Structural Transformation and the Transmission of Monetary Policy*

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Abstract

This paper examines how the secular sectoral reallocation of economic activity toward services shapes the transmission of monetary policy in the United States. Service prices adjust less frequently than goods prices, implying the Phillips Curve flattens over time. Moreover, high-income households allocate a larger share of their expenditure to services than low-income households, implying changes in the distributional effects of monetary policy as the services share rises. Using a two-sector heterogeneous-agent New Keynesian model with non-homothetic preferences, I find that the shift toward services between 1970 and 2019 amplified the effects of monetary policy by 21%. I show that the heterogeneous sectoral price rigidities documented are responsible for four-fifths of the enlargement of the propagation mechanism. This amplification of the monetary policy effects leads to a 5% higher welfare loss, with these losses being concentrated among low-wealth households. Furthermore, I also show that the sectoral reallocation towards services makes the economy less vulnerable to negative supply shocks.

Keywords: Structural Transformation; Monetary Policy; Heterogeneous-Agent Models; Non-homothetic Preferences; Price Rigidities

JEL classification: D11; D21; D31; E21; E23; E32; E52; O41

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1 Introduction

Economic growth comes with a process of structural transformation that shifts economic activity toward the services sector. In the United States, the share of consumer expenditure allocated to services rose from 50% in 1970 to 68% in 2019, according to the Bureau of Economic Analysis. While this transformation has been widely studied in the context of long-run growth, its implications for short-run economic dynamics — particularly the effects on monetary policy transmission — have received much less attention. One reason is the perception that structural transformation is a slow-moving process that spans decades, whereas monetary policy focuses on stabilizing the economy over months or years. Yet this separation overlooks an important interaction: changes in the composition of demand between goods and services reshape how different sectors respond to interest rate changes, thereby altering the transmission of monetary policy over time.

In this paper, I study how changes in the sectoral composition towards services driven by structural transformation affect the transmission of monetary policy in the United States. Using microdata on consumption and prices, I document two empirical facts about the services sector with implications for monetary policy transmission. First, I show that prices of services adjust less frequently than prices of goods, which means that structural transformation makes the Phillips Curve flatter. Second, I document that high-income households allocate higher shares of their total expenditure to the services sector than the goods sector, implying a new channel through which monetary policy generates distributional effects. Using a two-sector heterogeneous-agent model with sector-specific price rigidities and heterogeneous household demand composition, I quantify the effects of structural transformation for monetary policy transmission. I find that a one percentage point increase in the services share leads to a 1.2% stronger response of the economy to monetary policy. As demand shifts toward more price-sticky services, output, consumption, and employment become more responsive to monetary shocks. At the same time, the welfare costs of a monetary contraction increase, particularly for poorer households.

I begin by documenting two empirical facts about the services sector to motivate why differences between the services and goods sectors are relevant for monetary policy. First, using aggregate statistics compiled by Nakamura and Steinsson (2008) from the microdata underlying the U.S. Consumer Price Index, I show that within a month, only 11% of the goods change their price, whereas 35% of the goods change their price. This striking difference between sectors is robust to different time periods and countries, indicating a structural feature of price dynamics. Second, using detailed expenditure survey microdata from U.S. households, I show that the service share of consumption rises with income. Households in the top income quintile allocate, on average, almost 12 percentage points more of their consumption to services than those in the bottom income quintile.

These empirical patterns imply structural features that have important implications for the transmission of aggregate shocks over time, such as monetary policy shocks. As the share of the services sector in the economy increases over time, the overall degree of price rigidity in the economy rises. This amplifies the real effects of monetary policy, making output and consumption more responsive to changes in the nominal interest rate. Therefore, my paper presents a new reason why the Phillips Curve has flattened in the last decades.[1] The paper also accounts for the post-COVID steepening of the Phillips curve: the contraction of the services sector lowered its weight in the economy, diminished aggregate price rigidity, and thereby increased the slope.

On the other hand, because poorer households consume fewer services and adjust their spending more strongly, while richer households consume more services and respond less, the same monetary shock has unequal effects across the income distribution. This means that the aggregate impact of monetary policy depends not only on overall spending but also on how demand is distributed across households. As the economy shifts toward services, this distributional channel leads to a weaker effect on aggregate demand, in opposition to the price rigidities effects. Empirically, using a sample of advanced economies, I find a negative cross-country correlation between the service share in the expenditure and the response of output to contractionary monetary policy shocks.

To quantify these effects and study the role of shifts in the demand composition for monetary policy transmission, I develop a two-sector dynamic general equilibrium model with household and sectoral heterogeneity. The production side features two final production sectors — services and goods — each aggregates a continuum of differentiated intermediate inputs whose producers only use labor in a linear technology and face sector-specific price

[1] Leading explanations for the flattening of the Phillips Curve include anchoring of expectations (Coibion and Gorodnichenko, 2015, Ball and Mazumder, 2019, Hazell et al., 2022), globalization (Forbes, 2019), FED credibility (McLeay and Tenreyro, 2020), measurement issues (Stock and Watson, 2020), and special features of the 2008 financial crisis (Gilchrist et al., 2017).

adjustment costs. On the household side, the model builds on the standard incomplete markets framework, with endogenous labor supply choice, idiosyncratic productivity shocks, and a borrowing limit. Crucially and novel in comparison to standard heterogeneous-agent models, I add non-homothetic preferences over goods and services, creating heterogeneous demand composition. Households choose not only how much to work, consume, and save, but also how to allocate consumption across the two sectors.

I estimate the model to match both the long-run structural transformation trend of the U.S. economy and household cross-section heterogeneity on income, wealth, and consumption. I do this in three steps. First, I derive the relative demand between the two sectors, which allows me to use the cross-section and time variation of household consumption microdata and sectoral price level data to estimate the parameters that regulate the non-homothetic degree of preferences. Second, I set some parameters that can be identified based on external evidence, such as the idiosyncratic productivity, the sectoral productivity growth rates, and the sectoral price rigidities. Third, I use the Simulated Method of Moments to match the average service share in the U.S. economy in 2019 and the aggregate number of hours worked.

The model matches both long-run and short-run features of the economy. In the long run, it replicates the rise in the service share and the relative price of services: the 2019 levels are targeted in calibration, while the evolution over time emerges from changes in sectoral productivity, generating the structural transformation observed in the data. In the short run, the model generates an Engel curve for services that is consistent with the data, as well as realistic wealth and marginal propensity to consume distributions — crucial components in models where household behavior drives aggregate dynamics (Kaplan and Violante, 2018).

Using the U.S.-estimated model, I study how sectoral reallocation toward services generated by structural transformation shapes monetary policy transmission. I compare the effects of conventional monetary policy shocks that increase the nominal interest rate by 100 basis points in 1970 and 2019, when the service share was lower and higher, respectively. Using the consumption peak response as a comparison metric, I find that the same shock reduces consumption by 21% more in 2019 than in 1970. This means that for each percentage point increase in the services share, monetary policy effects amplify by 1.2%. Similarly, the recessionary effects on employment also increase, in this case by 32% in 2019 relative to 1970.

To understand the mechanisms behind the amplification, I use two distinct decompositions. The first decomposition focuses on the forces behind structural transformation. Two factors matter: changes in relative prices and the income effect from growth. To isolate them, I construct two counterfactual economies where only one force operates in each. If structural transformation were driven only by the income effect, the consumption response to monetary policy would be 12% larger in 2019 than in 1970. If it were driven only by relative price changes, the amplification would instead be 14%.

The second decomposition separates the role of sectoral differences in price rigidities from the role of heterogeneous demand composition. I find that the differences in the frequency of price adjustment amplify the monetary policy response of consumption between 1970 and 2019 by 17 percentage points, whereas the heterogeneous demand composition dampens the propagation of monetary policy effects by 3.5 percentage points, in comparison with the baseline result of 21%. To conclude this, I built two counterfactuals: one where the cost of price adjustment is the same for both sectors, and the other where preferences are homothetic and hence no differences across households in terms of the demand composition. In both counterfactuals, the service shares are equal to the baseline in 1970 and 2019.

I also study how the distributional effects of monetary policy changed with structural transformation. Household at the bottom of the wealth distribution decrease their consumption relatively less than households at the top of the wealth distribution. Structural transformation amplifies these differences. To understand the implications of these differences on welfare, I compute the wealth compensation necessary to restore welfare before the monetary policy shock. I find that monetary policy became 5% more costly in 2019 than in 1970, from a utilitarian perspective. This masks a significant difference across households. Low-wealth households are the ones that bear the highest welfare loss when interest rates rise. With a larger service share, their welfare loss is even larger, rising 7.2% for the households at the bottom of the wealth distribution. On the other hand, households at the top of the distribution benefit from the interest rate increase and, in an economy more concentrated in the services sector, their gains from the contractionary monetary policy shock are slightly higher. Overall, this means that structural transformation amplifies the inequality that monetary policy generates.

The model also demonstrates that monetary policy alters the composition of demand. An increase in the interest rate reduces consumption in both sectors, but the decline is larger for services than for goods, leading to a fall in the share of services in total household expenditure. This asymmetric response arises from two key differences between the sectors. First, the slopes of the sectoral Phillips curves differ due to the differences in price adjustments. Second, the income elasticity of demand varies across sectors, reflecting the non-homothetic nature of preferences. I show that both mechanisms contribute equally to the differential consumption responses across sectors.

Using the same framework, I also study how structural transformation changes the economic response to negative supply shocks. A negative supply shock raises prices, but due to differences in sectoral price rigidities, goods prices increase more than services prices. As a result, goods consumption falls more than services consumption. When a larger share of economic activity is concentrated in services, a smaller fraction of the consumption basket is directly exposed to sharp price increases, so aggregate consumption contracts less. In sum, structural transformation makes the economy less responsive to supply shocks.

These results have implications for policymakers, especially central bankers. The Euro area is characterized by a single monetary authority that determines the nominal interest rate for a set of countries that are heterogeneous in many dimensions as the sectoral composition. My results can shed light on the heterogeneous responses to monetary policy observed in Europe.[2]

Related Literature and Contribution. The paper contributes to three strands of the literature. The first strand studies how long-run trends affect monetary policy transmission. This literature has focused on how the change in inflation expectations (Boivin and Giannoni, 2006), population aging (Leahy and Thapar, 2022, Mangiante, 2025), labor market structure (Pancrazi and Vukotić, 2019), or changes in the production networks (Galesi and Rachedi, 2019) affect monetary policy transmission. This paper focuses instead on the structural transformation trend that shifts consumption demand towards services and changes the transmission of monetary policy. Specifically, I focus on the effects of a shift towards higher income elasticity of demand and a higher degree of price rigidity in consumption.

The second strand of the literature this paper contributes to studies how household heterogeneity matters in the propagation of monetary policy. This is often called the HANK literature, whose recent advances are summarized by Kaplan et al. (2018), Debortoli and Galí (2025), and Auclert et al. (2025). In terms of the relevance of heterogeneity for monetary policy efficacy, this literature's focus has been on the role of differences in income sources (Gornemann et al., 2016), household balance sheets (Kaplan et al., 2018, Auclert, 2019, Slacalek

[2]Several authors have examined the factors underlying these heterogeneous responses. Recent examples include Burriel and Galesi (2018), Almgren et al. (2022), Corsetti et al. (2022), and Pica (2023).

et al., 2020, Luetticke, 2021), sectoral price rigidities (Clayton et al., 2018, Cravino et al., 2020), and unemployment risk (Challe, 2020, Bonciani and Oh, 2021). My paper's novelty is to introduce heterogeneity in the household demand composition and income elasticity of demand between goods and services to study the impact of monetary policy on household consumption.

My paper also contributes to the growing literature that uses non-homothetic preferences to model economic phenomena. This literature has focused on using these preferences to model structural transformation, or, more recently, to study consumption and saving behavior, with implications for business cycles and public policy.[3] Regarding the first segment, refer to Herrendorf et al. (2014) for a review.[4] Regarding the second segment, Olivi et al. (2024) use them to analyze optimal monetary policy. Andreolli and Surico (2025) and Orchard (2025) show how heterogeneity in consumption baskets between necessities and luxuries interplays with business cycles. Boehnert et al. (2025) study monetary policy transmission through differences between tradable and non-tradable goods. De Nardi and Fella (2017) use this class of preferences to account for wealth inequality. Jaimovich et al. (2019) and Becker (2024) use them to account for differences in the product quality of consumption baskets.[5] My contribution is distinct in that I model heterogeneity in both income elasticities and in the composition of consumption baskets across goods and services with different price rigidities. This allows me to examine how such heterogeneity alters the transmission of monetary policy in the context of structural transformation.

Outline. The structure of the paper is as follows. Section 2 motivates why the sectoral composition between goods and services matters, documenting two empirical facts. Section 3 lays out the model used to study monetary policy transmission. In Section 4, I estimate the model and show the long-run and short-run fit of the model to the U.S. economy. Section 5 presents the results comparing the monetary policy effects when the service share of the economy changes, i.e., due to structural transformation. In Section 6, I leverage the framework presented and study how structural transformation changes the economic responses to negative

[3]Non-homothetic preferences have also been used in the finance literature. Ait-Sahalia et al. (2004) use them to explain the equity puzzle premium, Pakos (2004) to study asset prices, and Wachter and Yogo (2010) to explain the rise of portfolio shares in wealth.

[4]Other recent applications that look at long-run implications of using non-homothetic preferences include Hochmuth et al. (2025) that model heterogeneous energy use across the income distribution, and Arvai and Mann (2025) that model differences in digitally produced products consumption.

[5]Other recent applications of non-homothetic preferences to business cycle analysis include Danieli (2020) and Sonnervig (2025).

supply shocks. Section 7 concludes.

2 Motivating Empirical Evidence: Why Sectoral Composition Matters

In this section, I describe two empirical facts about the services sector in the United States. First, I demonstrate that prices in the services sector adjust less frequently than those in the rest of the economy. Second, I demonstrate that the Engel curve for services exhibits a positive income gradient, meaning that high-income households allocate a larger share of their total consumption to the services sector than low-income households.

2.1 Sectoral Price Rigidity

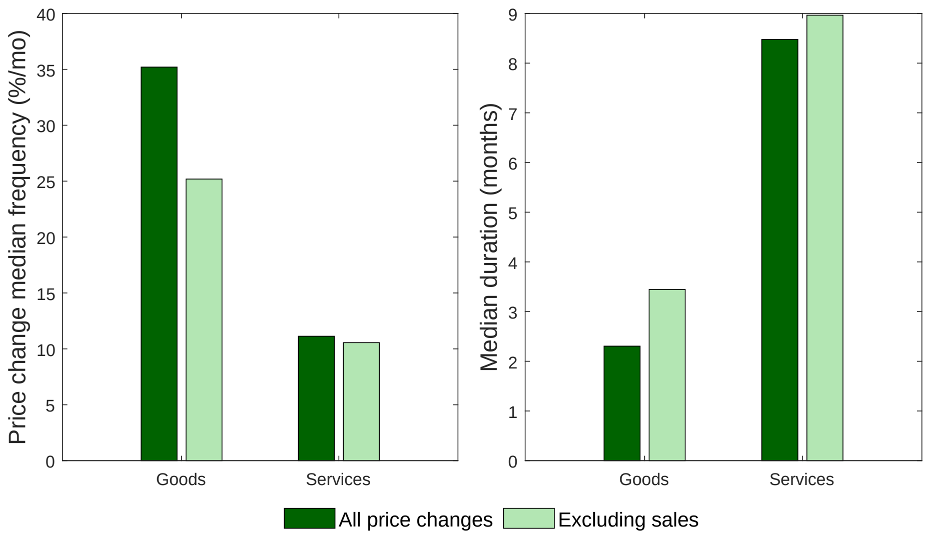
My first piece of empirical evidence is related to the differences in price rigidity between goods and services, where prices in the services sector adjust less frequently than prices in the goods sector. To document this fact, I use the data in Nakamura and Steinsson (2008) about price dynamics. In this paper, the authors assembled a dataset with the frequency of price adjustments for several categories of goods and services. It is built based on the confidential monthly product-level price data used to construct the CPI. The data covers the prices of around 70% of consumer expenditures (excluding housing prices) between 1998 and 2005 in the U.S. In particular, I use the median frequency of price change by consumption category between 1998 and 2005.

Based on the reported frequency of price adjustments for aggregated expenditure categories, I aggregate the different categories into goods or services, following the U.S. Bureau of Economic Analysis (BEA) classification. The aggregation is a weighted mean, using the average budget shares as weights. For interpretation, I also compute the implied median duration of a price spell, using a Poisson process.

In the left-hand-side panel of Figure 1, I show the median percentage of goods and services that have a change in price within a month. I compute this number for all price changes (dark green bars) and for regular price changes that exclude sales (light green bars). In the right-hand-side panel, I show the implied median duration in months of the price of a good and the price of a service, including and excluding price changes due to sales.

The figure illustrates a notable difference in the frequency of price adjustments between goods and services. 35% of the goods change their price within a month. On the other hand,

Figure 1: Frequency of Price Change for Goods and Services



Notes: The left panel shows the median frequency of price changes in a month for goods and services. The right panel shows the implied median price duration of a price spell in months. Duration is equal to $-1/\log(1-f)$, where f is the frequency of price changes. Data are sourced from Nakamura and Steinsson (2008) for both panels.

only 11% of the goods have a price change within the same time frame. The implied duration of a price spell is, therefore, longer for services than for goods. In fact, the price of goods lasts a median of 2.3 months, whereas the median duration of the price of services is 6 months longer, 8.5 months. When examining only price changes that do not result from a sale, the difference between goods and services is smaller; however, it remains clear that goods adjust their prices more frequently than services.[6]

Importantly, this regularity is not specific to the dataset, the time considered, or the U.S. In Appendix A.3, I use an alternative dataset assembled by Bils and Klenow (2004) that is similar in all aspects, except that it covers the years between 1995 and 1997. Furthermore, using prices for the Euro Area, Gautier et al. (2024) and Dhyne et al. (2006) also demonstrate that the prices of services adjust less frequently than those of food and industrial goods.

There are potential reasons that can explain these observed differences. First, most categories included in the goods sector are tradable and therefore face a higher degree of price competition, which creates pressure for more frequent price adjustments. A second reason is related to the production structure of goods vs. services. The production of services uses a higher

[6] As Nakamura and Steinsson (2008) point out, temporary sales play an important role in generating price flexibility for retail prices. These temporary sales are more common in goods than services, associated, for instance, with the perishability of goods.

share of labor than goods. Since wages are rigid, the higher labor share in the services sector could imply that service prices adjust less frequently. In this paper, I do not aim to explain the differences observed, but rather evaluate the implications of them for monetary policy transmission. Therefore, the model that I present below assumes heterogeneous sectoral price stickiness, which is exogenous. All the factors that explain these differences are captured in a reduced form by differences in the parameter of the cost of adjusting prices that firms face.

Over time, there is some weak evidence of an increase in the frequency of price adjustments in recent years. Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008) find minimal differences in the overall frequency of price changes when looking at the adjustments between 1988 and 2005 for the U.S. Gautier et al. (2024) compare their results with Dhyne et al. (2006) and find, in a similar way, small differences over time between 1996–2004 and 2011–2017 for the Euro Area. Because of these, in the next section, I assume that the frequency of price adjustment at the sectoral level is fixed.

Structural transformation reallocates economic activity toward the services sector. Because this sectoral gap in price flexibility persists, the overall frequency of price adjustment declines as the service share of the economy rises. A lower aggregate frequency of price adjustment translates into a flatter Phillips Curve, weakening the link between economic activity and inflation. This paper, thus, offers an alternative explanation for why the Phillips Curve has flattened over time.[7] The resulting increase in nominal rigidity amplifies monetary non-neutralities. In this way, shifts in sectoral composition have first-order consequences for the transmission of monetary policy.

2.2 Heterogeneous Demand Composition

The second motivating fact is about differences in the demand composition between low- and high-income households. Low-income households allocate a smaller share of their expenditures to services than high-income households. To document this, I use expenditure data from the Consumer Expenditure Survey (CEX) curated by the U.S. Bureau of Labor Statistics (BLS). The CEX has household-level consumption data that tracks spending in all product categories, such as food, housing, utilities, transportation, health, and education. This is the data that is used to estimate the expenditure weights to compute the official Consumer Price Index.

[7] Atkeson et al. (2001) were one of the first to report this change in the slope. See Stock and Watson (2020) for a review of other reasons that justify that.

The CEX has two datasets: the quarterly interview and the diary surveys. For this paper, I use the former between 2000 and 2019.[8] This dataset consists of a rotating panel in which, in each quarter, between 5,000 and 8,000 households are interviewed, and each household stays in the sample, at most, for five consecutive quarters. As most income questions are only asked in the final interview, I only use households that participate in all interviews. Furthermore, I exclude from the sample households with negative expenditure in a given category, zero food expenditures, negative income, and when the household head is below 25 years old. This leaves me with an average of around 6,000 households per quarter. In Appendix A.1, I describe the details of all the steps in the data cleaning.

As the goal is to document how consumption patterns change over the income distribution, I start by dividing households into five income groups. Household income is the sum across household members of their pre-tax income (including earnings, business income, social benefits, pensions, alimony, gifts, and gambling winnings), subtracted from personal taxes. I then regress income on the household size, the average age of the two main earners, and the number of earners in the household, to control for differences in household demographics. Based on the residuals of this regression for each quarter, I divide households into five income bins, corresponding to the 5-20, 20-40, 40-60, 60-80, and 80-95 percentiles.[9]

Second, I classify the non-durable expenditure items by economic activity. The CEX reports expenditures in several items. I divide these items into services or goods, following the U.S. Bureau of Economic Analysis (BEA) classification. Examples of goods expenditures include food and alcohol consumed at home, whereas service expenditures include food away, public transportation, or education. In Appendix A.2, I provide the complete classification.

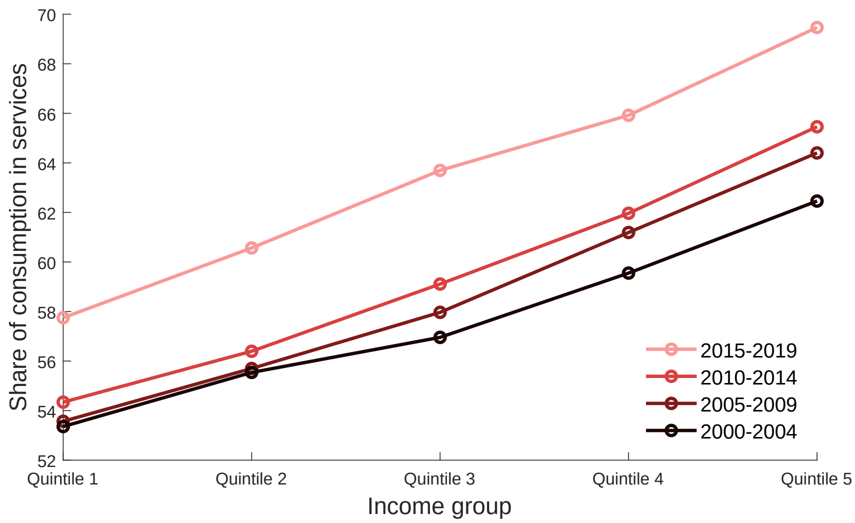
In the third and last step, I compute the average expenditure share on services and goods for each income group. Figure 2 plots the average service share by income group for different points in time.

Two patterns emerge in this figure. First, the share of total expenditure that households allocate to services increases over the income distribution. Households in the lowest income group have a smaller share of their expenditures on services than those in the highest income group. Second, there is an upward trajectory of the aggregate service share in consumption due

[8]Even though the CEX starts in 1980, the questionnaire had several changes in the 1980s and 1990s, which could make it harder to compare across time. I also exclude the years associated with the COVID-19 pandemic health crisis, as consumption patterns change substantially due to other circumstances beyond economic factors.

[9]Following Aguiar and Bils (2015), I exclude the bottom and top 5% to eliminate outliers and mitigate the impact of top-coding. In Appendix A.4, I show this exclusion does not affect the results.

Figure 2: Average Service Share by Income Quintiles



Notes: The figure shows the average service share in total expenditures for each income quintile grouped in 5 years. Table A.2 in the Appendix enumerates all the categories classified as services. The data source is the U.S. Consumer Expenditure Survey between 2000 and 2019.

to structural transformation. The slope of the Engel curve over time is relatively constant, with the high-income group allocating 11-12 percentage points more of their expenditure to services than the low-income group. This empirical fact can be seen as a generalization of Engel's law that states that as income rises, household expenditure spent on food increases in absolute terms, but its relative proportion declines (Engel, 1857, 1895). Boppart (2014) also documents this fact.

This regularity is also valid when I exclude the old-age population from the data. This group of the population consumes a higher share of services than the working-age population (on average, 4.3 percentage points more), and it could affect the pattern above. Moreover, including the bottom and top 5% of the income distribution in the first and last income group, respectively, does not significantly affect the pattern described above. In Appendix A.4, I describe these two robustness exercises in detail.

This second empirical fact means that differences in demand composition across the income distribution imply that aggregate shocks — such as changes in nominal interest rates — affect households asymmetrically. This also has implications for how aggregate shocks translate into demand and inflation, through the distributional channel of monetary policy.

Since low-income households consume relatively few services while high-income households consume many, shocks that primarily affect services — reflecting the sectoral differences in price rigidity — impact households at the top of the income distribution more. Given their lower marginal propensities to consume, this dampens the aggregate demand response. Because the price of services also adjusts more slowly than goods prices, this composition channel shapes the extent to which monetary policy influences inflation through the Phillips curve. To assess the quantitative relevance of these two channels, the next section develops a dynamic general equilibrium model with sectoral heterogeneity and demand composition, and uses it to study how structural transformation shapes monetary policy transmission.

2.3 Cross-country evidence

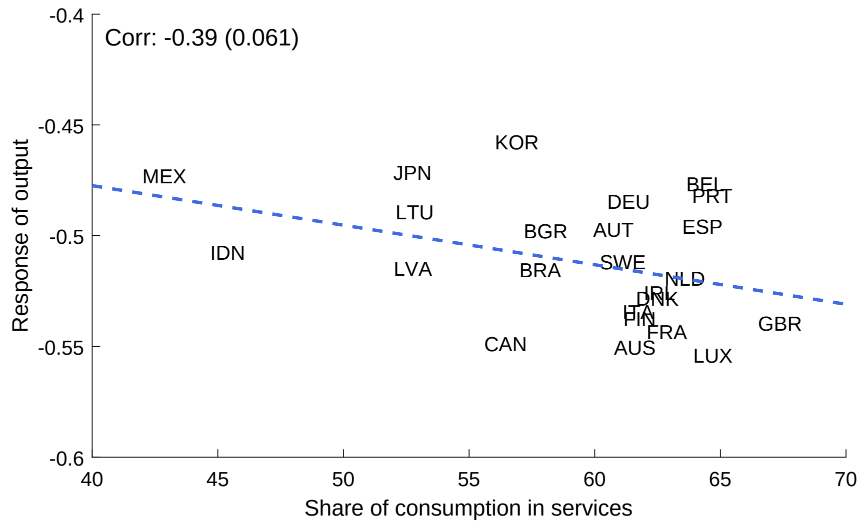
The third reason why the services share matters is a motivating correlation between the service share in the economy and the strength of monetary policy transmission. To show that, I compare the aggregate share of consumption in services with the output responses to a contractionary monetary policy shock in the same spirit as Brinca et al. (2016) or Almgren et al. (2022).

I use the output responses to monetary policy estimated by Galesi and Rachedi (2019). The authors estimate a structural VAR model using a panel of quarterly data on output, inflation, and interest rates for twenty-five countries. Monetary policy shocks are identified through sign restrictions on the impact of interest rates on output and prices. Specifically, the authors assumed that a monetary policy shock raises the nominal interest rate while reducing both inflation and output. The share of consumption in services is constructed from national accounts data reported by each country's statistical authority — the counterpart to the U.S. B.E.A. Table 2.3.5.

Figure 3 presents a scatter plot between the contemporaneous output response to monetary policy and the share of consumption in services. The figure suggests that monetary policy has bigger effects on output in countries with a higher share of consumption in services. In fact, the linear correlation coefficient between the output response and the share of consumption in services is -0.39, and the slope estimated in the linear regression between these two variables is also negative. Mexico is the country with the smallest service share (42%) with a response of -0.47%. On the other hand, the United Kingdom has the highest service share in the sample of countries (66.5%) and a response of -0.54%.

This exercise, naturally, has some limitations. First, the sample of countries is biased toward

Figure 3: Comparison between Output Response to Monetary Policy and the Service Share



Notes: The figure shows the relationship between the contemporaneous response of output to a 100 basis point increase in the interest rate and the share of consumption in services across countries for twenty-five countries. The correlation between the output response and the share of consumption in services is 0.39, with a p-value of 0.06.

the developed world, primarily due to data constraints. Moreover, this exercise is a cross-country comparison, and countries differ in many other aspects relevant to monetary policy transmission, such as how monetary policy is conducted, inflation expectations, and the share of constrained agents. Nevertheless, the exercise provides suggestive evidence of a negative relationship between service concentration and monetary policy responses. To address these limitations, the next section develops a model to study the role of sectoral demand composition in monetary policy transmission.

3 Model

In this Section, I describe the model used to study how changes in the composition of consumer demand, in terms of goods and services, affect the transmission of monetary policy. The model comprises two sectors: the goods and services sector. It combines features of heterogeneous-agent incomplete-markets models (Bewley, 1986, Imrohoroğlu, 1989, Huggett, 1993, Aiyagari, 1994) with non-homothetic preferences, as in Comin et al. (2021), and the New-Keynesian framework (Woodford, 2004, Galí, 2008). There is also a government that issues bonds on which it pays interest. A monetary authority determines the interest rate in accordance with a Taylor rule. Time is discrete, and one period in the model corresponds to one quarter.

3.1 Households

There is a continuum of infinitely lived ex-ante identical households with measure 1. They derive utility from consumption and disutility from supplying labor according to:

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t), \tag{1}$$

where $\beta \in (0,1)$ is the discount factor. The per-period utility function assumes CRRA preferences over consumption and additively separable preferences for leisure, using the MaCurdy (1981) specification:

$$u(c,h) = \frac{c^{1-\gamma}-1}{1-\gamma} - \chi \frac{h^{1+\eta}}{1+\eta}, \tag{2}$$

where γ is the inverse intertemporal elasticity of substitution, η is the Frisch elasticity, and χ is a parameter that regulates the disutility of working.

c is a consumption index that aggregates the sectoral consumption of goods, c_g, and services, c_s. It is implicitly defined through a non-homothetic Constant Elasticity of Substitution (CES) function, as in Comin et al. (2021)

$$1 = c^{\frac{1}{\sigma}} c_g^{\frac{\sigma-1}{\sigma}} + (\Omega c^{\epsilon})^{\frac{1}{\sigma}} c_s^{\frac{\sigma-1}{\sigma}}, \tag{3}$$

where σ is the demand price elasticity, Ω is the relative taste-shifter of services, and ϵ is a parameter that regulates the income elasticity of demand, i.e., the degree of non-homotheticity. I restrict the demand price elasticity to be positive, such that $\sigma \in (0,1)$, which implies that goods and services are gross complements. Under this restriction, ϵ must be larger than 1 for the services Engel's curve to have a positive slope (Figure 2). Moreover, Ω is positive. Note that if $\epsilon = 1$, I recover the homothetic CES aggregator.[10]

The household's labor productivity, ω_t, follows a log-AR(1) process with persistency ρ_ω and zero-mean shocks with variance σ_ω^2. I discretize this process in a 5-state Markov chain. These shocks are not insurable, and households face a no-borrowing constraint.

Households rent their labor services, $\omega_t h_t$, for a real wage w. Additionally, households, at a price p_b, can buy and sell bonds, b, which are the savings vehicle. The returns on savings are

[10] This formulation sets the goods sector as the base sector of this model. One could also write preferences for sector-specific ϵ and Ω. However, a uniform scaling of (ϵ_g, ϵ_s) or (Ω_g, Ω_s) would imply the same observable choice behavior. Hence, I opted for a parsimonious approach to simplify the exposition.

given by i_t, the nominal interest rate that is set by the Central Bank.

Thus, at time t, households face the following budget constraint:

$$\begin{aligned} p_{g,t}c_{g,t} + p_{s,t}c_{s,t} + p_{b,t}b_{t+1} &= w_t\omega_t h_t + (p_{b,t} + i_t)b_t + T_t + D_t, \\ \text{with } \log\omega_t &= \rho_\omega \log\omega_{t-1} + \varepsilon_t^\omega, \;\; \varepsilon^\omega \sim \mathcal{N}(0, \sigma_\omega), \end{aligned} \tag{4}$$

where $p_{g,t}$ and $p_{g,t}$ are the sectoral prices of goods and services, respectively, T_t is a lump-sum transfer (tax if negative), and D_t are the dividends distributed to households from the firms' profits. I distributed dividends according to the skill-level as in McKay and Reis (2016), resembling the bonus payments that higher productivity workers usually receive.

The household problem can be decomposed into two sub-problems: the allocation of consumption across sectors within each period (the intratemporal problem), and the allocation of consumption and savings over time (the intertemporal problem).[11] This means the household problem is solved sequentially, first the consumption-savings decision, and then the intratemporal allocation of consumption across sectors.

For the intratemporal problem, households take prices as given and minimize the total expenditure, E, subject to Equation (3), the non-homothetic CES aggregator:[12]

$$\begin{aligned} &\min_{c_g, c_s} E = p_g c_g + p_s c_s \\ &\text{s.to } \; c^{\frac{1}{\sigma}} c_g^{\frac{\sigma-1}{\sigma}} + (\Omega c^{\epsilon})^{\frac{1}{\sigma}} c_s^{\frac{\sigma-1}{\sigma}} = 1. \end{aligned} \tag{5}$$

The solution of the problem yields the sectoral Hicksian demands given by

$$c_g = \left(\frac{p_g}{E}\right)^{-\sigma} c^{1-\sigma} \text{ and } c_s = \left(\Omega \frac{p_s}{E}\right)^{-\sigma} c^{\epsilon(1-\sigma)}, \tag{6}$$

which indicates the quantity of goods and services households consume, given sectoral prices and total expenditure. The expenditure function is given by

$$E(c_g, c_s) \equiv \sum_{i \in \{g,s\}} p_i c_i = \left[\left(p_g c\right)^{1-\sigma} + \Omega \left(p_s c^{\epsilon}\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{7}$$

[11] This is an application of a two-stage budgeting approach that applies to explicitly additive preferences, as shown by Gorman (1971).

[12] In Appendix B.1, I derive the problem and show the relevance of this preference relation to match the heterogeneous demand composition fact reported in Section 2.

For the intertemporal problem, households choose how much to consume, save, and work, given wages and prices, maximizing Equation (1) subject to the household budget constraint, Equation (4). The household problem can be written recursively as follows:[13]

$$V(\omega, b; \Xi) = \max_{\{c, b', h\}} \quad u(c, h) + \beta \mathbb{E}\left[V(\omega', b'; \Xi')\right] \tag{8}$$
$$\text{s.to} \quad E + p_b b' = w\omega h + (p_b + i)b + T + D$$
$$E = \left[\left(p_g c\right)^{1-\sigma} + \Omega\left(p_s c^{\epsilon}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$
$$\Xi' = \Psi(\Xi)$$
$$c \geqslant 0,\ b' \geqslant 0,\ h \in (0, 1),$$

where $\Xi(\omega, b) \in \mathcal{M}$ is the distribution on the space $X = W \times B$, of labor productivity $\omega \in W$, and agents' bond holdings $b \in B$ across the population, which together with the policy variables determine the equilibrium prices. Ψ is an equilibrium object that specifies the law of motion of the distribution Ξ, and $\mathcal{M}$ is the set of probability measures on X.

3.2 Production

3.2.1 Sectoral Producer

Each sector $i \in \{g, s\}$ has a final representative producer that aggregates a continuum of intermediate inputs indexed by $j \in [0, 1]$ and with prices $p_i(j)$:

$$Q_i = \left(\int_0^1 q_i(j)^{\frac{\theta_i - 1}{\theta_i}} dj\right)^{\frac{\theta_i}{\theta_i - 1}}, \tag{9}$$

where θ_i is the elasticity of substitution across intermediate inputs for sector i. Given a level of sectoral demand Q_i, the final producer cost minimization problem yields the demand for intermediate input j, which is given by:[14]

$$q_i(j) = q(p_i(j); P_i, Q_i) = \left(\frac{p_i(j)}{P_i}\right)^{-\theta_i} Q_i, \tag{10}$$

[13] Note that Equation (7), maps expenditure (that appears in the budget constraint) to the consumption index (that appears in the objective function).

[14] In Appendix B.2, I show the full derivation of the intermediate input demand.

where P_i is the equilibrium price of the final good i and can be expressed as

$$P_i^{1-\theta_i} = \int_0^1 p_i(j)^{1-\theta_i} dj. \tag{11}$$

3.2.2 Intermediate Input Producers

Each input j is produced by an intermediate producer that operates under monopolistic competition using labor input $n_i(j)$ hired in a competitive labor market at the wage rate of w. The production technology is linear in labor:

$$q_i(j) = Z_i n_i(j), \tag{12}$$

where Z_i is the sector i productivity. This functional form of the production function implicitly assumes that capital is fixed. Since I am interested in comparing the responses to a monetary policy shock in the short run, and capital is a slow-moving variable, this assumption does not entail a significant cost.

Intermediate input producers face price adjustment costs as in Rotemberg (1982). These adjustment costs are measured in nominal terms and are given by a quadratic function of the change in prices:

$$\Phi_i\left(p_{i,t}(j), p_{i,t-1}(j)\right) = \frac{\theta_i}{2\kappa_i}\left[\log\left(\frac{p_{i,t}(j)}{p_{i,t-1}(j)}\right)\right]^2 Q_{i,t} P_{i,t}, \tag{13}$$

where κ_i is a sector-specific parameter that regulates the cost of price adjustment that is set to match Empirical Fact 2.

Firm's j optimizes nominal profits by solving the following pricing problem

$$\begin{aligned} V_{i,t}(p_{i,t-1}(j)) = \max_{\{p_t(j)\}} \; & d_{i,t}(j) = p_{i,t}(j) q_{i,t}(j) - w_t n_{i,t}(j) - \Phi_i\left(p_{i,t}(j), p_{i,t-1}(j)\right) + \frac{1}{1+i_t} V_{i,t+1}(p_{i,t}(j)) \\ & \text{s.to Equations (10) and (12).} \end{aligned} \tag{14}$$

Let $1+\pi_t \equiv \frac{P_t}{P_{t-1}}$. In a symmetric equilibrium, the optimal price-setting rule of sector i is

$$\log(1+\pi_{i,t}) = \frac{\kappa_i}{\theta_i}\left(1 - \theta_i + \theta_i \frac{w_t}{Z_i P_{i,t}}\right) + \frac{1}{1+i_t}(1+\pi_{i,t+1})\log(1+\pi_{i,t+1})\frac{Q_{i,t+1}}{Q_{i,t}}, \tag{15}$$

which is the New-Keynesian Phillips Curve (NKPC) of sector i.[15] Note that in the steady state, where there are no price adjustments, it is simply equal to the markup multiplied by the marginal cost, in this case, the wage rate:

$$P_i = \frac{\theta_i}{\theta_i - 1}\frac{w}{Z_i}. \tag{16}$$

The adjustment costs are not resource costs, but as if they were utility costs. This assumption is to avoid counterfactual price-adjustment booms that would arise from large resource costs associated with large price movements, as in Hagedorn et al. (2019). The profits of intermediate producers of sector i are distributed to households and are given by

$$d_{i,t} = \int_0^1 d_{i,t}(j)dj = P_{i,t}Q_{i,t} - w_t N_{i,t}, \tag{17}$$

with $N_i = \int_0^1 n_i(j)\,dj$.

3.3 Government

The government issues nominal bonds denoted by B that households can buy at the price of p_b. The total value of public debt in the economy is fixed. The government levies a lump-sum tax on households to finance interest payments on bonds. The government budget is balanced at each period and reads as

$$p_{b,t}B = \int (p_{b,t} + i_t)b_t d\Xi + T_t. \tag{18}$$

3.4 Monetary Authority

The monetary authority sets the nominal interest rate following a Taylor (1993) rule:

$$i_t = i_{SS} + \phi\pi_{t-1} + \varepsilon_t^M, \tag{19}$$

where i_{SS} is the steady-state inflation, π_t is the aggregate inflation rate in period t, which is the weighted average of the sectoral inflation rates, using sectoral consumption as weights. ε_t^M is the monetary policy shock that follows an AR(1) process with persistency ρ_M.

[15] In Appendix B.3, I show in detail the derivation of the New-Keynesian Phillips Curve.

3.5 Market Clearing and Competitive Equilibrium

Market clearing occurs when firms' demand for labor equals the total supply of labor from households, households' demand for bonds matches the quantity of outstanding bonds, and households consume all the goods produced by firms in each sector:

$$\int \hat{h}_t(\omega, b)\, d\Xi_t = N_{g,t} + N_{s,t} \tag{20}$$

$$\int \hat{b}_t(\omega, b)\, d\Xi_t = B \tag{21}$$

$$\int \hat{c}_{i,t}(\omega, b) d\Xi_t = Q_{i,t},\ i \in \{g, s\}, \tag{22}$$

where $\hat{h}_t(\omega, b), \hat{b}_t(\omega, b)$ and $\hat{c}_{i,t}(\omega, b)$ are the household policy functions of labor, savings, and sectoral consumption.

Definition. A competitive equilibrium is a sequence of lump-sum transfers T_t; interest rates i_t; value functions V_t with policy functions $\hat{c}_{g,t}, \hat{c}_{s,t}, \hat{h}_t$ and $\hat{b}_t$; prices p_t^b, p_t^g, p_t^s, and w_t; profits $\pi_{g,t}$ and $\pi_{s,t}$; and a law of motion Ψ, such that:

1. V_t satisfies the Bellman Equation (8), with the solution given by the policy functions $\hat{c}_{g,t}, \hat{c}_{s,t}, \hat{h}_t$ and $\hat{b}_t$ given sequences of lump-sum taxes, prices, interest rate and dividends.
2. Firms maximize profits according to Equation (14), which are distributed in the form of dividends to households.
3. The government runs a balanced budget as in Equation (18).
4. For all Ξ_t, the market clearing conditions (20) — (22) are satisfied.
5. The aggregate law of motion of the distribution, Ψ, is generated by the savings policy function.

4 Estimation and Model Fit

This section describes the estimation and fit of the model as a representation of the U.S. economy. The model is estimated to capture both the long-run shift in consumption towards services and short-run household cross-section heterogeneity in wealth, income, and consumption.

4.1 Estimation Strategy

As economies grow richer, consumption expenditures shift towards the services sector. The model described above does not follow a balanced growth path: rising sectoral productivities endogenously raise the service share of the economy. In the limit, as argued by Comin et al. (2021), the services sector may take over the entire economy.[16] For this reason, I use the model to study the transmission of monetary policy around distinct steady states, differing only in their service expenditure share. These differences arise endogenously from changes in relative sectoral productivities. This approach is akin to that in Da-Rocha and Restuccia (2006), Moro (2012), and Galesi and Rachedi (2019).

Changes in sectoral productivities operate through two channels. First, due to productivity growth differentials, relative prices adjust, creating a substitution effect which in turn affects expenditure shares. This is the well-known cost-disease channel described by Baumol (1967). Second, an income effect operates through the non-homotheticity of preferences. A higher income increases the consumption of luxuries (goods with positive income elasticities of demand), in this case services.[17]

All the other parameters are common across steady states. I fix 2019 as the reference year. For this year, the model is required to match the observed cross-sectional heterogeneity across households with respect to wealth, income, and consumption. These moments matter for two reasons. First, the income and wealth distributions shape the marginal propensity to consume, a central object in heterogeneous-agent models that governs the magnitude and propagation of aggregate shocks such as monetary policy (Kaplan and Violante, 2022). Second, to assess welfare, it is important to match the distribution of service expenditures across households (the Engel curve for services, as documented in Empirical Fact 2 in Section 2), since different sectors respond differently to a monetary shock, which may affect households heterogeneously.

The estimation of the common parameters proceeds in three steps. First, I derive the relative demand for services, which allows me to estimate the price and income elasticities of demand, ε and σ. Second, I fix a set of parameters identified from external evidence, such as the income

[16]This shift towards services is also observed in value-added and employment (Kuznets (1973) or Herrendorf et al. (2014) show these trends). In general, models featuring structural transformation do not exhibit balanced growth. Only when preferences belong to the class of non-Gorman aggregators (Boppart, 2014), or under specific parameter restrictions (Kongsamut et al., 2001, Ngai and Pissarides, 2007), can the trend be reproduced under a balanced path.

[17]The structural transformation literature has emphasized the quantitative role of these two channels. For example, Boppart (2014) finds that income and substitution effects have roughly equal importance, whereas Comin et al. (2021) argues that income effects dominate.

process and the price adjustment cost. Third, I use the Simulated Method of Moments (SMM) to estimate the disutility of work, χ, and the taste-shifter parameter, Ω, ensuring that the model matches the aggregate hours worked and the service expenditure share.

4.2 Model Estimation

4.2.1 Demand Estimation

To estimate the price and income demand elasticities, ϵ and σ respectively, I follow the estimation strategy proposed by Comin et al. (2021) and applied in other papers such as Buiatti et al. (2024). In summary, the non-homothetic CES preference relation — Equation (3) — allows me to derive the demand system described in Equation (6) that can be mapped to the data, allowing for the estimation of ϵ and σ.

Empirical Strategy. Take the Hicksian demands derived in Section 3 — Equations (6). I can combine both and write the relative demand for services as:

$$\log\left(\frac{\nu_{s,t}}{\nu_{g,t}}\right) = (1-\sigma)\log\left(\frac{p_{s,t}}{p_{g,t}}\right) + (1-\sigma)(\epsilon-1)\log\left(\frac{E_t}{p_{g,t}}\right) + (\epsilon-1)\log\nu_{g,t} + \log(\Omega),$$

where $\nu_{i,t}$ is the share of expenditure of sector i in period t and all other letters have the same meaning as before.

This equation shows that the relative demand for services depends on the relative price of services, total expenditure, the share of goods in consumption, and a constant taste shifter. Moreover, this expression is written only in terms of observables and model parameters. By exploiting the cross-section and time variation of the expenditure shares, sectoral prices, and total expenditure, I can estimate the value of σ and ϵ. The empirical counterpart of the equation above is

$$\log\left(\frac{\nu^n_{s,t}}{\nu^n_{g,t}}\right) = (1-\sigma)\log\left(\frac{p^n_{s,t}}{p^n_{g,t}}\right) + (1-\sigma)(\epsilon-1)\log\left(\frac{E^n_t}{p^n_{g,t}}\right) + (\epsilon-1)\log\nu^n_{g,t} + \zeta^n + \xi^n_t, \quad (23)$$

where the superscript n is the household identifier, ζ^n is a household fixed-effect that accounts for the taste parameter, and ξ^n_t denotes the error term of the equation.

Furthermore, two additional assumptions pertain to the structure of Equation (23). First, the term ζ^n is assumed to be a linear function of household characteristics (such as age, size, and number of earners) and regional characteristics. Including these controls accounts for taste differences in the estimates. Second, the error term may include common sector-time fixed effects across households. Including sector-time fixed effects thus captures potential aggregate consumption shocks.

I estimate σ and ϵ on this equation using the Generalized Method of Moments (GMM). There is also a constraint in the value of the coefficients of the equation: the product of the coefficient on relative prices, $(1-\sigma)$, and expenditure share on goods, $(\epsilon - 1)$, has to be equal to the coefficient on expenditure, $(1-\sigma)(\epsilon-1)$.

In order to account for potential measurement error due to self-reported consumption data, I instrument household expenditures with the annual household income after taxes and the income quintile of the household. This follows Aguiar and Bils (2015) and aims to capture the permanent household income that is correlated with household expenditures and is not affected by transitory measurement error in total expenditures.

Furthermore, the above equation suffers from potential endogeneity issues coming from regressing prices on quantities. I instrument household relative prices with a "Hausman" relative-price instrument (Hausman et al., 1994, Hausman, 1996) that is constructed in two steps. First, for each expenditure category included in a sector, I compute the average price across regions, excluding the own region. Second, the aggregation is done with the average region expenditure shares in each category as weights. These instruments aim to capture the common trend in U.S. prices (relevance condition) while alleviating endogeneity concerns due to regional shocks (exogeneity condition).

Data. I use the U.S. CEX quarterly interview dataset between 2000 and 2019. The data construction is as described in Section 2, which follows Aguiar and Bils (2015) closely. I classify the non-durable expenditure between goods and services, following the U.S. BEA categorization.[18]

The consumption data is combined with regional quarterly price series from the BLS's urban CPI. For each household and each sector, I construct a price index using household-specific expenditure weights, as in Comin et al. (2021). This way of building the price indexes, to a certain extent, takes into account that different households may face different effective prices.

[18] In Appendix A.1, I describe in detail the dataset construction, and in Appendix A.2, I provide a complete classification between goods and services.

Results. Table 1 reports the estimation results. Column (1) reports the results of the simplest estimation without any additional controls, column (2) when I add region fixed effects, and column (3) when I add region and year times quarter fixed effects. The value estimated for ϵ is larger than 1, which means that the Engel curve of the services sector is positively sloped. In other words, services are a luxury good, and the share of expenditure that households allocate to this sector increases with income. This is what I showed in Figure 2 in Section 2. Moreover, the price elasticity estimate is smaller than 1, which suggests that goods and services are gross complements in household preferences.[19]

Table 1: Demand Estimation

	(1)	(2)	(3)
σ	0.209	0.176	0.234
	(0.044)	(0.039)	(0.051)
ϵ	1.619	1.667	1.731
	(0.061)	(0.058)	(0.080)
Region FE	N	Y	Y
Year $\times$ Quarter FE	N	N	Y

Notes: The table presents the results of the GMM estimation of Equation (23). The number in parentheses corresponds to the standard error clustered at the household-level. All regressions include household controls.

4.2.2 Pre-estimated Parameters

Other Preference Parameters. I set the discount factor, β, to 0.99, as standard in models where a period corresponds to a quarter. The risk-aversion parameter, γ is set to 1.5, on the bulk part of values used in the HANK literature (e.g. Gaillard and Wangner, 2022). The Frisch elasticity, η, is set to 1, following micro-estimates (Chetty et al., 2011).

Income Process. The idiosyncratic productivity process is given by a log-AR(1) process that depends on two parameters: the persistence of an idiosyncratic shock, ρ_ω, and the variance of the idiosyncratic shock, σ_ω^2. I use the estimates by Krueger et al. (2016), based on the Panel Study of Income Dynamics (PSID) for both parameters, 0.99 and 0.1, respectively. These numbers are similar to other estimates used in the heterogeneous-agent literature, such as Storesletten et al.

[19] Comin et al. (2021) also find similar values even though they consider three sectors (agriculture, manufacturing, and services) instead of two.

(2004) or Karahan and Ozkan (2013). The log-AR(1) process is discretized into a 5-state Markov chain with the Tauchen (1986) method using the Flodén (2008)'s approach.

Sectoral Markups. The elasticity of substitution in the model has a direct mapping to markups as Equation (16) illustrates. Marto (2024) estimates an average markup for the services sector of 1.27 and an average markup of 1.21 for the non-services sector. This implies an elasticity of substitution of 4.70 in the services sector and 5.76 for the goods sector.

Sectoral Price Adjustment Costs. The adjustment cost parameter on prices is set using the first-order equivalence of Rotemberg- and Calvo-type adjustment frictions.[20] For each sector, I set the adjustment cost parameter such that the NKPC slope in the model, θ_i/κ_i, matches the slope of the corresponding equation implied by a Calvo (1983) price adjustment, where the frequency of price adjustments corresponds to the one in Section 2. As such, κ_s is set to 89.2 and κ_g to 9.9.

Sectoral Productivity. The sectoral productivities of goods and services are the only two parameters that differ between the 1970 and the 2019 steady-state. For the 2019 steady-state, I normalize Z_g to one and choose Z_s to match the relative price between goods and services (note that this ratio only depends on model parameters). For the 1970 steady-state, I back out the productivity levels by applying average sector-specific productivity growth rates observed in the U.S. postwar period — 1.1% for services and 2.1% for goods (Duarte and Restuccia, 2010).

Government. The total number of bonds in the economy, B, correspond to the outstanding public debt. These bonds have a very short maturity, one period, and do not carry any risk. The total amount is set to 1.

Monetary Authority. Inflation in the steady-state is 0 and the nominal interest rate in the steady-state is set to 0.75% to match an annual interest rate of 3%. Following the New-Keynesian literature (e.g. Auclert et al., 2024), the central bank follows a Taylor rule as in Equation (19) with corresponding weights on inflation $\phi_\pi = 1.5$ and zero weight on the output gap. Finally,

[20] Up to a first-order approximation, a Calvo (1983) and a Rotemberg (1982) setting yield the same results, as shown by Roberts (1995). Only in exceptional cases, the equivalence does not hold as, for example, when there is trend inflation (Ascari and Rossi, 2012).

the innovations of the monetary policy follow an AR(1) process with a persistency of 0.5 (e.g. Galí, 2008).

Summary. Table 2 lists the values of all the parameters that are chosen exogenously, as well as the source.

Table 2: Exogenous Parameters

Parameter	Description	Value	Source
I. Household			
β	Discount factor	0.99	Standard (quarterly model)
γ	CRRA	1.20	Standard
η	Frisch elasticity	1.00	Chetty et al. (2011)
ρ_z	Persistence of idiosync. productivity	0.99	Krueger et al. (2016)
σ_z	Std. dev. of idiosync. productivity	0.10	Krueger et al. (2016)
II. Firm			
θ_g	Elasticity of substitution (goods)	5.8	Marto (2024)
θ_s	Elasticity of substitution (services)	4.7	Marto (2024)
κ_g	Price adjustment cost (goods)	8	Section 2
κ_s	Price adjustment cost (services)	89	Section 2
III. Government and Monetary Authority			
i_{SS}	Steady-state interest rate	0.75%	3% annual rate
ϕ_π	Taylor rule weight on inflation	1.5	Standard NK literature
ρ_M	Persistence of MP innovations	0.5	Standard NK literature

Notes: The table shows the values of all the parameters which are calibrated exogenously, i.e., taking the value of empirical studies that estimate them. The last column contains the respective source.

4.2.3 Simulated Method of Moments

The last step uses the SMM to estimate the remaining parameters: the disutility from working, χ, and the taste-shifter, Ω. I choose the values of these two parameters to minimize the loss function below:

$$\mathcal{L}(\Omega, \chi) = ||M_m - M_d||, \tag{24}$$

which corresponds to the squared Euclidean norm between model moments, M_m, and data moments, M_d. I have two parameters to estimate, and I target two moments in the data, yielding an exactly identified system: the average fraction of hours worked between 1980 and 2023, and the consumption share in 2019. The first data moment is sourced from the Organization for Economic Co-operation and Development (OECD), and the second from the BEA.

The model moments are computed in the steady-state. In Appendix C, I describe the algorithm that I follow to solve for the steady-state and compute the necessary model moments. Table 3 displays the estimated parameter values, the model moments, and their data target.

Table 3: SMM: Calibration Fit

Moment	Model Mom.	Data Mom.	Data Source	Parameter	Param. Value
Average hours worked	0.217	0.212	OECD	χ	30.0
Average service share 2019	0.673	0.678	BEA	Ω	7.0

Notes: The table shows the fit of the parameters calibrated using the Simulated Method of Moments. The values of the parameters are chosen to minimize the loss function $\mathcal{L}$, from Equation (24).

4.3 Model Fit

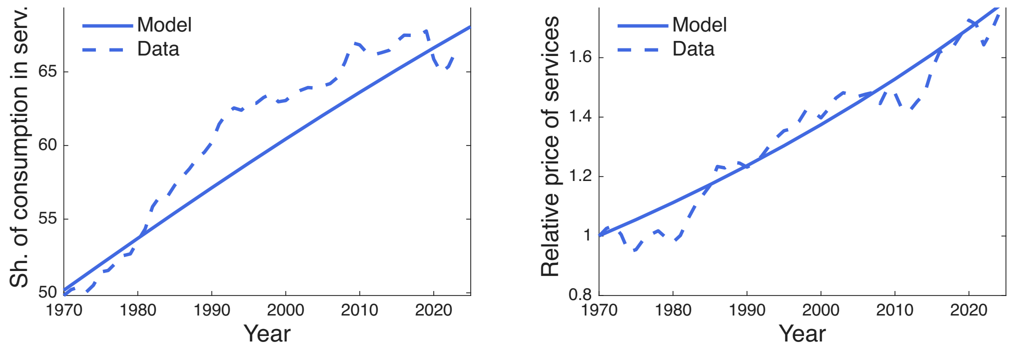
The model described in Section 3 aims to study the implications of the change in demand composition for monetary policy transmission. It is thus relevant that it matches both the long-run trend of the shift in the service share in the economy and the household micro-behavior that is central in the class of heterogeneous-agent models (Kaplan and Violante, 2022).

4.3.1 Long-run Fit

Figure 4 evaluates the long-run model fit by comparing the services share and the relative price in the model and data. The model values correspond to different steady-states that only differ in terms of relative sectoral productivities. The values for 2019 are targeted in the calibration. However, the service share and relative price for the other years are untargeted. They are generated through the income effect from the combination of the non-homothetic preferences and economic growth, and through the substitution effect generated by differences in the productivity growth rates of the two sectors that change the relative price.

Overall, the model provides a very good fit with the untargeted long-run moments being very close to the data moments. Notoriously, the service share in 1970 is only 1.5 percentage points above the observed one, and the relative price of services is also only slightly higher than the one in the data. Due to the nature of this exercise, where I am comparing the services share

Figure 4: Long-Run Model Fit: Services Share and Relative Price



Notes: The figure shows the average expenditure share in the services sector for each quintile of income. The dark blue bars correspond to the share obtained in the model, where income corresponds to the sum of earnings, dividends, and capital income, i.e., the right-hand side of Equation (4). The light blue bars correspond to the estimated shares using the CEX data for the U.S. as described in Section 2.

and the relative price for different steady-states, I cannot capture the full transitional dynamics of structural transformation.

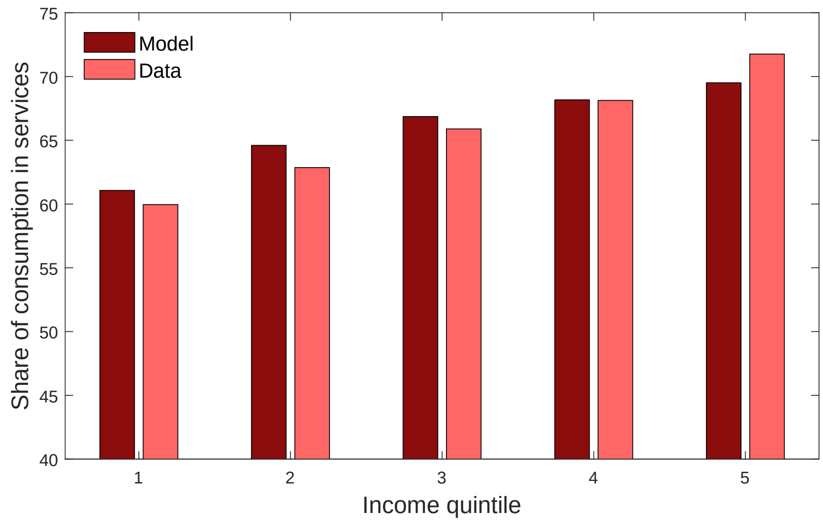
4.3.2 Household Behavior Fit

I now look to the model fit in terms of the household micro-behavior. I start by looking at the Engel curve of the services sector, which summarizes the differences in sectoral consumption allocations across households. I then look at the wealth and marginal propensity to consume distributions. These objects summarize the household heterogeneity in the model, which is key to understand the aggregate response to monetary policy.

The Engel Curve of Services. Figure 5 shows the average consumption share allocated to the services sector for each income quintile, both in the model (dark red bars) and in the data (light red bars). Income corresponds to the right-hand side of the household budget constraint in Equation (4). The data shares come from the CEX dataset, applying the data cleaning described in Section 2.

The model replicates the positive slope of the Engel curve documented in Empirical Fact 1 in Section 2, with lower-income households allocating a smaller share of expenditure to services relative to higher-income households. Furthermore, quantitatively, the model-implied slope is close to its empirical counterpart, though slightly attenuated. The difference between the model and the data service share is less than 1 percentage point. Importantly, this relationship

Figure 5: The Engel Curve of Services: Data vs. Model



Notes: The figure shows the average expenditure share in the services sector for each quintile of income. The dark blue bars correspond to the share obtained in the model, where income corresponds to the sum of earnings, dividends, and capital income, i.e., the right-hand side of Equation (4). The light blue bars correspond to the estimated shares using the CEX data for the U.S. as described in Section 2.

is not directly targeted in the calibration: the estimation of the income and price elasticities of demand, ϵ and σ, does not mechanically determine the slope of the Engel curve, except for the sign. This heterogeneity in the composition of consumption baskets means that an aggregate shock that has different sectoral impacts could affect households differently.

Wealth Distribution. Table 4 shows different statistics regarding the wealth distribution in the model and the data. The model does a relatively good job of matching the model and data wealth moments, especially considering that these are untargeted moments. The ratio of mean wealth to mean earnings in the model is in the same order of magnitude as in the data. The share of wealth owned by the bottom 50% of the wealth distribution is also in the same range that is observed in the data, as well as the share owned by the top 10% of the wealth distribution.

A key moment related to the wealth distribution is the share of Hand-to-Mouth (HtM) households, i.e., agents with zero savings. Having a good match with the wealth distribution, in particular with the share of HtM households in the economy, is key to modeling the responses to aggregate shocks, such as monetary policy shocks. HtM are agents characterized by having strong consumption and labor responses because they are not able to smooth out the shock.

Table 4: Model Wealth Distribution

Wealth Statistic	Data	Model
Mean wealth	4.1	4.5
Median wealth	1.5	1.8
Wealth, bottom 50%	2.5%	3.1%
Wealth, top 10%	49.9%	48.6%
HtM share	17.3%	23.4%

Notes: The table shows some moments of the wealth distribution in the data and the model. The mean wealth corresponds to the ratio of the mean wealth to the mean earnings. HtM stands for Hand-to-Mouth and corresponds to the share of households with zero savings. All data moments come from the 2019 wave of the Survey of Consumer Finances computed by Kaplan and Violante (2022) and Kaplan et al. (2014).

The value that the model generates is slightly above the one observed in the data. This value is closer to the total share of HtM agents in the economy, if we consider also those with positive illiquid assets — the wealthy HtM — and not only the poor HtM, as it is reported in the table (Kaplan et al., 2014).

Marginal Propensity to Consume. I now look at the marginal propensity to consume (MPC). This object is key in determining the transmission of aggregate shocks such as monetary policy (Kaplan et al., 2018, Kaplan and Violante, 2022). The MPC is the fraction of a small, unanticipated one-time additional income that a household spends within a given period. For a household with productivity ω and asset holdings b, the quarterly MPC out of an unexpected windfall of money, m, is computed as

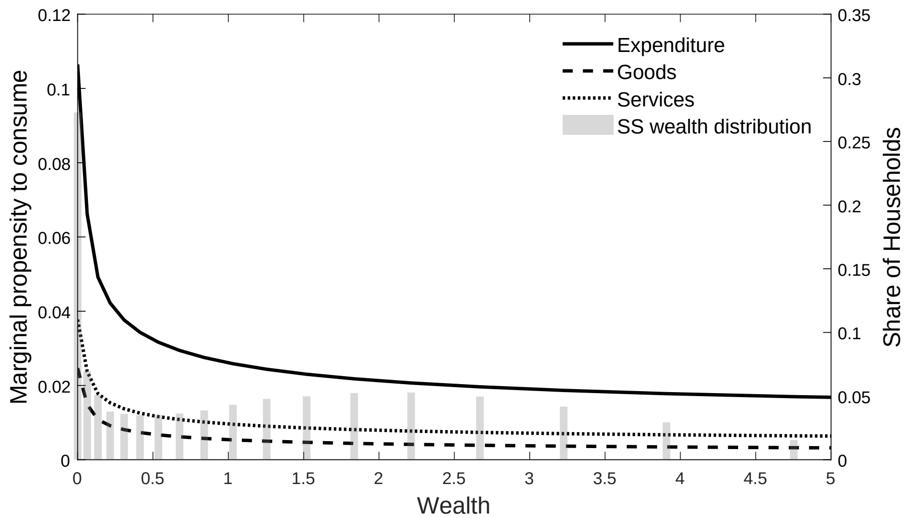
$$MPC_q = \frac{c_i(\omega, b+m) - c_i(\omega, b)}{m}. \tag{25}$$

Figure 6 plots the MPC for total expenditure (full line), goods (dashed line), and services (dotted line). The aggregate annual MPC of total expenditure is 28%, which is within the range of empirical estimates between 20% and 60% out of transitory income changes between \$500 and \$1000 (see Havranek and Sokolova (2020) for a review and Boehm et al. (2025) for a recent empirical application using a randomized control trial in France).[21]

The figure also shows that the MPC out of a transitory windfall is higher for services than for goods. In fact, the aggregate MPC of services is 5%, whereas the aggregate MPC of goods is

[21] I compute the annual MPC using the quarterly MPC from Equation (25) via the formula $MPC_a = 1 - (1 - MPC_q)^4$. The quarterly MPC is 8%.

Figure 6: Quarterly Marginal Propensity to Consume



Notes: The figure shows the marginal propensity to consume (MPC) out of a 5% of the average labor income unexpected transfer. The MPCs are computed according to Equation (25) and averaged across productivity. The solid line shows the MPC for total expenditure, the dashed line the MPC for goods consumption, and the dotted line shows the MPC for service consumption. The gray bars in the background correspond to the mass of agents with a given wealth.

2%. This difference is rooted in the non-homothetic preferences. Consumption in the goods sector is a necessity, whereas consumption in the services sector is a luxury. When households receive an unexpected windfall of money, they spend more on services than on goods, as their necessities for goods are already satisfied. The figure's third pattern is a decaying MPC along the wealth distribution. Poorer households have a higher MPC than richer households. For the household with no assets (around 30% of the households), the MPC of expenditure is 10%. The MPC decreases over the wealth distribution, converging to the MPC under no uncertainty, which is $1 - \beta$, i.e., 1%.

5 Structural Transformation and the Transmission of Monetary Policy

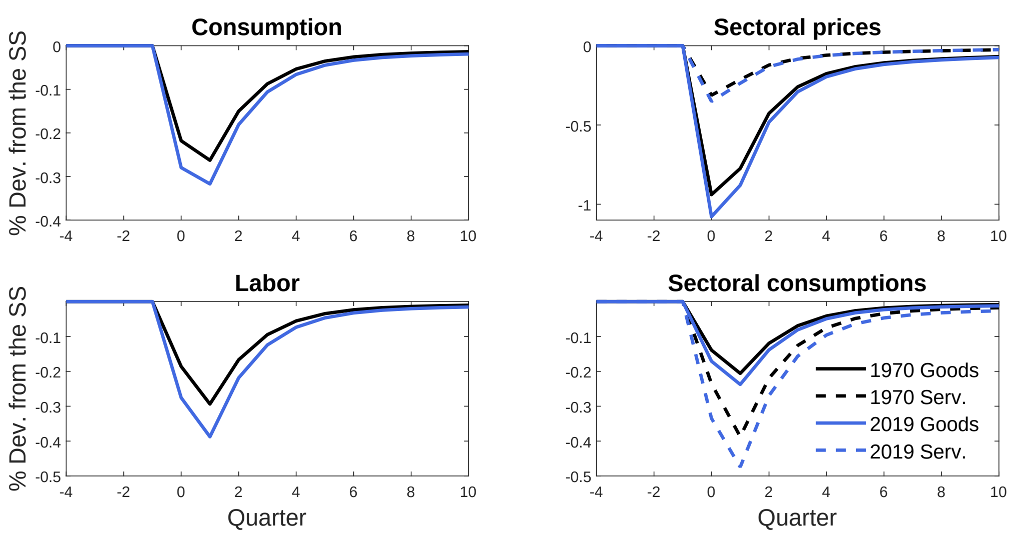
The primary objective of this paper is to quantify the impact of the shift in economic activity toward services on the transmission of monetary policy. To do that, I consider two economies that are similar to each other, except for their sectoral productivities, which endogenously generate different service shares, as described in Section 4. The first economy has a service share of 50%, which corresponds to the share observed in 1970, and the second economy has a service share of 68%, corresponding to the service share in 2019.[22]

In each economy, I consider an experiment in which, at time $t = 0$, there is an unexpected monetary shock that corresponds to a quarterly innovation to the Taylor rule (19) of $\varepsilon_0^M = 0.01$, i.e., a 100 basis points, which means-revert at rate ρ_M. I solve for the transition paths of prices and real aggregates where the shock is treated as an "M.I.T. shock" – the change in the interest rate is a surprise, but once it is realized, its path is known. This then generates impulse response functions to the monetary policy shock, which are the main object of interest in this section.[23] In Appendix C, I describe in detail the algorithm used.

5.1 Aggregate Response to a Monetary Shock

Figure 7 plots the aggregate impulse response functions to a one percentage point contractionary monetary policy for both economies. The top-left panel shows the consumption index response, the top-right panel the path of sectoral prices, the bottom-left panel the path of aggregate labor, and the bottom-right panel shows the path of sectoral consumption. The black line corresponds to the 1970 calibration and the blue line to the 2019 calibration.

Figure 7: Aggregate Responses to a Monetary Policy Contraction: 1970 vs. 2019



Notes: The figure shows the aggregate response after a monetary policy contraction of 100 basis points for two model calibrations. In black, I show the responses when the service share is equal to the one observed in 1970, and in blue when the service share is equal to the share observed in 2019. All responses are shown in percentage deviations from the steady state values.

[22]The policy functions and wealth distribution of these two economies can be found in Appendix D.1.

[23]Studying the economy's deterministic response to shocks that are ex-ante unexpected is useful to understand its response to recurring aggregate shocks, see Boppart et al. (2018).

A contractionary monetary policy shock induces a negative demand contraction, generating recessionary effects on both consumption and output. These effects operate through both direct and indirect channels. The direct channel arises because the nominal interest rate enters the household budget constraint (4), causing consumption to respond immediately to changes in the interest rate. This response reflects both an intertemporal substitution effect — where higher interest rates incentivize saving due to increased returns — and an income effect, as assets are in positive net supply and thus yield higher returns.

The indirect channel operates through the general equilibrium effects of monetary policy on wages and taxes. As the nominal interest rate increases, non-hand-to-mouth households reduce their consumption. In response, firms lower their labor demand, putting downward pressure on wages, which leads households to further reduce consumption. In addition, a rise in i_t increases government interest payments, requiring higher taxes to maintain a balanced budget. The resulting decline in disposable income further depresses household consumption.

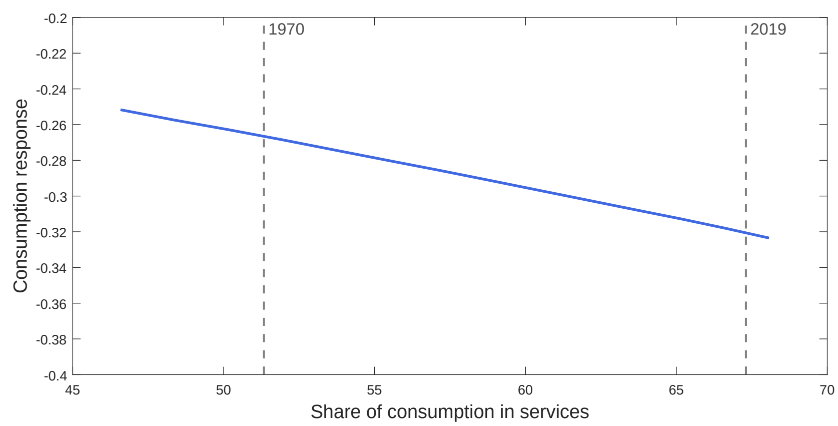
Focusing on the 1970-economy, represented by the black lines in Figure 7, aggregate consumption falls by 0.2% and aggregate labor by 0.3%. These aggregate responses qualitatively align with the empirical evidence from U.S. aggregate time series VARs by Christiano et al. (2005) or, more recently, using Norwegian administrative microdata by Holm et al. (2021).

There are, however, differences across sectors. In response to the 100 basis point contractionary monetary policy shock, the price of services falls by less than the price of goods. In fact, on impact, the price of services falls by 0.31% and the price of goods falls by almost 1% in comparison with their steady-state values. This is consistent with Empirical Fact 1 in Section 2 that shows nominal price rigidities are stronger in the services sector than in the goods sector. Because of that, and through the New-Keynesian channel, when prices do not adjust sufficiently, for markets to clear, quantities have to change. As such, the consumption in the services sector falls more than the consumption in the goods sector, as prices in the services sector adjust less than in the goods sector. While the fall in the service consumption is 0.4%, goods consumption only falls by 0.2% in comparison with their steady-state value. These differences across sectors are grounded in the different slopes of the sectoral New-Keynesian Phillips Curves, due to the differences in the cost of price adjustment and markups/elasticity of substitution, and in differences in the demand income elasticity generated by the non-homothetic preferences. In Appendix D.2, I decompose the differences in the responses.

When I compare the 1970 responses with the 2019 responses, I find that the aggregate responses are larger when economic activity is more concentrated in the services sector. Aggregate consumption responds 21% more on impact in the 2019-economy than in the 1970-economy, and employment responds 32% more. Sectoral consumption and prices also react more strongly with a higher service share. In the goods sector, prices respond 14% more and consumption 15% more on impact in the 2019-economy relative to the 1970-economy. In the services sector, prices fall 11% more and consumption 23% more on impact when the service share in the economy is larger.

Figure 8 generalizes the comparison above, plotting the aggregate response of consumption on impact to the same monetary policy shock of 100 basis points for different service shares. As the composition of the economic activity changes and the share of services rises, the recessionary effects of monetary policy also get larger. In fact, a one percentage point higher service share raises the consumption response to a monetary policy contractionary shock by 1.2%. Between 1970 and 2019, the services share rose by almost 18%, leading to the 21% higher response reported above.

Figure 8: Aggregate Consumption Responses to a Monetary Policy Contraction



Notes: The figure shows the aggregate response after a monetary policy contraction of 100 basis points for different shares of consumption in services. The responses are shown in percentage deviations from the steady state values. The two dashed vertical lines indicate the services share observed in 1970 and 2019, respectively.

5.2 Mechanisms

5.2.1 Income and Substitution Effects of Structural Transformation

The shift of the economic activity towards services is commonly believed to be driven by two separate forces. First, sectoral productivities grow at different rates, which affects the relative price of services, changing expenditure shares (Baumol, 1967). Second, growth generates an income effect through non-homothetic preferences, which shift consumption towards luxuries, i.e., services (Falkinger, 1990, Matsuyama, 1992).

Table 5 illustrates the significance of these two channels in generating structural transformation, which in turn affects the transmission of monetary policy. Column (1) shows the baseline response differential between 1970 and 2019, column (2) shows the consumption response if only there were income effects between 1970 and 2019, and column (3) shows the consumption response if there were only substitution effects operating between 1970 and 2019. The income effect counterfactual is obtained by increasing the overall income size of the economy while keeping the relative price of 1970. On the other hand, the substitution effect counterfactual is obtained by changing the relative price but keeping overall income constant. I get this by changing sectoral productivities.

Table 5: Counterfactuals of Monetary Policy Channels: Income and Substitution effects of Structural Transformation

	(1) 1970 (bsl)	(1) 2019 (bsl)	(2) Income effect	(3) Substitution effect
Consump. response (vs. 1970)	–	20.64	11.52	14.02
Relative price	1.00	1.68	1.00	1.68
SS consumption	0.03	0.05	0.05	0.03
Service share	51.34	67.30	58.09	61.22

Notes: The table shows how much the consumption response to a monetary policy shock changes in the baseline and under an income effect and a substitution effect counterfactuals. The income effect counterfactual is obtained by changing the sectoral productivities such that aggregate income is the same as in 2019, but the relative price is that of 1970. The substitution effect counterfactual is obtained by changing the sectoral productivities such that aggregate income is the same as in 1970 and the relative price is equal to the one in 2019.

Income effects lead to a 12% increase in the consumption response to monetary policy, whereas substitution effects are responsible for a 10% increase in the consumption response. This is related to how much the services share increases due to each of these effects. The income effect is responsible for a 6.75 percentage point increase in this share, whereas the substitution effect is responsible for almost a 10 percentage point increase in the services share.

5.2.2 The Role of Heterogeneous Price Rigidities and Non-Homothetic Preferences

In Section 2, I showed that goods and services are different from each other in two aspects. First, the prices in the services sector adjust less frequently than in the goods sector. In the model, this is reflected in a higher price adjustment cost for the services sector, and in turn, a flatter Phillips Curve for this sector. As the economy is more concentrated in the services sector, the aggregate Phillips Curve is also flatter, which translates into stronger effects of monetary policy. Second, I have also shown that the demand composition between goods and services changes along the income distribution. I model this through non-homothetic preferences. This second difference means that the sectoral marginal propensity to consume is different across sectors, influencing the aggregate demand response to monetary policy.

Table 6 compares aggregate responses of the baseline calibration and two counterfactual exercises designed to isolate the role of heterogeneous price adjustment costs and non-homothetic preferences. Column (1) reports the baseline, replicating the analysis from the previous subsection. The rise in the services share between 1970 and 2019 implies that the same monetary policy shock generates a 21% larger response of aggregate consumption, a 14% larger increase in goods prices, and an 11% larger increase in services prices.

Table 6: Counterfactuals of Monetary Policy Channels: Homotheticity and Homogeneous Sectoral Costs of Price Adjustment

	(1) Baseline		(2) Homog. κ		(3) Homothetic	
	1970	2019	1970	2019	1970	2019
Service share	51.3	67.3	51.3	67.3	51.0	67.2
MPC	8.1	7.6	8.1	7.6	8.6	8.4
Consump. response (% change vs. 1970)	20.6		3.5		24.1	
Price of goods response (% change vs. 1970)	13.7		5.9		6.3	
Price of serv. response (% change vs. 1970)	10.7		5.9		3.5	

Notes: The table compares the response of consumption in an economy with the services share equal to the one observed in 2019 and an economy with the services share equal to the one observed in 1970. Column (1) shows it for the baseline scenario, column (2) shows it for the case when preferences are homothetic, and column (3) shows it for the case when the NKPC slopes are the same between the two sectors.

Column (2) shows the responses for the counterfactual where the costs of price adjustments are homogeneous across sectors. I set $\kappa_g = \kappa_s = 56$, equal to the value used by Hagedorn et al. (2019). As this only affects the agents' decisions after a monetary policy shock, the 1970 and 2019 steady-states are equal to the baseline, and hence the same share of hand-to-mouth households and marginal propensity to consume. Having homogeneous costs of price adjustment has, however, consequences in the transmission of monetary policy. In fact, consumption responses are now only 3.5% larger in 2019 than in 1970, illustrating the importance of heterogeneous price rigidities to understand how the sectoral composition and structural transformation impact the transmission of monetary policy.

Column (3) shows the responses for the counterfactual where preferences are homothetic.[24] To build this counterfactual, I make preferences homothetic by setting $\epsilon = 1$ and recalibrate the taste-shifter, Ω, to match the services share in 1970 (51.3%) and in 2019 (67.3%). This way, the production side of the economy is unchanged in comparison to the baseline, and all differences come from changing to a homothetic preference relation.[25] The aggregate consumption responses difference between 1970 and 2019 increases from 21% to 24%, indicating that differences in the demand composition dampen the effects on aggregate demand that monetary policy has.

The intuition is that with non-homothetic preferences, services demand is concentrated among high-income households, who have lower marginal propensities to consume. When monetary policy shifts demand toward services, aggregate consumption responds less than in the homothetic case, where the burden is spread more evenly across the income distribution. In this way, demand composition interacts with the distributional channel to dampen the transmission of monetary policy. Non-homothetic preferences also affect the wealth distribution and, through that, the aggregate marginal propensity to consume. Since goods are a necessity, households seek to avoid the risk of falling short of their goods consumption, which raises precautionary savings, lowers the share of hand-to-mouth households, and thereby reduces the overall responsiveness of aggregate demand.

5.3 Distributional Responses to a Monetary Shock and Welfare Implications

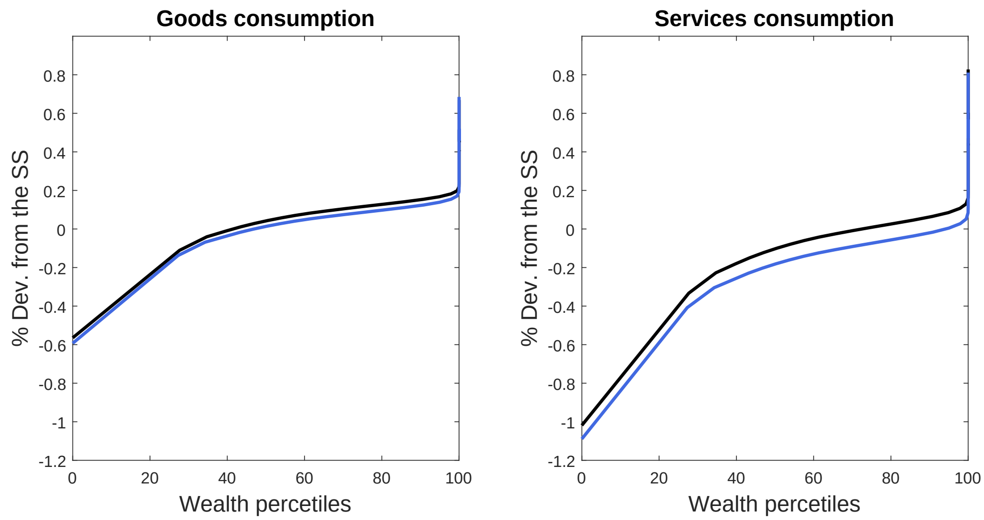
I now look into the distributional effects of a monetary policy shock and show that the share of services in the economy matters for welfare consequences. Figure 9 shows the average responses of goods and services consumption over the wealth distribution. Similarly to above, the black lines correspond to the responses when the service share is equal to 50% (the 1970-economy) and the blue lines to the responses when the service share is equal to 68% (the 2019-economy).

Focusing on the left-hand-side panel with the goods consumption heterogeneous responses, there is a clear divide between low and high-wealth households. Households on the bottom part

[24] In Appendix D.1, I plot the steady-state policy functions of this counterfactual exercise.

[25] Note that Ω does not affect households' decisions but the optimal preferred mix between services and goods. This strategy is similar to Hochmuth et al. (2025) to disentangle the effects of non-homothetic preferences on the distributional consequences of becoming climate neutral.

Figure 9: Sectoral Consumption Responses by Wealth Position



Notes: The figure shows consumption of goods and the consumption of services responses after a monetary policy contraction of 100 basis points by wealth position. The black lines depict the response for the 1970-economy and the blue line for the 2019-economy. All values are in percentage deviations from the steady state values.

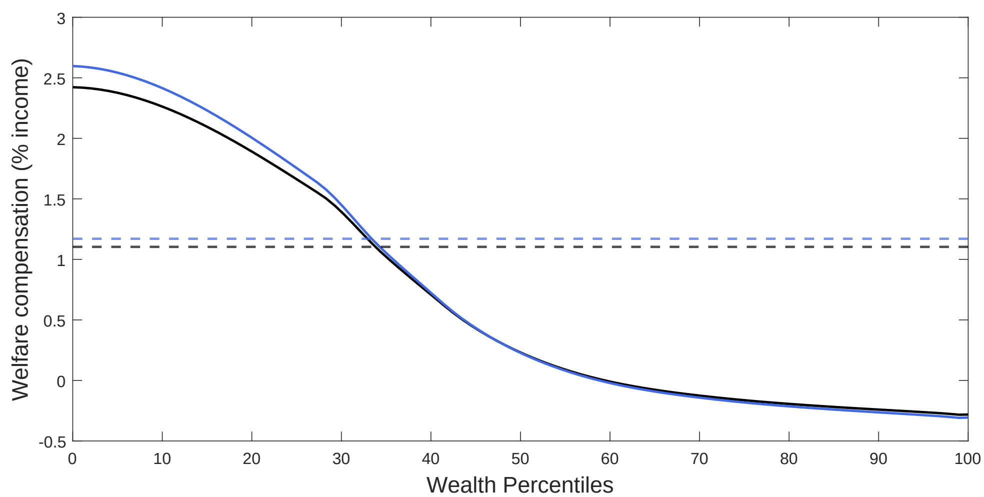
of the wealth distribution respond negatively to the contractionary shocks, whereas households on the top part of the distribution increase their consumption of goods. In particular, the bottom 20% of the wealth distribution, which includes the hand-to-mouth households, decreased their consumption of goods between 0.4–0.6% in comparison to what they were consuming before the shock. The top 20% of the wealth distribution, on the other hand, increase their consumption of goods between 0–0.4% compared to the steady-state value.

The right-hand-side panel shows a similar pattern, although the differences along the wealth distribution are larger. For this sector, the bottom 20% of the wealth distribution decreases their consumption between 0.6–1%, whereas the top 20% of the wealth distribution increases their consumption by a similar amount to the goods consumption, 0–0.2%.

As shown above, a higher share of services in the economy increases its responsiveness to monetary policy shocks. This pattern also holds across the wealth distribution. For the consumption of goods, the fall between 1970 to 2019 is more modest than for the consumption of services. The difference in goods consumption responses between 1970 and 2019 is relatively constant along the wealth distribution. For the services consumption, the difference enlarges along the wealth distribution, with high-wealth households decreasing their services consumption more than low-wealth households. Figure D.8 in the Appendix complements this analysis and plots the impulse response functions of consumption and labor supply. For the labor response, in particular, it shows a decrease between the 1970- and the 2019-economy. However, as low-wealth households have positive responses and high-wealth households have negative responses to the monetary policy tightening shock, this means that those at the top are better off in this regard than those at the bottom of the distribution.

These differences in responses to a monetary shock, together with the differences in the consumption baskets composition in terms of goods and services, motivate a welfare analysis. Figure 10 shows the wealth transfer, in percentage of income, required to offset the welfare losses/gains of a monetary policy contraction, for the median productivity ω state. I plot it along the wealth distribution. A positive value means that a positive transfer is needed to restore welfare, which implies that monetary policy is welfare-harmful.

Figure 10: Welfare Compensation by Wealth Position



Notes: The figure plots the welfare compensation to a 100 basis points monetary policy tightening over wealth. Positive values mean that a positive transfer is required to restore the steady-state welfare, i.e., that welfare decreased with the increase in the nominal interest rate. The values are in percentage of the household income (left-axis). In the background, I plot the steady state wealth distribution (right-axis). The dashed horizontal lines correspond to the aggregate welfare loss. The 1970-economy values are represented in black, and the 2019-economy values are represented in blue.

Independent of the service share level in the economy, a monetary policy tightening shock leads to a loss of welfare, such that a positive compensation of around 1% of the income is needed. Households at the bottom part of the wealth distribution are the ones more negatively affected by the shock since they are the ones with higher losses of consumption, as shown above. On the other hand, households at the top of the wealth distribution benefit from the shock.

This means that a monetary shock increases welfare inequality. In general, an increase in the interest rate affects households in two ways. A direct effect through an increase in the nominal return of assets and an indirect effect as the government has to increase taxes to finance the higher interest payments. These two channels explain why low-wealth households are worse-off from the negative shock – the increase in taxes is higher than the increase in the return – and high-wealth households are better-off – the increase in the nominal return compensates the higher tax payments.

Compared with the 2019-economy, the shift of economic activity towards the services sector also changed the welfare implications of monetary policy. The aggregate welfare cost increases by 5% of the income. In terms of the welfare distributional effects of the monetary shock, households with lower wealth levels now have a higher cost. Those with no assets need to receive compensation 7% larger in the 2019-economy in comparison with the 1970-economy. On the other hand, households with higher wealth levels are slightly better off with the monetary shock in the 2019-economy than they were in the 1970-economy. This implies that as the service share increases, monetary policy becomes more powerful, which increases the inequality generated as well.

6 Structural Transformation and Supply Shocks

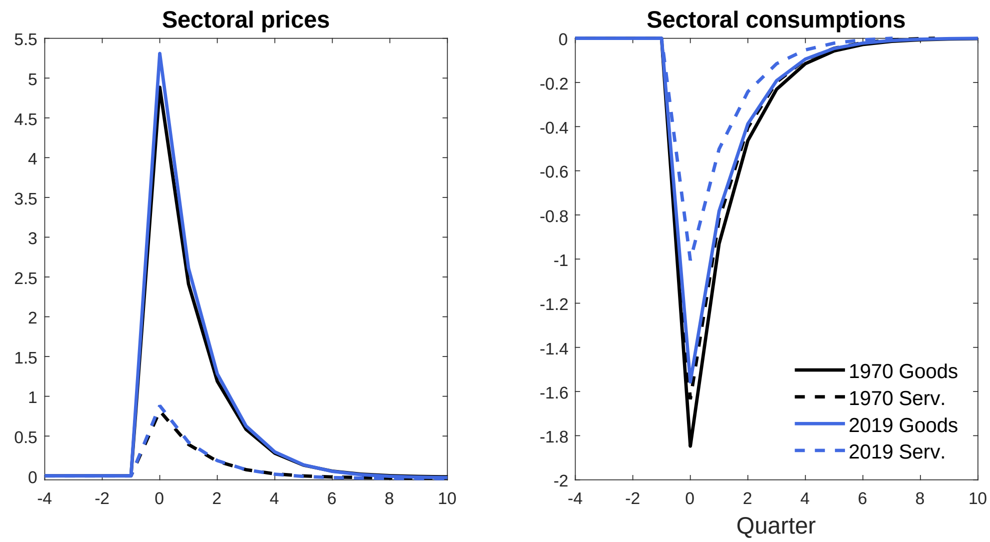
In this section, I extend the analysis by comparing the effects of supply shocks in economies with different demand compositions in terms of services. As before, I consider the same two economies as in Section 5: the 1970-economy that has a services share of 50% and the 2019-economy that has a services share of 68%. Except for the differences in the share of services that are generated by differences in relative sectoral productivity, these economies are identical to each other. These two years are particularly relevant in this context, as each experienced significant supply shocks—the oil crises in the 1970s and the COVID-related disruptions in 2019 and successive years.[26]

In each economy, I consider an experiment in which, at time $t = 0$, there is an unexpected TFP shock. This shock is common for both sectors, such that $\Delta Z_i / Z_i = -5\%$. The shock follows an AR(1) process with persistence 0.5. I solve for the transition paths of prices and real aggregates, treating the shock as an "M.I.T. shock".

[26]COVID is commonly thought of as a supply shock that caused demand shortages (Guerrieri et al., 2022).

Figure 11 plots the aggregate impulse response functions to this shock for both the low- and the high-services economy. The top-left panel shows the consumption index response, the top-right panel the path of sectoral prices, the bottom-left panel the path of aggregate labor, and the bottom-right panel shows the path of sectoral consumption. The black line corresponds to the 1970 calibration and the blue line to the 2019 calibration.

Figure 11: Aggregate Responses to a Negative Supply Shock: 1970 vs. 2019



Notes: The figure shows the aggregate response after a negative TFP shock of 5% for two model calibrations. In black, I show the responses when the service share is equal to the one observed in 1970, and in blue when the service share is equal to the share observed in 2019. All responses are shown in percentage deviations from the steady state values.

A negative supply shock leads to an increase in production costs. In response to that, firms increase prices. However, due to the differences in the frequency of price adjustment between the two sectors, the price of goods adjusts more than the price of services. This means that consumption falls with goods consumption decreasing more than services consumption, generating an increase in the services share, given that the relative price of services decreased. These responses align with the estimated impulse response functions to oil shocks by Känzig (2021) for the U.S. and Broer et al. (2025) for Germany.

In fact, focusing on the 1970-economy's responses, I find that the negative TFP shock leads to a contemporaneous increase in the price of goods by 4.9% and the price of services by 0.8%. As a result, goods consumption falls by 1.8% and services consumption by 1.6%. The smaller decline in goods consumption, relative to the large price increase, reflects the non-homothetic nature of preferences: goods are a necessity, so households cannot reduce their consumption proportionally to the price change. Overall, this implies that the consumption index, a proxy for welfare, declines by 1.3% immediately following the negative TFP shock.

Comparing the 1970-economy responses with the 2019-economy responses, I find that the overall recessionary effects of the negative TFP shock are milder. Aggregate consumption responses are 37% smaller and sectoral consumption responses are 16% smaller for goods and 38% for services. Since goods are the sector in which prices rise more strongly, a larger services share implies that a smaller portion of the consumption basket is exposed to this adjustment. Consequently, aggregate consumption contracts less, and output falls by a smaller amount, as the economy is relatively more insulated by the service sector.

7 Conclusion

Economic growth is associated with a reallocation of economic activity towards the services sector. In this paper, I study how this shift affects the transmission of monetary policy. I start by documenting two empirical facts about the services sector. First, I show that the prices of services change more infrequently than the prices of goods. Second, I show a positive income gradient of the service share expenditure: high-income households allocate a higher share of their consumption to services than low-income households. These facts imply that as the economy shifts toward services, greater price rigidity amplifies the real effects of monetary policy. Moreover, because high- and low-income households consume different service shares, monetary shocks also generate heterogeneous distributional effects.

To quantify how these two characteristics of the service sector affect the transmission of monetary policy, I build a two-sector Heterogeneous-Agent New-Keynesian model with non-homothetic preferences. I estimate the model to fit the U.S. long-run behavior of the economy in terms of economic activity growth and reallocation toward services, as well as the household micro-behavior of consumption, income, and wealth that are key to studying the propagation of aggregate shocks in the economy.

I find that a one percentage point increase in the services share leads to a 1.2% stronger response of consumption to a contractionary monetary policy shock. This means that in the last 50 years, where the service share increased by almost 18%, monetary policy became 21% more powerful when analyzing the consumption responses. I show that the sectoral differences in price rigidities contribute 17 percentage points to the amplification of the transmission of monetary policy, whereas the heterogeneous demand composition dampens it by 3.5 percentage points.

I also find that the shift of economic activity toward services made monetary policy more costly in terms of welfare. The same shock in 2019 is 5% more costly, on average, than in 1970. This difference is even larger when I look at low-income households. Overall, this implies that as the service share increases, monetary policy becomes more powerful; at the same time, it increases the welfare costs and inequality generated as well.

These findings carry important implications for policymakers, particularly central bankers. In the Euro area, a single monetary authority sets the nominal interest rate for economies that differ widely in their sectoral composition. My results help explain why monetary policy does not affect all countries in the same way and can shed light on the heterogeneous responses observed across Europe.

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Structural Transformation and the Transmission of Monetary Policy

Appendix

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A Data and Empirical Motivation

A.1 Data Cleaning

One of the data sources I use is the CEX survey. This is a well-known survey used to compute the CPI expenditure weights each year. In my analysis, I consider the years between 2000 and 2019, which include 622,266 observations. I then exclude households that report negative expenditures in a given expenditure category (mostly health-related expenditures), households that report zero food consumption (both at home and away), households younger than 25 years old, and finally, households that report a negative income. This leaves me with 558,848 households, which corresponds to an average number of 6,009 households per quarter. Table A.1 summarizes these steps.

Table A.1: Data-Cleaning Steps of the CEX sample

Step	Description	Observations	HH/quarter
0	Initial dataset	622,266	6,691
1	Exclude HH with negative expenditures	618,533	6,651
2	Exclude HH with zero food expenditures	615,289	6,616
3	Exclude HH below 25 years old	577,224	6,207
4	Exclude HH with negative income	558,848	6,009

Notes: This table shows the cleaning steps performed in the CEX data. Each observation corresponds to a household in a given quarter. The last column shows the average number of households per quarter.

A.2 Classification into Goods and Services

From the several expenditure items reported in the CEX data, I use the aggregation suggested in Hobijn and Lagakos (2005) with only small differences that allow me a better categorization into goods and services. I then follow the Bureau of Economic Analysis to classify these categories into goods and services. Table A.2 shows this classification.

A.3 Robustness to Empirical Fact # 1

In this subsection of the Appendix, I show that Empirical Fact 1 also holds when using a different dataset.

Table A.2: Classification into Goods and Services

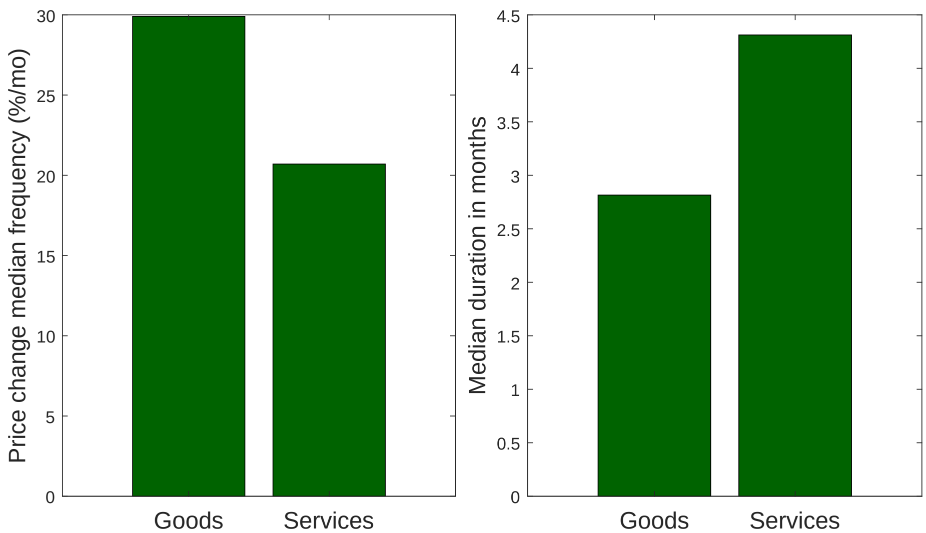
Category	**CEX code**	**Classification**
Household operations	HOUSOPPQ	Services
Reading	READPQ	Services
Entretainment	ENTERTPQ	Services
Food away	FDAWAYPQ	Services
Education	EDUCAPQ	Services
Other vehicles	EOTHVEHP OTHVEHPQ	Services
Public transportation	TRNOTHPQ TRNTRPPQ	Services
Personal care	PERSCAPQ	Services
Medical services	HLTHINPQ MEDSRVPQ	Services
Other lodging	OTHLODPQ	Services
Utilities: natural gas	NTLGASPQ	Services
Utilities: electricity	ELCTRCPQ	Services
Utilities: fuel	ALLFULPQ	Services
Utilities: telephone	TELEPHPQ	Services
Utilities: water	WATRPSPQ	Services
Medical drugs and supplies	PREDRGPQ MEDSUPPQ	Goods
Tobacco	TOBACCPQ	Goods
Gasoline	GASMOPQ	Goods
Food at home	FDHOMEPQ	Goods
Apparel	APPARPQ	Goods
Alcoholic beverages	ALCBEVPQ	Goods

Notes: The table shows, for the different categories considered, the corresponding variable code in the Consumer Expenditure Survey and the corresponding classification by the Bureau of Economic Analysis into goods and services.

Using the Bils and Klenow (2004) dataset. I use an alternative dataset, assembled by Bils and Klenow (2004), to compare the frequency of price changes between goods and services. In this paper, they consider the underlying microdata used to compute the CPI between 1995 and 1997. Similar to Nakamura and Steinsson (2008), this covers about 70% of consumer expenditures. I follow the same aggregation procedure that I describe in the main text to compute the median price frequency and the median duration of prices in the goods and services sector.

In Figure A.1, I show the median frequency of price changes within a month for goods and services. The same pattern as the one described in the main text appears, although for this dataset, services adjust slightly more frequent than in the data assembled by Nakamura and Steinsson (2008). Within a month, almost 30% of the price quotes of goods change, whereas only 20.7% for the services. This implies that the median duration of a good price spell is 2.8 months, and for a service is 4.3 months.

Figure A.1: Robustness to Fact 1: using Bils and Klenow (2004) Dataset



Notes: The left panel shows the median frequency of price changes in a month for goods and services. The right panel shows the implied median price duration of a price spell in months. Duration is equal to $-1/\log(1-f)$, where f is the frequency of price changes. Data are sourced from Bils and Klenow (2004).

A.4 Robustness to Empirical Fact # 2

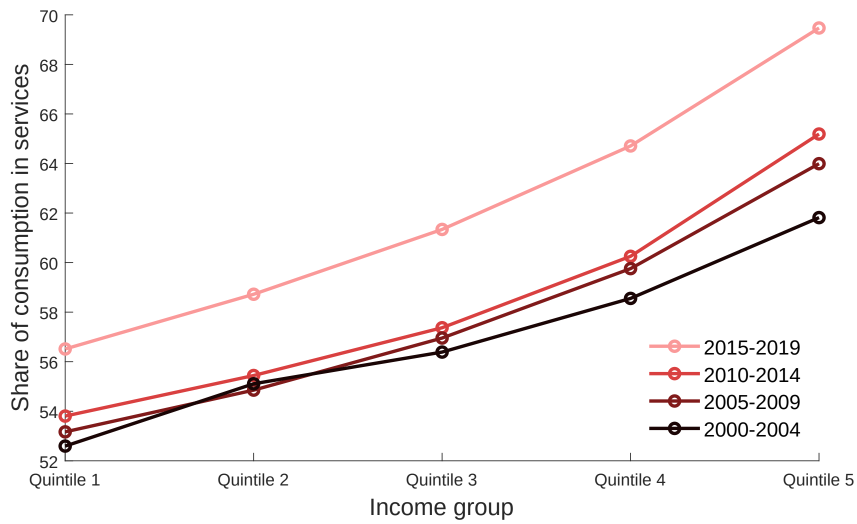
In this subsection of the Appendix, I show that Empirical Fact 1 is robust to different sample constructions.

Excluding households older than 65 years old. Consumption patterns change along the life cycle. Nie and Gautam (2020) show that the implicit average inflation rate between 1984 and 2018 faced by older households is 0.4 percentage points larger than it is for younger households. All these differences come from the fact that they allocate their expenditures differently, and expenditure categories have different price changes.

I show that excluding households older than 65 years old does not affect qualitatively

Empirical Regularity 1. Figure A.2 shows that old household consumption patterns do not drive the result, as the difference between the first and the fifth income groups is 10 percentage points, similar to the baseline figure in the main text. There is, however, a downward shift of the average share, which indicates that older households consume a higher share of services (namely, healthcare services and nursing homes).

Figure A.2: Robustness to Fact 2: Excluding Old Households

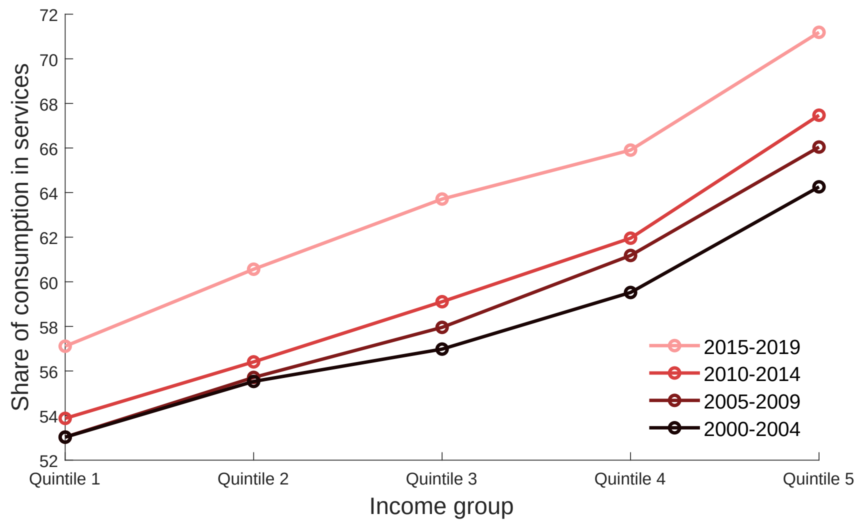


Notes: The figure shows the average service share for each income group, excluding households above 65 years old. Table A.2 in the Appendix enumerates all the categories classified as services. The data source is the Consumer Expenditure Survey for the U.S. between 2000 and 2019.

Including households in the bottom and top 5% of the income distribution. The CEX dataset is constructed to have a representative sample of the American population that self-reports their expenditures. It might have, therefore, data points that are outliers. Furthermore, the BLS uses top-coding rules on some variables, such as income.

To account for potential problems arising from outliers and censored data, I follow Aguiar and Bils (2015) and exclude each quarter's top and bottom 5% of income earners in the main text. In Figure A.3, I reproduce Empirical Regularity 1, including these extreme income earners. The pattern is the same, with high-income households allocating a larger share of their expenditures to services than low-income households. The major difference is in the highest income quintile, which has an even higher share of consumption in services. For the years 2015–2019, which reaches 71%, whereas when I exclude the extreme values from the analysis, the value is 69%.

Figure A.3: Robustness to Fact 2: Including the Bottom and Top 5% of the Income Distribution



Notes: The figure shows the average service share for each income group, including households on the bottom and top 5% of the income distribution. Table A.2 in the Appendix enumerates all the categories classified as services. The data source is the Consumer Expenditure Survey for the U.S. between 2000 and 2019.

B Additional Model Derivations

B.1 Household Intratemporal Problem

Each period, households choose how to allocate their total expenditure between goods and services. For that, they solve the expenditure minimization problem given by

$$\min_{c_g, c_s} E = p_g c_g + p_s c_s$$
$$\text{s.to} \;\; c^{\frac{1}{\sigma}} c_g^{\frac{\sigma-1}{\sigma}} + (\Omega c^{\epsilon})^{\frac{1}{\sigma}} c_s^{\frac{\sigma-1}{\sigma}} = 1.$$

The first-order conditions are

$$p_g = \lambda c^{\frac{1}{\sigma}} \frac{\sigma - 1}{\sigma} c_g^{\frac{-1}{\sigma}},$$

and

$$p_s = \lambda (\Omega c^{\epsilon})^{\frac{1}{\sigma}} \frac{\sigma - 1}{\sigma} c_s^{\frac{-1}{\sigma}},$$

where λ is the Lagrange multiplier associated with the restriction of the problem.

Solving for c_g and c_s yields the Hicksian demands:

$$c_g = \left(\frac{p_g}{E}\right)^{-\sigma} c^{1-\sigma} \text{ and } c_s = \left(\Omega \frac{p_s}{E}\right)^{-\sigma} c^{\epsilon(1-\sigma)},$$

corresponding to Equation (6) in the main text. Furthermore, the expenditure function is

$$E(c_g, c_s) \equiv \sum_{i \in \{g,s\}} p_i c_i = \left[\left(p_g c\right)^{1-\sigma} + \Omega \left(p_s c^{\epsilon}\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}.$$

Note that when $\epsilon = 1$, the consumption aggregator is the standard homothetic CES. For the relevant case when goods and services are gross complements with $\sigma \in (0, 1)$, when $\epsilon > 1$, services are a "luxury consumption good" and when $\epsilon < 1$, services are instead a "necessity consumption good". As Empirical Regularity 1 points out, in Section 2, the slope of the Engel curve of services is positive, meaning that high-income households consume relatively more services than low-income households, i.e., services are a "luxury consumption good".

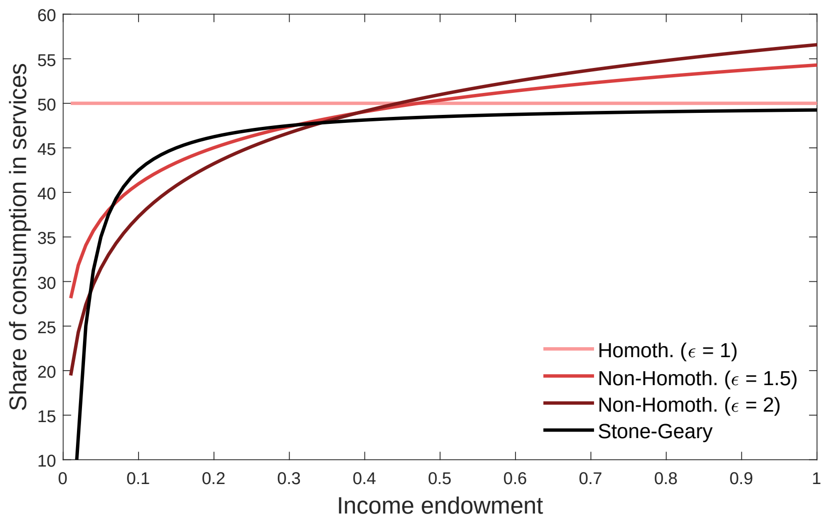
Figure B.4 illustrates the relevance of modeling preferences with a non-homothetic relation for the household micro-behavior consumption heterogeneity. The figure shows the service share in consumption for different income endowments when the CES aggregator is homothetic ($\epsilon = 1$), when the CES aggregator is non-homothetic ($\epsilon = 1.5$ and $\epsilon = 2$), and when there is a subsistence point (Stone-Geary), the most used form of non-homothetic preferences in the literature (Geary, 1950, Stone, 1954).[27]

For the homothetic case, independently of the income, households always spend half of their budget on services. However, for the non-homothetic cases, the service share increases with income. For the nhCES, a higher ϵ implies a higher slope of the Engel curve. For the Stone-Geary case, the slope occurs mainly in the first income levels, and asymptotically converges to the homothetic case of a service share equal to 50%.

This figure justifies the modeling choice of the non-homothetic CES preference relation. With the homothetic relation, I could not reproduce the household heterogeneity implied by Empirical Regularity 1, nor the shift of the economic activity towards services. But even among the different non-homothetic preference relations possible, the non-homothetic CES gives a better fit of the service share heterogeneity.

[27] I set $\sigma = 0.2$ and $\Omega = 1$ for the homothetic and non-homothetic CES cases. For the Stone-Geary preferences, I use an additive log specification with a subsistence point on goods equal to 0.015.

Figure B.4: Illustration of the Non-Homothetic CES Aggregator



Notes: The figure plots the service share in consumption for different levels of income. In red, it shows for the homothetic CES case, orange and pink for the non-homothetic CES case with different values of ϵ, and in green for the Stone-Geary case. Both CES cases use $\sigma = 0.2$ and $\Omega = 1$. The Stone-Geary case uses an additive log specification with a subsistence point on goods equal to 0.015.

B.2 Final Producer Problem

The final producer of sector i aggregates a continuum of intermediate inputs indexed by $j \in [0, 1]$, according to Equation (9). Given a level of aggregate demand Q_i, the final producer solves:

$$\min_{\{q_i(j)\}} \int_0^1 p_i(j) q_i(j) dj$$

$$\text{s.to } Q_i = \left(\int_0^1 y_i(j)^{\frac{\theta_i - 1}{\theta_i}} dj \right)^{\frac{\theta_i}{\theta_i - 1}}.$$

The first-order condition for input j is

$$p_i(j) = \lambda \left(\frac{Q_i}{q_i(j)} \right)^{\frac{1}{\theta_i}},$$

where λ is the Lagrange multiplier. For two different intermediate inputs, I have that

$$\left(\frac{p_i(j)}{p_i(\ell)} \right)^{\theta_i} = \frac{q_i(\ell)}{q_i(j)} \Leftrightarrow \int_0^1 p_i(\ell) y_i(\ell) d\ell = \int_0^1 \left(\frac{p_i(j)}{p_i(\ell)} \right)^{\theta_i} q_i(j) p_i(\ell) dl.$$

Note that the LHS of the above equation corresponds to the expenditure done in sector i.

Hence,

$$P_i Q_i = p_i(j)^{\theta_i} q_i(j) \int_0^1 p_i(\ell)^{1-\theta_i} d\ell.$$

The integral in the above equation is the definition of the price index of sector i as defined in Equation (11). Therefore, I obtain the demand for intermediate input j as in Equation (10):

$$q_i(j) = \left(\frac{p_i(j)}{P_i}\right)^{-\theta_i} Q_i.$$

B.3 Intermediate Input Producer Problem

In this subsection, I solve the intermediate input producer dynamic pricing problem. I omit the subscript for the sector, i, for convenience. The intermediate firm j operates under monopolistic competition and sets the input j price, $p(j)$. These firms face a demand given by Equation (10). Moreover, they have a cost for adjusting prices given by Equation (13).

The dynamic problem is given in (14), but I reproduce it here for convenience:

$$\begin{aligned} V_{i.t}(p_{t-1}(j)) = \max_{\{p_t(j)\}} \; & d_{i,t} = p_t(j) q_t(j) - w_t n_t(j) - \Phi\left(p_t(j), p_{t-1}(j)\right) + \frac{1}{1+i_t} V_{i,t+1}(p_t(j)) \\ & \text{s.to Equations (10) and (12)}, \end{aligned}$$

or equivalently,

$$\begin{aligned} V_t(p_{t-1}(j)) = \max_{\{p_t(j)\}} \; & p_t(j) \left(\frac{p_t(j)}{P_t}\right)^{-\theta} Q_t - w_t \left(\frac{p_t(j)}{P_t}\right)^{-\theta} Q_t - \Phi\left(p_t(j), p_{t-1}(j)\right) \\ & + \frac{1}{1+i_t} V_{t+1}(p_t(j)) \end{aligned}$$

The first-order condition with respect to $p_t(j)$ is

$$\begin{aligned} \frac{\partial V_t}{\partial p_t(j)} = & \left(\frac{p_t(j)}{P_t}\right)^{-\theta} Q_t - \theta p_t(j) \left(\frac{p_t(j)}{P_t}\right)^{-\theta-1} \frac{Q_t}{P_t} \\ & + \theta w_t \left(\frac{p_t(j)}{P_t}\right)^{-\theta-1} \frac{Q_t}{P_t} - \frac{\theta}{\kappa} \log\left(\frac{p_t(j)}{p_{t-1}(j)}\right) \frac{Q_t P_t}{p_{t-1}(j)} + \frac{1}{1+i_t} \frac{\partial V_{t+1}}{\partial p_t(j)} = 0, \end{aligned}$$

and the Envelope Condition of this problem is

$$\frac{\partial V_t}{\partial p_{t-1}(j)} = \frac{\theta}{k} \log\left(\frac{p_t(j)}{p_{t-1}(j)}\right) \frac{Q_t P_t}{p_{t-1}(j)}.$$

Combining the FOC and the Envelope Condition, I obtain the following expression:

$$\left(\frac{p_t(j)}{P_t}\right)^{-\theta} Q_t - p_t(j)\theta\left(\frac{p_t(j)}{P_t}\right)^{-\theta-1}\frac{Q_t}{P_t} + w_t\theta\left(\frac{p_t(j)}{P_t}\right)^{-\theta-1}\frac{Q_t}{P_t} - \frac{\theta}{\kappa}\log\left(\frac{p_t(j)}{p_{t-1}(j)}\right)\frac{Q_t P_t}{p_{t-1}(j)}$$
$$+\frac{1}{1+i_t}\cdot\frac{\theta}{\kappa}\log\left(\frac{p_{t+1}(j)}{P_t(j)}\right)\frac{Q_{t+1}P_{t+1}}{p_t(j)} = 0.$$

In a symmetric equilibrium, all firms choose the same prices, so $p_t(j) = P_t$. Hence, the above expression is simplified to

$$1-\theta+\theta w_t\frac{1}{P_t} - \frac{\theta}{\kappa}\log\left(\frac{P_t}{P_{t-1}}\right) + \frac{1}{1+i_t}\frac{\theta}{\kappa}\log\left(\frac{P_{t+1}}{P_t}\right)\frac{Q_{t+1}}{Q_t}\frac{P_{t+1}}{P_t} = 0$$

Defining $\frac{P_t}{P_{t-1}} \equiv 1+\pi_t$, yields the optimal price setting rule, Equation (15), which is the New-Keynesian Phillips Curve of sector i.

C Computational Algorithms

C.1 Steady-state Equilibrium

To solve for the steady-state, I make use of my production setting with monopolistic competition and linear production. In the steady-state, prices are constant, so the optimal sectoral prices are simply given by the product of the markup and the marginal cost as in Equation (16).

Moreover, the use of non-homothetic CES preferences as in Equation (3) implies an additional step. Consumption and Expenditure are not the same as in a standard heterogeneous-agent model, i.e., the object that enters the utility function, C, and the objects that appear in the household budget constraint, E. However, I can use Equation (7) to map expenditure to consumption. In practice, for given parameters and prices, I solve for 500 values of expenditure the implied consumption index values, and then interpolate using a piecewise cubic interpolation.

The goal is to find the steady-state equilibrium. That the household's equilibrium objects — value function, policy functions of consumption, labor, sectoral consumptions and savings, and distribution — prices and dividends — w, p_g, p_s, p_b and D — and taxes, T. For that, I use the following algorithm:

1. Set parameters, normalize $w = 1$, use Equation (16) to compute p_g and p_s
2. Guess value for p_b
   (a) Guess T and D
      i. Solve the household problem with a value function iteration (VFI) algorithm, interpolating with a piecewise cubic method → get value function and policy functions (expenditure, consumption, savings, and labor supply)
      ii. Solve for the stationary distribution using the lotteries algorithm (Young, 2010)
      iii. Solve for the sectoral consumption
      iv. Aggregate and obtain aggregate consumption, expenditure, sectoral consumption, labor supply, and asset demand
      v. Solve the firms' problems → get sectoral profits, labor demand, prices, and quantities

(b) Compute the difference between total profits and guessed dividends, and check if the government budget constraint holds. Update D and T, using a convex combination update

3. Check for asset market clearing. Update p_b using a bisection update

The algorithm provides an approximate solution. I choose a tolerance criterion for each of the steps that is high enough to give precise results. The intertemporal household problem is solved with the builtin MATLAB `fminsearch` and `fminbnd` with a precision of 1e-11; the VFI algorithm is solved with a precision of 1e-10; the dividend and the lump-sum tax with a precision of 1e-8; and the price of bonds with a precision of 1e-5.

C.2 Transition Path Equilibrium

The goal is to find the sequence of equilibrium prices $\{p_t^b\}_{t=0}^T$, $\{p_t^g\}_{t=0}^T$, $\{p_t^s\}_{t=0}^T$, and $\{w_t\}_{t=0}^T$; profits $\{\pi_t^g\}_{t=0}^T$ and $\{\pi_t^s\}_{t=0}^T$; taxes $\{T_t\}_{t=0}^T$; interest rate, $\{i_t\}_{t=0}^T$; value functions, policy functions and law of motion, Ψ that solve for an exogenous shock in the nominal interest rate, ε^M.

In general solving for this is computationally challenging as the distribution of wealth evolves with the shock as well. I adapt the proposed algorithm in Boppart et al. (2018) and guess the sequence of prices along the transition.[28] Note that prices are not constant anymore and that wages cannot be normalized, which creates two additional loops. I use the following algorithm:

1. Set the nominal interest rate shock, ε^M

2. Guess the price of bonds sequence $\{p_t^b\}_{t=0}^T$

   (a) Guess the sequences of sectoral prices $\{p_t^g\}_{t=0}^T$ and $\{p_t^s\}_{t=0}^T$, and compute the sectoral inflation rates and the aggregate inflation rate

   (b) Use the Taylor rule in Equation (19) to compute the nominal interest rate

      i. Guess the wage sequence $\{w_t\}_{t=0}^T$

         A. Guess the dividend and tax sequence, $\{D_t\}_{t=0}^T$ and $\{T_t\}_{t=0}^T$

         B. Solve the household problem backwards (in $t = T + 1$, the economy is in the SS)

[28] I truncate the convergence at $T = 150$, when the economy is very close to the steady-state again.

C. Solve for the distribution forwards (in $t = 0$, the economy is in the SS)

D. Solve for the sectoral consumption

E. Aggregate and obtain aggregate consumption, expenditure, sectoral consumption, labor supply, and asset demand

F. Solve for the firm problem and get sectoral profits, labor demand and prices

G. Compute the difference between total profits and guessed dividends, and check if the government budget constraint holds. Update $\{D_t\}_{t=0}^{T}$ and $\{T_t\}_{t=0}^{T}$ using a convex combination update for each period

ii. Check for labor market clearing and update $\{w_t\}_{t=0}^{T}$ using a shooting method for each period

(c) Check if guessed sectoral prices are equal to firm optimal prices and update $\{p_t^g\}_{t=0}^{T}$, $\{p_t^s\}_{t=0}^{T}$ using a convex combination update for each period

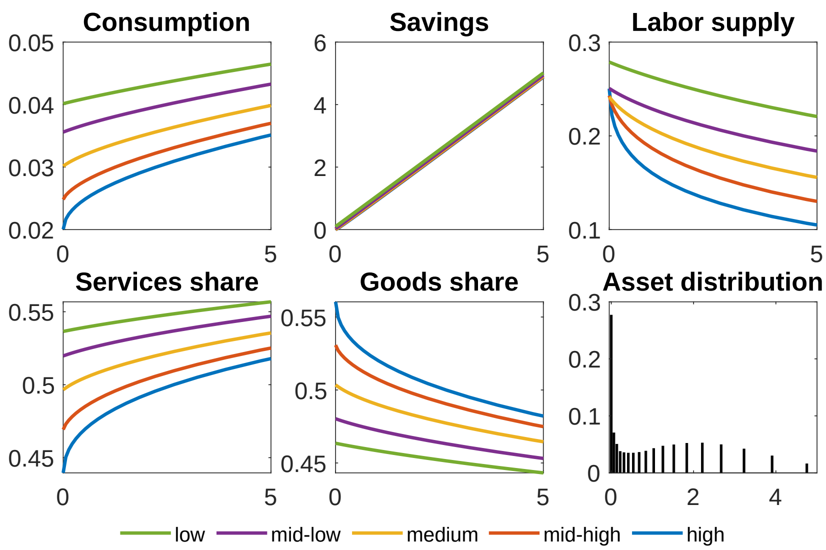
3. Check for asset market clearing and update $\{p_t^b\}_{t=0}^{T}$ using a shooting algorithm for each period

The algorithm provides an approximate solution for the impulse response functions that can be used to analyse the dynamic effects of the monetary policy shock. I choose a tolerance criterion for each of the steps that is high enough to give precise results. The intertemporal household problem is solved with the builtin MATLAB `fminsearch` and `fminbnd` with a precision of 1e-11; the dividend loop and the lump-sum tax with a precision of 1e-7; the labor market clearing with a precision of 1e-6; the sectoral prices with a precision of 1e-5; and the asset market clearing with a precision of 1e-4.

D Additional Results

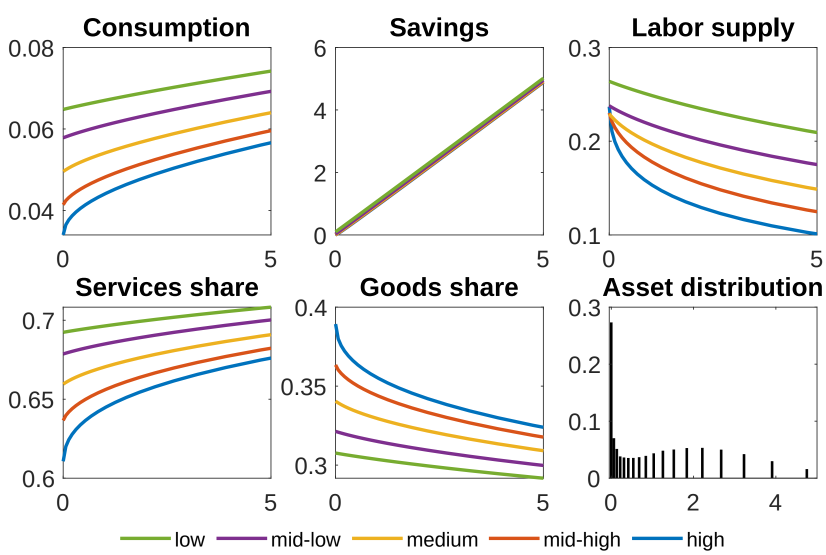
D.1 Additional Figures

Figure D.5: Steady-State Policy Functions for the 1970-Economy



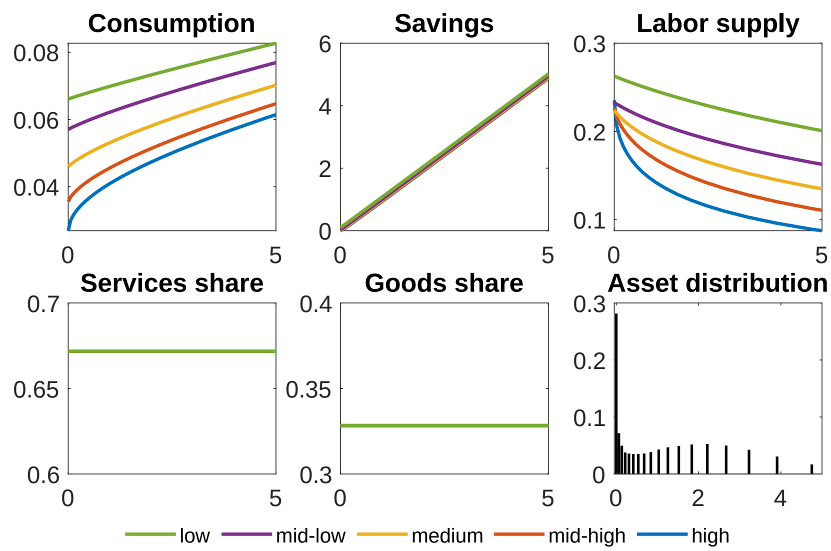
Notes: The figure shows the steady-state policy functions of consumption, savings, and labor along the state-space — asset grid (x-axis) and labor productivity (different lines). It also shows the expenditure share allocated to services and goods in the state-space and the asset distribution.

Figure D.6: Steady-State Policy Functions for the 2019-Economy



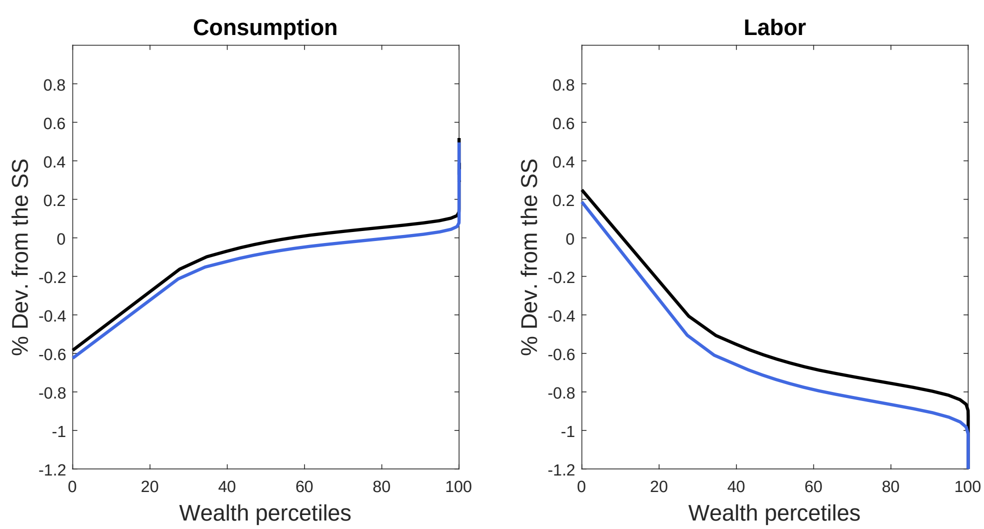
Notes: The figure shows the steady-state policy functions of consumption, savings, and labor along the state-space — asset grid (x-axis) and labor productivity (different lines). It also shows the expenditure share allocated to services and goods in the state-space and the asset distribution.

Figure D.7: Steady-State Policy Functions when Preferences are Homothetic (2019)



Notes: The figure shows the steady-state policy functions of consumption, savings, and labor along the state-space — asset grid (x-axis) and labor productivity (different lines). It also shows the expenditure share allocated to services and goods in the state-space and the asset distribution.

Figure D.8: Consumption and Labor Responses to a Contractionary Monetary Policy Shock by Wealth Position



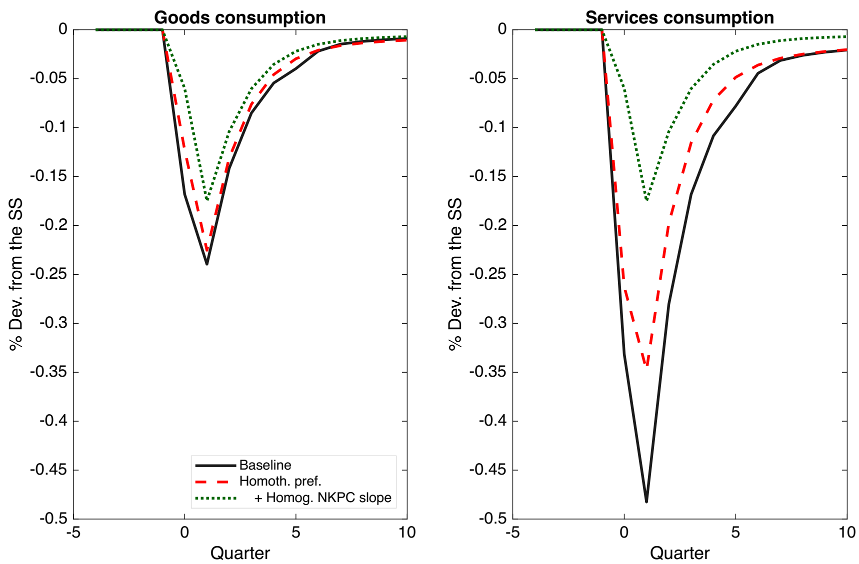
Notes: The figure shows the consumption index and labor responses after a monetary policy contraction of 100 basis points by wealth position. The black lines depict the response for the 1970-economy and the blue line for the 2019-economy. All values are in percentage deviations from the steady state values.

D.2 Sectoral Response Heterogeneity Decomposition

One of the model's predictions is that a contractionary monetary policy shock alters the composition of demand. Although consumption falls in both sectors, the decline is smaller for goods than for services. As a result, the share of services in total demand decreases following the shock. This shift in demand composition is driven by sectoral differences in price rigidity and markups — captured by the slope of the NKPC in Equation (15) — as well as by differences in income elasticity, which arise from the non-homothetic nature of preferences.

In this subsection, I construct counterfactual impulse response functions to the same 100 basis point contractionary monetary policy shock. The goal is to disentangle the role of the differences in the slope of the NKPC and the role of non-homothetic preferences. The counterfactuals are constructed such that the share of services in the economy equals 68%, the value observed in 2019.

Figure D.9: Decomposition of Responses



Notes: The figure shows the homothetic and the homogeneous NKPC counterfactuals of the impulse response function of sectoral consumptions to a contractionary 100 basis point monetary contraction.

Figure D.9 shows these counterfactuals. The black full lines show the response as in Figure 7 in 2019. The first counterfactual is the case when preferences are homothetic. For that, I set ϵ equal to 1, which makes the sectoral consumption aggregator in Equation 3 become the standard CES aggregator and, in turn, the share of services across households constant. The dashed blue line plots this first counterfactual. The second counterfactual eliminates the differences in the slope of the NKPC in addition to the homothetic preferences. This means that both sectors face the same costs of price adjustments and have the same markups. The dotted purple line shows the sectoral consumption responses in this case.

When both sectors have no differences between them, the sectoral consumption responses are the same. In response to a contractionary 100 basis point monetary contraction, services and goods consumption fall by 0.175%. When both sectors only differ on the supply side and have different NKPC slopes, the response of services consumption becomes larger than the response of goods consumption to a monetary policy shock. Services consumption response is almost two times larger and goods consumption 29% larger with respect to the homogeneous sector case. This means that services consumption falls by 0.348% and goods consumption by 0.225%. Finally, when I reintroduce the non-homothetic structure of preferences, we restore the baseline results and the differences in sectoral responses. Services respond three times more compared to the baseline case. Overall, differences in the slope of the NKPC and the non-homothetic preference structure have the same relevance in explaining the monetary response differences between the two sectors.