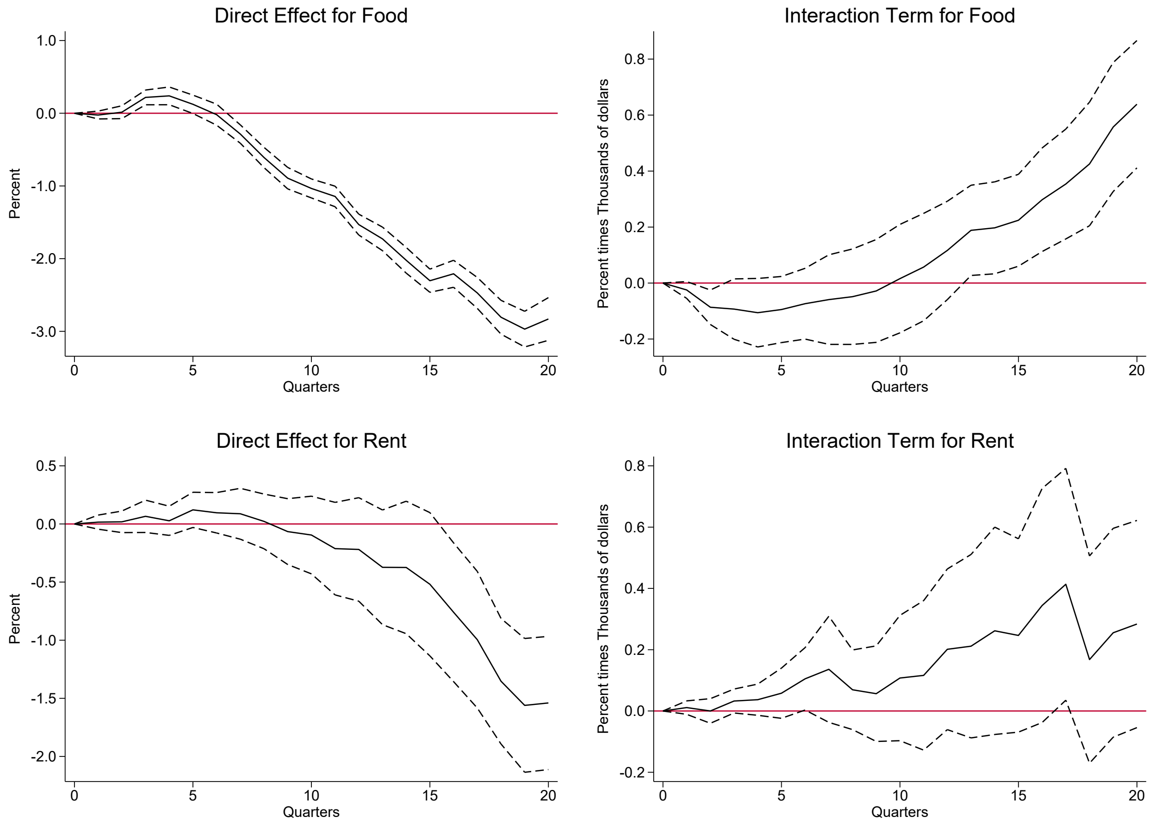
Note: The figure shows the results of equation (1) for the panel of cities. We use $H = 20$, $J = 8$ and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city and time level.

Figure A.2: Effect of a Monetary Policy Shock with time cluster



Note: The left panel shows the β^h coefficient and the right panel shows the γ^h coefficient of equation (2) for Food. We use $H = 20$, $J = 8$ and $K = 8$. The dashed lines show 90 percent intervals.. Standard errors are clustered at the city and time level.

Figure A.3: Effect on Narrow Price Indexes



Note: The left panel shows the β^h coefficient and the right panel shows the γ^h coefficient of equation (2) for different price indexes. We use $H = 20$, $J = 8$ and $K = 8$. The dashed lines show 90 percent intervals. Standard errors are clustered at the city level.

A.2 TANK Monetary Union

In this appendix we present the log-linearized equations that characterize the model explained in Section 4.1. In the following equations, lower case represents deviation from the steady state, other than for the case of the price index $P_{j,t}$ and the inflation of the price index $\Pi_{j,t}$, to differentiate it from the price of the good produced in j, $p_{j,t}$ and the price inflation $\pi_{j,t}$.

$$\pi_{H,t} = \kappa mc_{H,t} + \beta \pi_{H,t+1}$$

$$\pi_{F,t} = \kappa mc_{F,t} + \beta\pi_{F,t+1}$$

$$c_{HR,t} = -\frac{1}{\gamma}(i_t - \Pi_{H,t+1}) + c_{HR,t}$$

$$c_{HH,t} = w_{H,t} - P_{H,t} + l_{HH,t}$$

$$-\gamma c_{HR,t} + \gamma c_{F,t} = P_{H,t} - P_{F,t}$$

$$i_t = \phi_\pi(\Pi_{H,t} + \Pi_{F,t}) + \phi_y(y_{H,t} + y_{F,t}) + e_t$$

$$P_{H,t} = \phi p_{H,t} + (1-\phi)p_{F,t}$$

$$P_{F,t} = \phi p_{F,t} + (1-\phi)p_{H,t}$$

$$\Pi_{H,t} = P_{H,t} - P_{H,t-1}$$

$$\Pi_{F,t} = P_{F,t} - P_{F,t-1}$$

$$\pi_{H,t} = p_{H,t} - p_{H,t-1}$$

$$\pi_{F,t} = p_{F,t} - p_{F,t-1}$$

$$mc_{H,t} = \alpha y_{H,t} + (\gamma - (1/\nu))c_{H,t} + (1/\nu)(\lambda c_{HH,H,t} + (1-\lambda)c_{HR,H})$$

$$mc_{F,t} = \alpha y_{F,t} + (\gamma - (1/\nu))c_{F,t} + (1/\nu)c_{FF,t}$$

$$y_{H,t} = \lambda l_{HH,t} + (1-\lambda)l_{HR,t}$$

$$\gamma c_{HR,t} + \alpha l_{HR,t} = w_{H,t} - P_{H,t}$$

$$\gamma c_{HH,t} + \alpha l_{HH,t} = w_{H,t} - P_{H,t}$$

$$-c_{FF,t} + c_{FH,t} = \nu(p_{F,t} - p_{H,t})$$

$$-c_{HH,H,t} + c_{HH,F,t} = \nu(p_{H,t} - p_{F,t})$$

$$-c_{HR,H,t} + c_{HR,F,t} = \nu(p_{H,t} - p_{F,t})$$

$$c_{H,t} = \lambda c_{HH,t} + (1-\lambda)c_{HR,t}$$

$$c_{HH,t} = \phi c_{HH,H,t} + (1-\phi) c_{HH,F,t}$$

$$c_{HR,t} = \phi c_{HR,H,t} + (1-\phi) c_{HR,F,t}$$

$$c_{F,t} = \phi c_{FF,t} + (1-\phi) c_{FH,t}$$

$$y_{H,t} = \lambda \phi c_{HH,H,t} + (1-\lambda) \phi c_{HR,H,t} + (1-\phi) c_{FH,t}$$

$$y_{F,t} = \phi c_{FF,t} + \lambda (1-\phi) c_{HH,F,t} + (1-\lambda)(1-\phi) c_{HR,F,t}$$

$$\varepsilon_t = \rho \varepsilon_{t-1} + e_t$$

We consider values of $\beta = 0.99$, $\alpha = 1.0$, $\eta = 4$, $\rho = 0$, $\gamma = 1$, $\theta = 0.9$, $\phi_\pi = 1.5$, $\phi_y = 0.5$ and $\nu = 3$, $\phi = 0.85$. The values of λ go between 0 and 0.5.

A.3 Alternative New Keynesian Models

We simplify the model used in Section 4. In this case, we assume $\lambda = 0$, but we allow for regional heterogeneity in the parameters of the model. The model is characterized by the following equations:

$$\pi_{Ht} = \beta \mathbb{E}_t \pi_{H,t+1} + \kappa_H mc_{Ht} \tag{9}$$

$$\pi_{Ft} = \beta \mathbb{E}_t \pi_{F,t+1} + \kappa_F mc_{Ft} \tag{10}$$

with

$$mc_{Ht} = \alpha_H y_{H,t} + \left(\gamma_H - \frac{1}{\nu}\right) C_{H,t} + \left(\frac{1}{\nu}\right) C_{H,H,t} \tag{11}$$

$$mc_{Ft} = \alpha_F y_{F,t} + \left(\gamma_F - \frac{1}{\nu}\right) C_{F,t} + \left(\frac{1}{\nu}\right) C_{F,F,t} \tag{12}$$

where $C_{k,j,t}$ is the consumption of region k on region j good in time t. Since here $\lambda = 0$, there are only Ricardian agents; then the IS curve is characterized by:

$$C_{H,t} = -\frac{1}{\gamma_H}\left(i_t - E_t \Pi_{H,t+1}\right) + E_t C_{H,t+1} \tag{13}$$

For region F, we replace that condition with the risk-sharing condition (does not really matter which one we replace).

$$\gamma_H C_{H,t} - \gamma_F C_{F,t} = P_{F,t} - P_{H,t} \tag{14}$$

Finally, we have a national monetary policy rule that symmetrically weights both regions:

$$i_t = \phi_\pi(\pi_{Ht} + \pi_{Ft}) + \phi_y(y_{Ht} + y_{Ft}) + \varepsilon_t.$$

In Section 4, we allow for differences in the intertemporal elasticity of substitution γ_i, extent of nominal rigidities κ_i and the elasticity of labor supply α_i.

The values for α and γ we consider are values between 1 and 3. The values for θ that we consider are between 0.6 and 0.9. The benchmark values for these parameters for the Foreign region, which we keep fixed, are $\alpha = 1$, $\gamma = 1$, and $\theta = 0.75$.