(Dis-)Aggregate Consumption and Monetary Policy

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Abstract

This paper studies the implications of consumption choices over goods with different degrees of price flexibility for monetary policy. I empirically show that households consume disproportionately more sticky price goods in response to intensive margin income increases. Upon employment at the extensive margin however, they spend more on flexible price goods. Impulse responses to high-frequency identified monetary policy shocks show increases in employment rates but little changes in earnings implying that monetary policy works rather through the extensive margin. Using a multi-sector New Keynesian model with non-homothetic preferences, home production and labor market frictions I analyze the implications for the trade-off between inflation and output-stabilization. First, compared to the standard New Keynesian model higher employment creates additional demand for goods that are not home-produced anymore. This leads to larger responses of real output but at the cost of disproportionately higher inflation because the additional demand occurs for flexible price goods. Second, monetary policy is state-dependent facing a worsening trade-off over the business cycle. The deeper the downturn and thus the higher the number of unemployed, the more important does the extensive margin consumption response and transmission into prices become for stimulus policy. Third, I show that optimal monetary policy follows a dual mandate in inflation and unemployment.

Keywords: Monetary Policy, Consumption, Unemployment, Price Stickiness

JEL Codes: E20, E24, E31, E32, E52

1 Introduction

The trade-off between transmission into quantities and prices is of particular concern to monetary policy with its prime mandate of price stability. Strong consumption responses to expansionary policy provide a positive argument for demand stimulus. However, they raise the natural concern of higher inflation. Yet, Consumption elasticities are heterogeneous across goods and potentially vary across the type of stimulus. Policies that work through intensive margin income increases might face a very different trade-off than policies that raise employment. This is particularly true if they stimulate consumption of a different set of goods and if there is a systematic relationship between consumption elasticities and price change frequencies that differs across margins.

In this paper I empirically and theoretically study the implications of heterogeneity in consumption elasticities and price flexibility for the conduct of monetary policy. First, I empirically show that the expenditure elasticity of a good due to intensive margin income increases differs from its expenditure elasticity upon employment at the extensive margin. I relate both to the degree of price flexibility of a good and show that at the intensive margin households consume disproportionately more sticky price goods, whereas at the extensive margin they consume more flexible price goods. I then show that expansionary monetary policy affects the extensive margin by raising employment but find little evidence for an intensive margin through increased labor earnings. Finally I build a multi-sector New Keynesian model with non-homothetic preferences, home-production and labor market frictions to theoretically assess the implications for monetary policy.

I empirically show that households disproportionately spend more on sticky price goods, when their income increases at the intensive margin. Expenditures increase more for luxuries with high income elasticities like jewelry, recreation services and household durables than for necessities like food at home, gasoline or household utilities. Luxuries in turn have a lower price change frequency. On average only 6.4% of luxuries change their price in any given month, compared to 14.5% for necessities. To estimate intensive margin consumption elasticities, I use household level expenditure data from the Consumption Expenditure Survey and estimate Engel curves for narrowly defined expenditure categories. I restrict the sample to households which do not see a change in the number of employed household members and thereby capture any increase in permanent

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income that is not due to changes in employment. Overall the expenditure-weighted correlation between intensive margin elasticities and price flexibility is around -0.5.

Upon employment, households show the opposite behavior and disproportionately increase expenditures on flexible price goods instead. Most of these expenditures are on necessities like gasoline, TV, telecommunication and purchases of new and used cars that are directly employment related. Households increase consumption of necessities by almost 3% with little changes in luxury consumption when a household member becomes employed. In order to capture pure extensive margin changes I use a difference-in-difference strategy. Controlling for time and household fixed effects I estimate elasticities for households with a change in the number of earners. Using demographic controls additionally captures predictable consumption changes, e.g. due to switches from college into first-time employment. The overall expenditure-weighted correlation between extensive margin elasticities and price flexibility is around 0.44.

The household-level consumption patterns matter in the aggregate. Using aggregate expenditure data I show that during recessions expenditures on flexible price goods fall. I construct an aggregate price flexibility measure as an expenditure-weighted average of good-specific price change frequencies. This measure captures changes in the aggregate price flexibility that are solely due to changes in consumption. I show that during a recession the aggregate price change frequency drops on average by 0.4 basis points implying an increase in the price duration of an additional 20 days during a recession. Viewed through the lens of household data this implies that over the business cycle extensive margin consumption elasticities are relatively more important.

I provide suggestive empirical evidence that monetary policy works through extensive margin consumption. I identify policy shocks through high frequency changes in the federal funds rate in tight windows around interest rate announcements of the Federal Open Market Committee. Using the Current Population Survey I construct synthetic cohorts based on age, gender and education and calculate weighted cohort-averages of earnings and unemployment rates. As opposed to aggregate wage data this allows explicit distinction between intensive and extensive margin income changes. Panel regressions with cohort fixed effects show that a one standard deviation expansionary shock lowers the unemployment rate by 0.2 percent through increasing employment but has no significant effects on weekly labor earnings.

To gauge the implications of these findings for monetary policy I build a multi-sector New Keynesian model with non-homothetic preferences, home-production and labor market frictions. To capture intensive margin consumption changes I introduce non-homothetic preferences between necessities with a high degree of price flexibility and luxuries with sticky prices. I model non-homotheticity via additively logarithmic utility along the lines of Houthakker (1960). To capture the extensive margin consumption changes due to employment, I introduce a home-production technology for necessities. Unemployed individuals automatically produce basic goods at home. Once they switch into employment, they substitute reduced home production by increasing market purchases of necessities. I assume complete consumption insurance of individuals within a representative family to avoid modeling heterogeneity across agents due to differences in their employment status.

I use my model to derive three results. First, monetary policy is more effective in raising output but at the cost of disproportionately higher inflation compared to a standard New Keynesian model. In a standard New Keynesian model, decreases in the nominal interest rate reduce the real interest rate because of nominal rigidities. This reduces the opportunity cost of consumption and thus alters the inter-temporal trade-off for households which subsequently choose to bring consumption forward. The increased demand in turn leads to higher output, prices and employment. My model exhibits an additional demand channel through home production. The increased employment leads to a reduction in home-produced necessities which is substituted by increased market purchases. Because necessities have a higher price change frequency the overall trade-off for monetary policy is somewhat worse. A 25 basis point innovation to a typical Taylor Rule increases inflation by an additional 0.4 percentage points compared to a 0.3 percentage point increase in real output.

Second, I show that monetary policy is state-dependent. In times of high unemployment expansionary monetary policy feeds more strongly into prices compared to times of low unemployment. I compute generalized impulse response functions to a monetary policy shock at the steady state unemployment rate of 5% and compare them to impulse responses at a higher out-of-steady-state unemployment rate of 10%. Because of the larger deviation of unemployment from its natural rate stimulus policy leads to more switches into employment. As the formerly unemployed do not engage in home produc-

tion anymore they increase market demand for necessities which in turn leads producers of necessities to raise their prices. Overall the stimulus leads to a 1.2 percentage point higher annualized inflation rate with negligible additional effects on real output.

Third, I show that optimal monetary policy follows a dual mandate in inflation and unemployment. Using a Taylor rule with interest rate smoothing that reacts to inflation, real output and unemployment, I perform a numerical search over the response parameters to compute optimal welfare. In line with the literature I find that unemployment figures into an optimal monetary policy rule, albeit with a coefficient close to zero. More interestingly, I show that a typical Taylor rule reacting jointly to inflation and real GDP is suboptimal if it does not respond to deviations of unemployment from the natural rate. The weight on unemployment in such a suboptimal rule should be larger than the response coefficient for real output and is an order of magnitude larger than under the optimal policy rule.

Related Literature

This paper relates to several strands of the literature. There is a large literature estimating consumption elasticities to income changes. One strand relies on deriving and estimating demand systems to estimate price and income elasticities (Deaton et al. (1980); Taylor and Houthakker (2009); Bils and Klenow (1998)). I make use of that literature to estimate intensive margin consumption elasticities by estimating Engel curves for households without a change in employment. The more recent literature has turned to quasi-experimental evidence (Johnson et al. (2006); Parker et al. (2013)) or statistical decompositions of the income process into permanent and transitory components (Blundell et al. (2008); Arellano et al. (2017)). Interest usually lies in the excess sensitivity of consumption, e.g. upon retirement or in response to anticipated income changes, or the marginal propensities to consume out of windfall income gains, e.g. due to tax rebates.[1] I contribute to the literature by explicitly distinguishing between changes at the intensive and extensive margin. Closest in spirit to my paper is Alonso (2016), who shows that households consume more labor intensive goods upon employment. I instead focus on the degree of price flexibility of goods and do so for both, intensive and extensive margin adjustments.

My paper also relates to the literature on household production. Benhabib et al. (1991)

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[1] See Attanasio (1999) and Jappelli and Pistaferri (2010) for superb surveys of the literature.

and Greenwood and Hercowitz (1991) are amongst the first to incorporate substitutability between market and non-market work into business cycle analysis. Aguiar and Hurst (2005, 2007) use home production to rationalize the excess sensitivity of consumption upon retirement as a switch towards home production. Empirically, my paper is most closely related to Nevo and Wong (2015). Using observed shopping time behavior during the Great Recession they infer a high elasticity of substitution between market expenditures and time spent on non-market work. My extensive margin estimates are consistent with a shift towards home production when becoming unemployed. I additionally show that the decline in market purchases tends to happen for flexible price necessities. I theoretically embed these results via a home-production function but allow only a subset of goods (necessities) to be home-produced, whereas the literature considers substitutability for the entire consumption basket.

Third, there is a small but growing literature on the state-dependence of monetary policy. An older empirical literature (Weise (1999); Garcia and Schaller (2002); Peersman and Smets (2002); Lo and Piger (2005)) employs (structural) vector autoregressions with regime-switches to estimate how the effectiveness of monetary policy varies over the business cycle. Results in this literature are mixed however. In a recent paper Tenreyro and Thwaites (2016) investigate state-dependence of monetary policy via local projection and smooth transitioning methods. They find that monetary policy has larger effects during expansions than during recessions. On the theoretical side, state-dependence has largely been neglected. Vavra (2013) constitutes a notable exception by showing that firms increase the size and frequency of their price changes in times of uncertainty, which inhibits monetary policy precisely in times of need.[2] I instead focus on the household side and propose extensive margin consumption of flexible price goods as a mechanism for the varying effectiveness of monetary policy over the business cycle.[34]

Lastly, my paper relates to a vast literature on New Keynesian DSGE models. I con-

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[2]Eichenbaum et al. (2018) show the history-dependence of monetary policy. In their model people react to expansionary monetary policy by refinancing their mortgages, if the gains to do so are large enough. After a series of contractionary policy shocks, expansionary monetary policy is less effective due to low gains of refinancing compared to the earlier cycle of interest rate cuts.

[3]There is a complement literature that analyzes the state-dependence of fiscal policy. See Ramey and Zubairy (2018) and Auerbach and Gorodnichenko (2012) for recent empirical contributions and Sims and Wolff (2018b,a) for a numerical analysis within the context of an estimated medium-scale DSGE model.

[4]The fiscal theory of the price level investigates "state-dependence" of monetary policy as well. State-dependence within the context of this theory however is understood as the dependence of price level determinacy (and equilibrium existence) on the stance of fiscal policy.

tribute to this literature by implementing a more complex preference structure with non-homothetic preferences that nests household production. This structure explicitly captures intensive and extensive margin consumption responses. I model non-homotheticity as an additively logarithmic function after Pakoš (2011) and Wachter and Yogo (2010) who in turn rely on Houthakker (1960). In order to allow for extensive margin consumption through employment I incorporate labor market frictions with hiring cost in the spirit of Blanchard and Gali (2010) and Galí (2010).[5] Multi-sector extensions have been studied amongst others by Barsky et al. (2003, 2007) and Bils et al. (2003).

The paper proceeds as follows. Section 2 describes the data and estimation methodology. Section 3 documents the difference between intensive and extensive margin consumption behavior. Section 4 introduces non-homothetic preferences and home-production into a New Keynesian model. Section 5 describes the calibration. Section 6 shows the model implications for monetary policy and Section 7 concludes.

2 Measuring Intensive and Extensive Margin Consumption Elasticities

In this section I describe the data sources I employ for the empirical analysis. I also lay out the econometric approach for estimating intensive and extensive margin consumption elasticities and their relevance for monetary policy.

2.1 Data Description

Consumption Data

The Consumption Expenditure Survey (CEX) collects extensive information on the consumption expenditures of American households and is conducted as a monthly rotating panel by the Bureau of Labor Statistics (BLS). About 1,500-2,500 households are surveyed in any given month and each household is interviewed once per quarter for at most four

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[5]This approach differs from the usual search and matching approach by i) only implicitly modelling a matching function, ii) considering hiring cost instead of vacancy posting costs and iii) assuming that new hires become immediately productive. See Walsh (2005); Ravenna and Walsh (2008); Trigari (2006, 2009) and Gertler and Trigari (2009) for alternatives.

consecutive quarters.[6] Though the survey started in 1960, it is continuously available only from 1980 onwards. I therefore use all survey waves from 1980 until 2016.

The CEX collects expenditure information in two separate surveys, the interview survey and the diary survey. I restrict my analysis to the interview survey, as the diary survey focuses only on expenditures on small items such as beverages and personal care items and can not directly be linked to the expenditure data from the interview survey. I thus capture up to 95% of the typical household's consumption expenditure, including aggregated food expenditures.

Since the CEX serves as the main input into the Consumer Price Index (CPI), it records expenditures at the detailed good level. The interview surveys allow construction of 52 of the 70 good categories used in the CPI. I further aggregate these categories into 22 expenditure classes guided by the expenditure classifications of the BLS and as described in Appendix A, which also contains details on data adjustments and sample selection.

The CEX also provides detailed demographic characteristics for all household members, including age, gender, education and race. Other variables like the employment status, earnings and income are only asked in the first and fourth interview for the prior 12 months to that interview. Additionally, replication weights designed to map the CE sample into the national population are available, which I use for all calculations.

My analysis sample contains around 168000 observations for 43000 households for the intensive margin estimates and 14264 households with a change in the number of earners for estimating extensive margin elasticities. Table 1 provides summary statistics for the expenditure shares of different goods. Unsurprisingly housing (31%) and food at home (14%) are the biggest expenditure categories as measured by the CEX. The CEX however under-samples some categories because it only measures out-of-pocket expenditures, which is most notable for medical services (4% as opposed to 19% in the National Income and Product Accounts (NIPA)). For weighted regressions and correlations I thus exclusively rely on expenditure shares from NIPA.

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[6]In practice households are interviewed for up to five consecutive quarters, but the first interview is solely used for pre-sampling purposes and not available for analysis.

Measures of Price Flexibility

For my analysis I use two different measures of price flexibility. The first one measures the monthly frequency of regular (as opposed to sale-related) price changes for each expenditure category and is based on micro price data underlying the CPI. I obtain these price change frequencies from published tables by Klenow and Kryvtsov (2008) for the period 1988-1997 and from Nakamura and Steinsson (2008) for the period 1998-2005 and pool both datasets to construct average and median price change frequencies for the time period 1988-2005.[7]

Both data sets provide information on all good categories except for housing which consists of rent of renters and owner's equivalent rent. For rent that renters pay, I assume a monthly price change frequency of 1/12. This is in line with the modal long-term rental contract in the US having a minimum lease duration of one year and landlords being legally prohibited to change lease terms during a lease. For owner's equivalent rent I assume a price frequency twice as high, implying an average price duration of 6 month. This is consistent with the bi-annual survey frequency of the CPI Housing Survey conducted by the BLS to construct price indices for owner's equivalent rent. I construct a unique price change frequency for housing by weighting rent and imputed rent with their respective expenditure share from NIPA.[8]

The second measure relies on the cyclicality of good-specific price indices. In particular, following Bils et al. (2013) I estimate

$$\log\left(\frac{P_{ct}}{P_t}\right) = \alpha + \beta \cdot \log\left(\frac{Y_t}{P_t}\right) + \nu_t \tag{2.1}$$

regressing quarterly (hp-filtered) log relative prices on quarterly (hp-filtered) real GDP. The idea behind this measure is that flexible price goods vary more (relative to the overall

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[7]While there have been methodological changes in the construction of the CPI in 1998, both datasets provide data at the ELI-level so that I can construct price change measures according to my definition of expenditure categories.

[8]In an exercise similar to mine, Bils et al. (2013) estimate Engel curves for residential structures and derive a much higher price change frequency of 0.733 based on assumptions about the price change frequency for build-to-order and built-to-stock houses. I deviate from their measure because residential structures rather constitute an investment decision, whereas my focus lies on the consumption component of housing, i.e. rent or imputed rent. My measure is nevertheless consistent with their observation that a built-to-stock house has a median availability of five month on the housing market. Additionally, the assumptions I make imply a ranking that is conforming to the one provided by the second price flexibility measure.

price level) over the business cycle and thus have a larger regression coefficient. Goods with rather inflexible prices have instead smaller or negative coefficients. For relative prices I use the good-specific price indices from NIPA divided by the GDP deflator but show that results are robust to using price indices from the CPI.[9]

Using different measures of price flexibility provides a good robustness check. Table 1 tabulates price change frequencies and price cyclicalities for each good. The expenditure-weighted correlation between both measures is around 0.7 as shown in the left panel of figure 1. The right panel however shows that this is sensitive to the inclusion of gasoline as the most flexible price category. Exclusion leads to lower correlations of 0.36 when using price indices from NIPA and 0.48 for CPI price indices. The biggest difference between the two measures occurs for household utilities. Utilities have the second highest price change frequency but a price cyclicality only slightly above average. Excluding gasoline and utilities jointly yields correlations around 0.5.[10]

Labor Market Data

I use data on labor market outcomes from the Current Population Survey (CPS) to assess the relative importance of intensive and extensive margins for monetary policy. The CPS is a monthly survey and has been conducted by the Census Bureau since 1940. It contains information on the labor force status, working hours, earnings and demographics on about 94000 persons. I rely on the monthly basic files from 1990 to 2007 and restrict the sample to people aged 25-65 not related to the agricultural or armed forces sector.

Because of the survey design of the CPS I rely on pseudo-panel analysis of synthetic cohorts instead of using the individual-level panel data directly.[11] The CPS interviews each household for four consecutive months, then drops it for 8 month and starts interviewing it again for another four consecutive month exactly one year after the first interview. Though cost efficient this makes panel analysis difficult. Because monetary policy usually operates with a time-lag, its effects are likely to set in when individuals are out

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[9]I also check that different filtering methods for the price cyclicality measure, such as the band-pass filter of Baxter-King and Christiano-Fitzgerald als well as quadratic and cubic detrending, do not substantially alter my results.

[10]The correlation between average and median price change frequencies for the pooled period 1988-2005 is 0.99 (not shown). The correlation between the Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008) dataset is 0.94 for the average and 0.87 for the median price change frequency.

[11]This also avoids attrition bias and reduces measurement error.

of the panel. Following Wong (2015) I therefore construct synthetic age-education-gender cohorts with ten year age brackets and three different education levels (less than high school, high school and some college, college and higher education). This guarantees a sufficient number of observations within each cohort.[12] I use labor earnings and within cohort (un-)employment rates as outcome variables and construct them as weighted averages of the persons within a cohort.

Identified Monetary Policy Shocks

In order to estimate labor market responses to monetary policy I rely on policy shocks identified through high-frequency changes of the Federal Funds (FF) futures. FF futures contracts have been traded since 1989. The rate on a futures contract for a particular month reflects expectations on the average effective FF Rate that will prevail during that month. It thus provides a market-based measure of the anticipated path of the FF Rate.

The Federal Reserve announces changes of the FF Rate through regularly scheduled Federal Open Market Committee (FOMC) meetings or at inter-meeting announcements outside of the regular schedule. I obtain times and dates of FOMC and inter-meeting press releases as well as data on Federal Funds Futures rates through Gorodnichenko and Weber (2016), Gurkaynak et al. (2004) and the Federal Reserve Board website.

To identify exogenous changes in monetary policy I rely on changes in the traded rate of the FF futures in a narrow window around these FOMC announcements as a measure of unanticipated changes in the FF Rate. In particular, I define the monetary policy shock at FOMC date t as

$$\epsilon_t = \frac{D}{D-T}(ffr_{t+\Delta^+} - ffr_{t-\Delta^-})$$

where $ffr_{t+\Delta^+}$ is the FF futures rate Δ^+ minutes after the FOMC press release. Following the literature I consider a 60 minute window around the FOMC announcement that starts $\Delta^- = 15$ minutes before the announcement and ends $\Delta^+ = 45$ minutes after. D is the number of days in the month of the announcement and $D/(D-t)$ is an adjustment term.[13] The identifying assumption for exogeneity is that during the narrow window

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[12]The minimum number of individuals in each cohort is 1293 with an average number of 7890.

[13]This adjustment term takes into account that a FF future contract for a particular month trades on the average effective overnight Federal Funds Rate anticipated for the entire month. FOMC announcements however usually happen during a month and not at the beginning.

around the announcement there are no other relevant shocks (e.g. financial, news or risk premium shocks) moving the FF futures rate.

To get a quarterly measure of monetary policy shocks I sum the identified shocks as in Wong (2015). I observe 72 estimated quarterly shocks between 1990 and 2007. 43 are expansionary and 24 are contractionary. The average shock is roughly zero with a standard deviation of 12 basis points. The largest expansionary shock of 48 basis points occurred in the fourth quarter of 1991.

2.2 Econometric Methodology

Estimating Intensive Margin Consumption responses

In order to estimate consumption responses to intensive margin income increases I use the expenditure data from the CEX. I estimate log-linear approximations to the Engel curves, which characterize how household expenditures on a good vary with household income.[14] I gauge income elasticities for each good c via the following regression:

$$y_{cht} = \alpha_{ct} + \alpha_{ch} + \beta_c^i \cdot \log(C_{ht}) + \gamma_c X_{ht} + \nu_{cht} \tag{2.2}$$

where y_{cht} is the expenditure of household h in time t on good c, α_{ct} are good-time specific fixed effects, α_{ch} are good-household specific fixed effects, C_{ht} are household total expenditures and X_{ht} are demographic controls including family size and family composition, e.g the number of children, number of person greater than 64, age, gender, race, education and marital status of the household head.

The parameter of interest is β_c^i which measures the expenditure elasticity of good c with respect to an increase in (permanent) household income.[15] I undertake the following steps to assure that β_c^i indeed measures a consumption response due to an intensive margin income increase. First, household fixed effects ensure that unobserved, time-invariant

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[14]As Deaton et al. (1980) show, log-linear approximations to the Engel curves do not satisfy the "adding up" constraint globally, i.e. Engel curves cannot be log-linear globally unless all elasticities are one. This means that for a given log change in total expenditure the predicted good-specific expenditure elasticities do not necessarily add up to the assumed change in total expenditure. However, virtually all demand systems neglect this issue of global consistency. I provide evidence in the results section that the log-linear functional form employed here is a sufficiently good approximation.

[15]As is standard in the literature I use total consumption as a proxy for permanent income, which is the relevant margin for household decision making as opposed to disposable or current income. Additionally, the CEX surveys current household income only in the first and fourth interview.

household characteristics do not contribute to the identification of β_c^i. Second, including household demographics controls for variation in expenditures that are purely due to changes in household composition. For example children switching from high school to college but remaining in the household are fully taken account of. Third, I select the sample such that I include only households that do not change in size or the number of earners and for which the employment status of the household head and the spouse does not change, thus ensuring absence of any extensive margin adjustments.

One complication in the estimation of (2.2) arises for cases, where household expenditures on a particular good are zero, rendering a log-log specification inappropriate. I follow the literature (e.g. Bils and Klenow (1998), Aguiar and Bils (2015)) and replace good-specific expenditures with the gross percentage deviation from average household expenditure on that good in that quarter: $\tilde{y}_{cht} = y_{cht}/\bar{y}_{ct}$.[16]

A second concern is that measurement error of individual good expenditures is accumulated into total expenditures. This could introduce correlation between the error term v_{cht} and the regressor of interest, $\log(C_{ht})$, and thus potentially bias estimates. A standard technique is to instrument total expenditures with income and other proxies of total expenditures. I follow Bils et al. (2013) and add expenditures for the second to fourth interview and estimate (2.2) by instrumenting $\log(C_{ht})$ with total expenditures from the second interview. This strategy exploits the fact that total expenditures are based on permanent income and hence are strongly correlated over time, thus satisfying the relevance condition.[17]

Finally, (relative) prices do not enter the estimation of equation (2.2). To the degree that relative price movements are common across all households, they will be absorbed by time fixed effects. Recent research however has shown that households potentially face different relative prices based on shopping behavior and quality choices.[18] Due to the lack of household level price data in the CEX, I therefore rely on the additional identifying assumption that relative price movements are common across households.

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[16]Because of concerns that households with large deviations may influence the estimation I check and report results for the log-specification as well.

[17]Additionally, all results are robust to instrumenting with labor income, total before- or after-tax income and using total expenditures and income as joint instruments.

[18]See e.g. Kaplan and Schulhofer-Wohl (2017) and Nevo and Wong (2015).

Estimating Extensive Margin Consumption responses

I estimate extensive margin consumption responses by exploiting the panel dimension of the CEX. In particular I use within-household variation to identify the expenditure responses to switches into and out of employment. For each consumption category c I separately estimate the following regression:

$$y_{cht} = \alpha_{ch} + \alpha_{ct} + \beta_c^e \cdot \#\text{Earners}_{ht} + \gamma_c X_{ht} + \nu_{cht} \tag{2.3}$$

where y_{cht} is the expenditure on good c by household h at time t, α_{ch} and α_{ct} are good-specific household and time fixed effects, $\#\text{Earners}_{ht}$ is the number of earners in the household and X_{ht} are demographic controls such as age, education, sex and gender of the household head, family size, marital status and the number of persons below 18. I again approximate good-specific expenditures with the gross percentage deviation from average household expenditure on that good as $\tilde{y}_{cht} = y_{cht}/\bar{y}_{ct}$.

The parameter of interest β_c^e measures the average expenditure response of good c to a change in the number of earners in a household. Household fixed effects control for any time-invariant household characteristics. This ensures that β_c is identified only from those households, for which at least one household members switches into or out of employment. Time fixed effects control for any seasonality, business cycle variation or long-term trends affecting expenditure patterns similarly across all households. Household demographic controls account for predictable expenditure changes due to variations in household composition. By estimating (2.3) I implicitly assume that consumption responses upon employment are symmetric to those upon unemployment. Appendix table B.2 shows that this is a reasonable assumption as elasticities are fairly symmetric.

For robustness checks I also rely on the employment status of the household head (see Appendix B). I define employment as a positive number of weeks worked in the 12 month prior to the interview. However, the CEX only asks information on the employment status in the first and fourth interview. The considerably lower sample size (2614 households) makes the number of earners (14264 households) therefore my preferred measure.

Correlating Consumption Elasticities and Price Flexibility

I combine the good-specific estimates of intensive and extensive margin consumption elasticities with my price flexibility measures. To gauge statistical significance I estimate the regression

$$\text{Elasticity}_c = \alpha + \beta \cdot \text{Price Flexibility}_c + \nu \tag{2.4}$$

where $\textit{Elasticity}_c \in \{\beta_c^i, \beta_c^e\}$ is the good-specific intensive or extensive margin elasticities estimated from (2.2) and (2.3) respectively. $\textit{Price Flexibility}_c$ in turn is either the monthly price change frequency or the price cyclicality of good c.

Estimating labor market responses to monetary policy

I estimate responses of labor market outcomes to identified monetary policy shocks in order to gauge the relative importance of intensive and extensive margin consumption for monetary policy. I use the synthetic cohort data constructed from the CPS together with the identified monetary policy shocks and estimate impulse responses via regressions of the form:

$$\Delta y_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k \cdot \epsilon_{t-k}^- + \sum_{k=1}^{K} \gamma_k \cdot \varepsilon_{t-k}^+ + \lambda_{s(t)} + \nu_{it} \tag{2.5}$$

where Δy_{it} is the change for cohort i in quarter t of either (i) real log weekly earnings, (ii) log hourly earnings, (iii) the cohort unemployment rate defined as unemployed over the labor force (sum of unemployed and employed) or (iv) the cohort employment rate defined as the number of employed over the sum of people in and out of the labor force, excluding retirees and disabled. α_i are age-gender-education (i.e. cohort) fixed effects, $\lambda_{s(t)}$ denotes seasonality fixed effects and $\epsilon_t^- = \min(\epsilon_t, 0)$ and $\epsilon_t^+ = \max(0, \epsilon_t)$ denote expansionary and contractionary shocks respectively.

The regression coefficients β_k and γ_k estimate the change of the outcome variable in period $t + k$ due to an expansionary or contractionary shock in period t. The elasticity T periods after an expansionary shock is then given by

$$\frac{\partial y_{it+k}}{\partial \epsilon_t^-} = \sum_{k=1}^{T} \frac{\partial \Delta y_{it+k}}{\partial \epsilon_t^-} = \sum_{k=1}^{T} \beta_k \tag{2.6}$$

with a similar expression for the impulse response to a contractionary shock.

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I separate monetary policy shocks into expansionary and contractionary shocks in order to allow for differential effects of labor market outcomes. Such asymmetric effects can arise for a number of potential mechanisms, for example downward sticky wages or because people asymmetrically change their labor market status between employed, unemployed and out of the labor force.

Regression (2.5) provides suggestive evidence but is not comprehensive. Changes in cohort unemployment rates do capture the extensive margin. The intensive margin consumption estimates in (2.2) however are estimated through changes in permanent income of which labor earnings are a major - but not the sole - component. Recent research on monetary policy transmission has established the additional importance of wealth gains through house and asset price changes as well as mortgage refinancing. Since all these channels affect permanent income I abstain from any back-of-the-envelope calculations to infer the relative importance of intensive margin consumption through labor earnings.

3   Empirical Results

In this section I establish four main empirical facts: (i) in response to intensive margin income increases households consume disproportionally more sticky price goods (ii) upon employment households disproportionally increase consumption in flexible price goods (iii) these effects are visible and do not wash out at the aggregate level (iv) monetary policy stimulus seems to work almost solely through the extensive margin.

3.1   Intensive Margin Consumption Response

Intensive margin consumption elasticities vary widely. Table 2 summarizes the estimated Engel elasticities which range from necessities with low income elasticities like gasoline (0.476) and utilities (0.518) to luxuries with high income elasticities like durables (1.665) and jewelry (1.949) In line with previous research I find that housing exhibits a near-unit elasticity. All estimated coefficients are all highly statistically significant. Furthermore the expenditure-weighted average elasticity is close to one (0.96), which alleviates concerns about the potential inaccuracy of the log-linear approximation to the Engel curves.[19]

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[19]I exclude tobacco from all regressions as it constitutes the only inferior good with a negative elasticity.

Households disproportionately spend income increases on goods with sticky prices. Panel a) of figure 2 graphically shows that intensive margin consumption elasticities are strongly negatively correlated with the average price change frequency of a good. Using expenditure shares according to NIPA the weighted correlation coefficient is -0.49. Luxuries (dark blue) have a lower average price change frequency of 8 percent per month compared to 18 percent for necessities (light blue).[20] Excluding public transportation as an obvious outlier raises the correlation to -0.55.[21]

The result is not solely driven by gasoline, utilities and purchases of new and used cars - the three good categories with the highest price flexibility. Excluding all three still yields a remarkably negative correlation of -0.38. Additionally, panel b) shows a similarly negative correlation of -0.4 when using price cyclicality from aggregate data as a price flexibility measure. Again excluding gasoline still yields a comparably negative correlation of -0.36.

The negative correlation between intensive margin consumption elasticities and the average price change frequency of a good is robust to sample selection and different price flexibility measures. Table 3 shows that restricting the sample to households with a male head (column 2) or increasing the age range to households between 20 and 65 (column 3) leaves results virtually unchanged. Weighting the regression with the expenditure shares observed in the CEX (column 4) strengthens results. Due to a higher weight on housing, utilities and food at home the correlation increases to -0.53. Column (5) checks that deflating expenditure categories by their good-specific price index does not change results. The last column (6) shows that results are robust when using a log-specification for the outcome variable. Panel b) of table 3 shows that using the median instead of the average price change frequency yields very similar results. Panel d) confirms that measuring price cyclicality via CPI price indices yields similar results to using price indices from NIPA.

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[20]These price change frequencies imply average price durations of 12.5 month for luxuries and 5.5 month for basic goods. The median price change frequencies are 6.4 and 14.5 percent respectively, implying durations of 15.6 and 6.9 month.

[21]Besides inter-city train and intra-city bus and taxi fares, public transportation also contains airline and water travel and hence partially incorporates a recreation component.

3.2 Extensive Margin Consumption Response

Extensive margin consumption elasticities exhibit pronounced heterogeneity. Table 2 shows that expenditures increase the most for purchases of new and used cars (.079), vehicle maintenance (.066), gasoline (.046) and TV and audio recreation (.054). At the other end households decrease expenditures on personal services such as legal, accounting and business services (-0.11), educational goods (-0.10), educational services (-.039) and information equipment (-.039) when becoming employed.

When switching to employment, households disproportionately increase consumption of goods with more flexible prices. Panel a) of figure 3 graphically shows that extensive margin consumption elasticities are positively correlated with the frequency of price changes. The expenditure-weighted correlation coefficient is 0.36 and thus opposite to the observed negative correlation for intensive margin elasticities. Excluding gasoline as a potential outlier still yields a reasonable, albeit weaker correlation of 0.31. The price cyclicality measure yields a stronger correlation of 0.44 which increases to 0.5 when excluding expenditures on gasoline.

Most of the consumption increase is due to increased consumption of necessities (light blue). Figure 3 shows that the four goods with the highest extensive margin elasticity are all basic goods. Additionally, all consumption elasticities for basic goods are positive, except for educational goods with a negligible expenditure share of 0.2%. The average extensive margin elasticity is 3% for basic goods but close to zero for luxuries.[22] Figure 4 provides a graphical representation on the statistical significance of the estimates. Whereas seven out of ten elasticities for necessities are statistically significant (treating housing as a near-unit elastic good), only four out of eleven coefficients for luxury goods are significant. Setting the elasticity estimate to zero for goods with p-values higher than 0.1 increases the expenditure-weighted correlation to 0.42 for the price change measure and 0.47 for the price cyclicality measure.

The positive correlation between extensive margin consumption and the price flexibility of a good is robust to sample selection and the specific price measure. Table 4 shows

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[22]The overall extensive margin elasticity is around 1.6% which is somewhat lower than the estimated 2.5% in Alonso (2016) using the same dataset. These differences are likely due to differing definitions of good-categories as well as different measures of employment. Other research on the consumption effects of (un-)employment are rather scarce. Christelis et al. (2014) for example estimate negative consumption effects of unemployment of around 10%, but do so for a sample of people aged 50 or above during the Great Recession.

the same robustness checks as for the intensive margin estimates. Reassuringly, the results barely change when considering only male heads (column 2), which is a commonly used sample restriction to capture households with a strong attachment to the labor force. Increasing the age range of households (column 3), weighting the correlation regression with expenditure shares from the CEX directly (column 4) or using good specific deflators (column 5) influences results very little. The only exception is the log-log specification (column 6) which yields still positive but weak correlations around 0.15 for the price change measure and around 0.2-0.3 for the price cyclicality measure. Appendix table B.1 additionally establishes robustness to using the employment status of household heads as a measure of employment. The correlation is again positive around 0.3 for both measures and above 0.4 when excluding gasoline.

One potential concern is the endogeneity of switches to employment. In particular the decrease in expenditures for personal services and educational goods and services could be interpreted as the first-time transition of household members into the labor market. To the degree that I control for household composition and restrict the sample to households aged 25 and older - an age well above most first-time transitions into the labor market - such an interpretation is unlikely.[23] A much more plausible interpretation is, that educational and personal expenditures are necessary to increase the likelihood of employment and are cut back once a job opportunity arises.

3.3   Aggregate Evidence

I construct a measure of aggregate price flexibility as the expenditure-weighted sum of (the good-specific) average price change frequencies. This allows me to check whether the consumption patterns observed at the household level matter in the aggregate. By construction this measure is purely composition-based. An increase indicates that aggregate consumption of flexible price goods has increased. However it does not necessarily imply, that price stickiness in the economy has generally increased as the measure does not take into account potential changes of the good-specific price change frequencies.[24]

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[23]Additionally, the robustness checks do not indicate any sensitivity to sample selection, e.g. by including people aged between 20 and 25 or restricting to male heads, which have a higher attachment to the labor force.

[24]Vavra (2013) shows that firms reset their prices more often during times of economic uncertainty, which potentially are correlated with business cycle downturns. My measure can be understood as a

The household level evidence from the previous two sections is reflected in the aggregate level as well. Panel a) of figure 5 shows that (hp-filtered) real GDP and the (hp-filtered) aggregate price flexibility comoves positively with a contemporaneous correlation of 0.5. The comovement is especially visible during recessions when the price change frequency drops by approximately 0.5 percentage points (peak to trough). This translate into a 2.9 percent increase in the degree of aggregate price stickiness.[25] During the financial crisis aggregate price flexibility dropped by 5.7 percent. Compared to an average price duration of 5.7 month, this implies a duration increase of 1.7 month (annualized) purely due to changes in consumption expenditures.

When the unemployment rate increases, the aggregate price flexibility goes down as shown in panel b). Once the economy exits a recession, aggregate price flexibility increases as well. Interestingly this increase exhibits pronounced dips well into the business cycle (visible e.g. around 1998 and 2006), where aggregate price flexibility temporarily decreases. Viewed through the household-level evidence from the previous section, this is consistent with extensive margin consumption of flexible price goods being more important immediately after a recession and intensive margin consumption of sticky price goods increasing in importance throughout the business cycle.

The expenditure-weighted price change frequency also closely comoves and precedes changes in the GDP deflator. While the contemporaneous correlation is only around 0.33, a two-quarter lead has a correlation of 0.55 with the GDP deflator. Consumption composition changes thus seem to be important for economic activity as well as observed aggregate price patterns.

3.4   Implications for Monetary Policy

Monetary policy shocks have a pronounced effect on unemployment rates. A one-standard deviation expansionary monetary policy shock decreases the unemployment rate by 0.2 percent after 3-4 quarters as shown in figure 6. Although evidence on the labor market effects of monetary policy is scarce, these estimates are in line with evidence from for

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consumption-based counterpart that indicates in which direction consumption patterns affect economy-wide price stickiness over the business cycle.

[25]The aggregate average price change frequency is around 17.5 percent, implying an average price duration of 5.7 month. A 0.5 percentage point decrease translates into an annualized increase of the price duration of 0.75 month.

Swedish data by Alexius and Holmlund (2007). Contractionary shocks are mostly insignificant. This is likely due to the lower number of observed contractionary shocks in my data, as I observe twice as many expansionary (43) than contractionary shocks (24).

Changes in the unemployment rate are due to increased employment as opposed to changes in the size of the labor force. Figure 6 shows responses of the employment rate defined as fraction of people employed over those able to work (but not necessarily in the labor force). A one-standard deviation expansionary monetary policy shock increases the employment rate by 0.3 percent after 3-4 quarters. Contractionary shocks seem to have little effect initially but reduce the employment rate eventually by 0.4 percent after five quarters. Together with the insignificant effect for the unemployment rate this implies that in response to a contractionary shock people mostly switch out of the labor force.

Monetary policy seems to have little effect on earnings. Figure 7 shows that expansionary shocks lead to an initial (though statistically insignificant) increase in real log earnings of around 0.1 percent. The impulse responses for hourly and weekly earnings are however surprisingly flat indicating little overall effects. Contractionary shocks decrease hourly earnings by 0.6 percent after four quarters indicating some initial wage rigidity. The insignificant response of weekly earnings however suggest that this is compensated through working more hours, implying little overall change in total labor income.[26]

The intensive margin impulse responses have to be interpreted cautiously. Because earnings information in the CPS is only available for the outgoing rotation groups, the sample size is only one fourth of the sample for extensive margin estimates. This is clearly visible in the wider confidence intervals in particular for expansionary shocks. With this caveat in mind, this section provides suggestive evidence that monetary policy works rather through extensive than intensive margin consumption.

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[26]Indeed, the CPS constructs weekly earnings as the number of hours worked times hourly earnings. Because not all workers are paid an hourly rate, the sample of observations for weekly earnings is larger (on average 1456 individuals per cohort) and thus more reliable than the one for hourly earnings (816 individuals per cohort).

4 A New-Keynesian Model with non-homothetic preferences, home production and unemployment

In this section I develop a New Keynesian model that explicitly incorporates intensive and extensive margin consumption elasticities. I use the model to study the implications for monetary policy transmission and the trade-off between inflation and output-stabilization.

4.1 Main Components

The model integrates four features into an otherwise standard New Keynesian model: Non-homothetic preferences and home-production at the household level, search and matching frictions at the intermediate firm level and heterogeneous pricing frictions at the retail sectors.

An infinitely lived representative household consists of a continuum of individuals. Each individual can either be employed or unemployed. The household completely insures its members against the idiosyncratic risk from unemployment. Preferences over basic and luxury consumption are non-homothetic and follow an additively logarithmic specification, capturing the intensive margin response. Luxury consumption can only be acquired on the market but basic consumption can also be obtained through household production of unemployed members, hence capturing the extensive margin.

The production side follows a two-tiered structure. Final consumption goods are produced by sector-specific, monopolistically competitive retail firms. Retail firms face Calvo-frictions in price adjustment which differ across sectors, with basic goods having more flexible prices. In order to produce, retail firms rely on a (single) intermediate good from intermediate firms as a production input.[27] Intermediate firms are perfectly competitive and recruit workers in a frictional labor market.[28] I follow a slightly modified search and matching framework by imposing hiring costs (instead of vacancy posting costs) where new workers become immediately productive. Wages are determined through

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[27]This is isomorphic to assuming that each retail sector relies on a sector-specific intermediate input, as long as labor is perfectly mobile across intermediate sectors.

[28]The two-tiered structure avoids the difficulties associated with having price setting decisions and wage bargaining concentrated in the same firm. See Kuester (2007); Thomas (2011) or Furlanetto et al. (2018) for models where price setters are subject to labor market frictions.

period-by-period Nash bargaining which directly takes place between household members and intermediate firms.

4.2 Households

There is a large number of identical households with a continuum of members represented by the unit interval. In equilibrium some members are unemployed while others work. Following Merz (1995) and Andolfatto (1996) I assume complete consumption insurance against idiosyncratic income risk from unemployment.

The household seeks to maximize the objective function

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{V(C_{Bt}, C_{Lt})^{1-\sigma}}{1-\sigma} - \chi \frac{N_t^{1+\varphi}}{1+\varphi} \right) \tag{4.1}$$

where V_t is an intra-temporal consumption aggregator of basic and luxury consumption, C_{Bt} and C_{Lt} respectively. $N_t \in (0,1)$ is the fraction of employed household members, $\beta \in [0,1]$ is the discount factor, $1/\sigma$ is the elasticity of inter-temporal substitution,[29] χ is a scaling parameter for disutility of work and φ is the inverse Frisch elasticity of labor supply.

The period utility function for consumption is given by an additively logarithmic (add-dilog) specification of the form

$$V(C_{Bt}, C_{Lt}) = \left(C_{Bt}^{1-\lambda} + \frac{\eta(1-\lambda)}{1-\phi} C_{Lt}^{1-\phi} \right)^{1/(1-\lambda)} \tag{4.2}$$

where λ and ϕ are curvature parameters and η governs the relative expenditure share. The specification nests a standard homothetic CES aggregator as a special case for $\lambda = \phi$, which implies that relative consumption between basic goods and luxuries depends only on relative prices. This functional form follows Pakoš (2011) and Wachter and Yogo (2010) and allows for a tractable parametric model of non-homotheticity along the line of Houthakker (1960).[30] Appendix C on the calibration shows how the parameters are re-

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[29]More precisely, the relative risk aversion σ (i.e. the inverse inter-temporal elasticity) is decreasing in income and can be shown to approach $\varpi \equiv (\sigma(1-\phi)+\phi-\lambda)/(1-\lambda) < \sigma$ in the limit. However, since I set $\sigma = 1$ in my baseline calibration, I shut down any time variation in the inter-temporal elasticity.

[30]Further applications can be found in Deaton et al. (1980); Bils and Klenow (1998); Campanale (2015) and Taylor and Houthakker (2009) for analyzing consumption behavior, and in Ait-Sahalia et al. (2004) which analyze portfolio choices, as do Pakoš (2011) and Wachter and Yogo (2010).

lated to the intra-temporal elasticity of substitution, income elasticities and expenditures shares.[31]

I assume that luxury consumption can only be obtained through market purchases of luxury goods (i.e. formally $C_{Lt} = X_{Lt}$). Basic consumption however can either be obtained through market purchases X_{Bt} or through home-production by unemployed household members. Basic consumption is thus an aggregate with assumed functional form

$$C_{Bt} = \left(X_{Bt}^{\rho} + \psi(1 - N_t)^{\rho}\right)^{1/\rho} \tag{4.3}$$

where ψ and ρ govern how the expenditure bundle of the household changes upon employment. In particular, if $\psi = 0$, there is no home-production and households obtain both goods only through market purchases. For $\psi > 0$ households home-produce some of the basic goods. Implicit in the above formulation is the assumption that all unemployed members automatically devote their time to the home-production of basic consumption.

Employment N_t evolves over time according to

$$N_t = (1 - \delta)N_{t-1} + x_t U_t^0 \tag{4.4}$$

where δ is an exogenously given constant separation rate and $x_t \equiv H_t / U_t^0$ is the job finding rate, defined as the number of hires H_t during period t over the fraction U_t^0 of household members that are unemployed at the *beginning* of period t. I assume that household members individually search for jobs and directly interact with intermediate firms on the labor market so that employment is not a choice of the representative household. The number of members looking for a job at the beginning of t is given by those that have been unsuccessfully looking for a job in $t - 1$ and those that separated from their job at the beginning of period t

$$U_t^0 = 1 - N_{t-1} + \delta N_{t-1} = 1 - (1 - \delta)N_{t-1}. \tag{4.5}$$

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[31]A popular approach of introducing non-homothetic preferences is via Stone-Geary utility with subsistence-level consumption. This utility however implies non-homotheticity only close to the subsistence point. For high enough consumption, income elasticities are close to one as in the typical CES specification. Recent research has started to use non-homothetic CES preferences (see e.g. Comin et al. (2015) and Bertoletti et al. (2018)). While this preference structures provides neat analytical properties for own-, cross- and income elasticities, it requires defining the utility function indirectly. Cavallari (2018) achieves non-homotheticity through a functional form assumption for aggregate consumption which however requires symmetry in the consumption of individual goods.

Equation (4.4) implies that current hires become immediately productive.[32] I assume that unemployed members passively search for work and hence don't explicitly model labor market participation. The participation decision however is implicitly captured by the trade-off between the wage of an available job and the marginal cost to the household. Note that unemployment at t is given by $U_t = (1 - x_t)U_t^0$.

The household faces a standard budget constraint given by

$$P_{Bt}X_{Bt} + P_{Lt}C_{Lt} + Q_tB_t = \int_0^1 W_t(j)n_t(j)dj + B_{t-1} + \Phi_t + T_t \tag{4.6}$$

where B_t is a nominal, risk-free, one-period government bond available at price Q_t. $W_t(j)$ is the individual wage that an employed member receives when working for an intermediate firm[33], $\Phi_t = \sum_s \Phi_{st}$ denotes the sum of sectoral profits Φ_{st} remitted by retail firms in sector $s \in \{B, L\}$ and T_t are lump-sump taxes. As usual, the household faces a solvency condition which prevents it from engaging in Ponzi schemes.

Using (4.2) directly in the household objective function (4.1) and using μ_1 and μ_2 as Lagrange multipliers for the budget constraint and the household production function respectively, one can derive the first order conditions (FOC) for the household problem. Combining FOCs for C_{Bt} and C_{Lt} yields an expression for the marginal rate of substitution between basic and luxury consumption given by

$$\frac{\partial V_t/\partial C_{Bt}}{\partial V_t/\partial C_{Lt}} = \frac{\mu_{2t}}{\mu_{1t}}\frac{1}{P_{Lt}} = \frac{C_{Bt}^{-\lambda}}{\eta C_{Lt}^{-\phi}}. \tag{4.7}$$

The FOC for market purchases of the basic consumption good, X_{Bt} combined with the FOC for basic consumption, C_{Bt}, yields

$$\frac{P_{Bt}}{P_{Lt}} = \left(\frac{X_{Bt}}{C_{Bt}}\right)^{\rho-1}\frac{C_{Bt}^{-\lambda}}{\eta C_{Lt}^{-\phi}} \tag{4.8}$$

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[32]This differs from the standard search-and-matching framework where new hires become productive in $t+1$ after a vacancy was posted (and a match occurred) in period t. However it is in line with the bulk of the business cycle literature, where employment is assumed to be a non-predetermined variable and hence allowed to react contemporaneously to shocks.

[33]As shown below, in equilibrium each employed member receives the same wage $W_t(j) = W_t$ so that $\int_0^1 W_t(j)n_t(j)dj = W_tN_t$

and the inter-temporal optimality condition is given by

$$Q_t = \beta E_t \left\{ \frac{\mu_{1t+1}}{\mu_{1t}} \right\} = \beta E_t \left\{ \left(\frac{V(C_{Bt+1}, C_{Lt+1})}{V(C_{Bt}, C_{Lt})} \right)^{\lambda-\sigma} \left(\frac{C_{Lt+1}}{C_{Lt}} \right)^{-\phi} \frac{P_{Lt}}{P_{Lt+1}} \right\}. \tag{4.9}$$

Employment and wages are bargained bilaterally between individual members and intermediate firms so that employment N_t is not part of the representative household's choice set. It is however useful to derive an expression for the opportunity cost to the representative household of an additional employed household member. This marginal rate of substitution between employment and unemployment is given by

$$MRS_t = \frac{P_{Lt}}{\eta C_{Lt}^{-\phi}} \left[\chi N_t^{\varphi} V(C_{Bt}, C_{Lt})^{\sigma-\lambda} + C_{Bt}^{-\lambda} \psi \left(\frac{1 - N_t}{C_{Bt}} \right)^{\rho-1} \right] \tag{4.10}$$

and consists of two components both evaluated in terms of luxury consumption. The first term describes the household disutility from working and the second term denotes the cost from decreased home production due to a decrease in the number of unemployed members working at home.

4.3 Retail Firms

There is a separate retail sector for basic goods and luxuries and output of sector $s \in \{B, L\}$ is determined by the aggregation technology $Y_{st} = \left[\int Y_{st}(j)^{(\epsilon-1)/\epsilon} d(j) \right]^{\epsilon/(\epsilon-1)}$, where ϵ measures the elasticity of substitution between individually differentiated goods and is equal across sectors. This leads to a standard demand curve for output of retail firm j given by $Y_{st}(j) = (P_{st}(j)/P_{st})^{\epsilon} Y_{st}$ with sectoral price levels $P_{st} = \left[\int P_{st}(j)^{1-\epsilon} dj \right]^{1/(1-\epsilon)}$.

Each retail firm j produces output according to the identical technology $Y_{st}(j) = M_{st}(j)$, where $M_{st}(j)$ is the quantity of the (single) intermediate good used as an input bought at price P_t^I. Retail firms in each sector are monopolistically competitive and face sector-dependent price-setting frictions as in Calvo (1983) so that a retail firm is able to adjust its price each period only with probability $1 - \theta_s$. Nominal profits of firm j in period $t + k$ given that it has not reset its price $P_{st}(j)$ chosen at t are given by

$\Phi_{st,t+k}(j) = P_{st}(j)Y_{st,t+k}(j) - P^I_{t+k}M_{st,t+k}(j).$[34] The firm thus chooses its price to maximize

$$E_t \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} Y_{t,t+k}(j) \left[P_{st}(j) - P^I_{t+k} \right]$$

where $Q_{t,t+k} = \prod_{s=1}^{k} Q_{t+s-1,t+s} = \beta^k \mu_{1t+k}/\mu_{1t}$ is the stochastic discount factor for nominal payoffs. The above formulation is similar to the standard New Keynesian model with marginal costs being equal to the price of the intermediate good. However due to labor market frictions the price of the intermediate good in this model will be different from the usual marginal cost.

The optimal price given by the first order condition is

$$P^*_{st}(j) = \frac{\epsilon}{\epsilon - 1} E_t \left\{ \frac{\sum_{k=0}^{\infty} \theta_s^k Q_{t,t+k} Y_{st+k} P^\epsilon_{st+k} P^I_{t+k}}{\sum_{k=0}^{\infty} \theta_s^k Q_{t,t+k} Y_{st+k} P^\epsilon_{st+k}} \right\}. \tag{4.11}$$

The price level in sector s is given by

$$P_{st} = \left[\theta_s P^{1-\epsilon}_{st-1} + (1 - \theta_s) P^{*1-\epsilon}_{st} \right]^{\frac{1}{1-\epsilon}}. \tag{4.12}$$

since all retail firms in a given sector reset to the same price, i.e. the right hand side in equation (4.11) does not depend on j.

4.4 Intermediate Firms

The intermediate good is produced by a continuum of identical, perfectly competitive firms, represented by the unit interval and indexed by $i \in [0,1]$. All intermediate firms have access to a production function

$$Y^I_t(i) = A_t N_t(i)^{1-\alpha} \tag{4.13}$$

where A_t represents the aggregate state of technology, which is common across firms and follows an exogenous process $ln A_t = \rho_a ln A_{t-1} + \varepsilon_{at}$ with $\varepsilon_a \sim N(0, \sigma_a^2)$.

Each intermediate firm is a multi-worker firm and its employment evolves according

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[34]$Y_{st,t+k}(j) = (P_{st}(j)/P_{st+k})^{-\epsilon} Y_{st+k}$ is the demand for firm j in $t+k$ given that it has last reset its price in t, $X_{st,t+k}(j)$ is its intermediate input demand respectively.

to

$$N_t(i) = (1 - \delta)N_{t-1}(i) + H_t(i) \tag{4.14}$$

where once again $\delta \in (0,1)$ is an exogenous separation rate and $H_t(i)$ is the measure of workers hired by firm i in period t. Note that new hires start working in the same period that they are hired.

Following Blanchard and Gali (2010), Galí (2010), Di Pace and Hertweck (2016) and others I introduce labor market frictions in the form of a cost per hire G_t, which is defined in terms of the basic good and assumed to be exogenous.[35] Though G_t is exogenous, it is natural to think of it as depending on aggregate factors, in particular on the degree of tightness in the labor market. The idea is that it is hard to find suitable employees during business cycle expansions and hence costly to hire. Labor market tightness can be approximated by the job finding rate $x_t \equiv H_t/U_t^0$, i.e. the ratio of aggregate hires to the size of the unemployment pool at the beginning of t. I assume the functional form [36]

$$G_t = G(x_t) = \Gamma x_t^{\gamma}. \tag{4.15}$$

In the presence of labor market frictions, wages (and employment) may differ across firms as they cannot be automatically arbitraged out by workers switching from low to high wage firms. Given a wage $W_t(i)$ the optimal firm i's optimal hiring policy is described by the condition[37]

$$MRPN_t(i) = W_t(i) + P_{Bt}G_t - (1 - \delta)E_t\{Q_{t,t+1}P_{Bt+1}G_{t+1}\} \tag{4.16}$$

where $MRPN_t(i) \equiv P_t^I(1 - \alpha)A_t N_t(i)^{-\alpha}$ is the (nominal) marginal revenue product of labor, which equals the cost of a marginal worker. The latter depends on the nominal

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[35]Since hiring cost are going to be small in steady state, the implications of the model are not altered when hiring cost are defined in terms of the luxury good or in terms of a bundle of final goods.

[36]Note that a typical search and matching model posits a constant returns to scale matching function $M(V_t, U_t^0)$ with vacancy posting cost Γ. Defining labor market tightness as $\theta_t \equiv V_t/U_t^0$ we can define the job finding rate as $p(\theta_t) \equiv M(V_t, U_t^0)/U_t^0 = x_t$ (thus $\theta_t = p^{-1}(x_t)$) and the vacancy filling rate as $q(\theta_t) \equiv M(V_t, U_t^0)/V_t$. The cost per hire is then given by $G_t = \Gamma/q(\theta_t) = \Gamma/q(p^{-1}(x_t))$. Under the typical assumption of a Cobb-Douglas matching function $M(V_t, U_t^0) = V_t^\varsigma (U_t^0)^{1-\varsigma}$ this yields per-hire-cost $G_t = \Gamma x_t^{(1-\varsigma)/\varsigma}$ and coincides with the assumed cost specification for $\gamma \equiv \frac{1-\varsigma}{\varsigma}$.

[37]The corresponding nominal profit function that the intermediate firm maximizes is $\Phi_t^I(i) = E_t\left\{\sum_k Q_{t,t+k}\left(P_{t+k}^I Y_{t+k}^I(i) - W_{t+k}(i)N_{t+k}(i) - P_{bt+k}G_{t+k}H_{t+k}(i)\right)\right\}$ subject to (4.14).

wage, hiring costs and discounted savings of future hiring costs.

4.5 Wage Determination

I assume that wages are flexible, renegotiated every period and determined through Nash bargaining so that a constant fraction of the total surplus of an existing employment relation accrues to the worker (or his household respectively). Additionally the worker is assumed to act in a way consistent with the utility maximization of his household (as opposed to the maximization of their own hypothetical individual utility).

The nominal surplus value accruing to the representative household from a member employed at firm i (expressed in terms of final goods) is then given by

$$S_t^H(i) = W_t(i) - MRS_t + (1-\delta)E_t \left\{ Q_{t,t+1} S_{t+1}^H(i) \right\} \tag{4.17}$$

where MRS_t is the household's marginal disutility of labor market effort given by the right hand side of (4.10).

The nominal surplus value from an existing employment relationship accruing to firm i is given by

$$S_t^F(i) = MRPN_t(i) - W_t(i) + (1-\delta)E_t \left\{ Q_{t,t+1} S_{t+1}^F \right\}. \tag{4.18}$$

Together with (4.16) this implies $S_t^F(i) = P_{Bt} G_t$ for all intermediate firms i, i.e. the surplus that a profit maximizing firm gets from an existing employment relation is equal to the hiring cost.

The presence of a surplus associated with existing relations implies that many wages may be consistent with equilibrium because employment relationships will be privately efficient as long as the surplus value for both parties involved remains positive. I therefore follow Hall (2005); Shimer (2005) and the subsequent literature by relying on period-by-period Nash-Bargaining as an equilibrium "selection mechanism". In particular wages are determined by maximizing the joint surplus value as

$$\max_{W_t(i)} S_t^H(j)^{1-\xi} S_t^F(i)^{\xi}$$

where $\xi \in (0,1)$ denotes the relative bargaining power of firms. The solution to the

problem implies a constant share rule of the form

$$\xi S_t^H(i) = (1 - \xi)S_t^F(i).$$ (4.19)

Together with (4.17) and (4.18) this implies the associated nominal wage

$$W_t(i) = \xi MRS_t + (1 - \xi)MRPN_t(i).$$ (4.20)

Using (4.16) to substitute for $MRPN_t(i)$ establishes that the real wage is common to all firms which in turn implies that employment, the hiring rate and the marginal revenue product are the same across firms as well. Omitting the subscript i and using the wage equation in (4.16) further yields

$$P_{Bt}G_t - (1 - \delta)E_t\{Q_{t,t+1}P_{Bt+1}G_{t+1}\} = \xi(MRPN_t - MRS_t)$$ (4.21)

i.e. the cost of hiring an additional worker less the saved hiring cost next period equals the match surplus accruing to the firm.

4.6 Monetary & Fiscal Policy

The government runs a balanced budget period by period and obeys its budget constraint

$$T_t + Q_t B_t = B_{t-1}$$

The monetary authority pursues a generalized Taylor rule of the form

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_r}\left[\left(\frac{\Pi_t}{\Pi}\right)^{\phi_p}\left(\frac{Y_t}{Y}\right)^{\phi_y}\right]^{1-\rho_r}\varepsilon_{r,t}$$ (4.22)

where $ln\varepsilon_{r,t} \sim N(0, \sigma_\varepsilon^2)$ and letters without a time subscript denote steady state values. R_t is defined as the inverse bond price $1/Q_t$. The degree of monetary policy inertia is governed by $0 \leq r_r < 1$, whereas $r_y \geq 0$ indicates the responsiveness of monetary policy to aggregate output growth while $r_p \geq 1$ governs the responsiveness of the monetary authority to economy wide inflation.

I define nominal GDP naturally as $P_{Bt}Y_{Bt} + P_{Lt}Y_{Lt}$ and real GDP as $Y_t = P_B Y_{Bt} + P_L Y_{Lt}$, which implies that the GDP deflator takes the form

$$P_t = \frac{P_{Bt}Y_{Bt} + P_{Lt}Y_{Lt}}{P_B Y_{Bt} + P_L Y_{Lt}} \tag{4.23}$$

which resembles the Paasche GDP deflator using the steady state as the base period. Inflation then is defined as the change in the GDP deflator $\Pi_t = P_t / P_{t-1}$.

4.7 Market Clearing

Market Clearing of the intermediate goods market requires that

$$\sum_{s \in \{B,L\}} \int_0^1 M_{st}(i) di = \int_0^1 Y_t^I(j) dj. \tag{4.24}$$

The left hand side is given by the relationship between retail goods and intermediate input as

$$\int_0^1 M_{st}(i) di = \int_0^1 Y_{st}(i) = Y_{st} \int_0^1 \left(\frac{P_{st}(i)}{P_{st}} \right)^{-\epsilon} di = Y_{st} S_{st}$$

where $S_{st} \equiv \int (P_{st}(i)/P_{st})^{-\epsilon} di$ captures the efficiency loss in production due to price dispersion in sector s.[38] Because hiring cost are paid in terms of the basic good, market clearing in the retail sector for basic goods is given by

$$Y_{Bt} = X_{Bt} + H_t G_t \tag{4.25}$$

while market clearing for the luxury good is simply

$$Y_{Lt} = C_{Lt}. \tag{4.26}$$

The right hand side of (4.24) is described by

$$\int_0^1 Y_t^I(j) dj = \int_0^1 A_t N_t(j)^{1-\alpha} dj = A_t N_t^{1-\alpha}$$

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[38]These price dispersions are zero in steady state and up to a first order approximation outside of the steady state.

where $N_t = \int N_t(j)dj$ is total labor demand (and equals labor supply from the household). The last equality follows because there is no wage dispersion and hence employment is equalized across intermediate firms.

4.8 Equilibrium Definition

A stationary competitive equilibrium is a set of endogenous stationary processes $\{X_{Bt}, C_{Lt} \\ N_t, Q_t, P_{Bt}, P_{Lt}, P_t^I, A_t, Y_t^I, G_t, x_t, W_t, P_t, R_t, \Pi_t, Y_t\}_t$ and exogenous processes $\{\varepsilon_{at}, \varepsilon_{rt}\}_t$ satisfying equations (4.2)-(4.4), (4.7)-(4.10), (4.12), (4.15), (4.16), (4.22)-(4.26).

5 Model Calibration and Steady State

Calibration of the model requires assigning values to the preference parameters $\{\beta, \sigma, \varphi, \chi\}$, the parameters for the non-homothetic utility aggregator $\{\lambda, \eta, \phi\}$, the home production function $\{\psi, \rho\}$, the retail and intermediate firm sector $\{\epsilon, \theta_B, \theta_s, \alpha\}$, the labor market $\{\delta, \gamma, \xi, \Gamma\}$ and parameters for the monetary policy rule $\{\rho_r, \phi_p, \phi_y, \sigma_\varepsilon^2\}$.

Preferences. I assume a steady state nominal interest rate of four percent per year, $(1+R)^4 = 1.04$, so that the discount factor is $\beta = 0.99$. I set $\sigma = 1$ implying a logarithmic functional form for the consumption goods aggregator. The inverse Frisch elasticity of labor supply φ has been a controversial parameter in the literature due to differences in the estimates between micro- and macro-elasticities. I set $\varphi = 5$ in the baseline calibration which corresponds to a Frisch elasticity of 0.2. χ and ψ are jointly determined by equation (4.21) for a given value of ξ. I set $\psi = 0.15$ implying $\chi = 0.39$ for a standard worker bargaining power of $\xi = 0.5$. The elasticity of substitution towards basic goods upon employment is around 3% implying $\rho = 2/3$.

I calibrate $\{\lambda, \eta, \phi\}$ jointly by targeting i) the expenditure share of basic goods, ii) the relative income elasticities of basic goods and luxuries and iii) the elasticity of substitution between basic goods and luxuries. Appendix C provides details on the analytical expressions for each. The expenditure share of basic goods in NIPA is around 0.65. Weighted Engel estimates from the CEX imply a relative income elasticity of 0.6, which is close to the (relative) expenditure elasticity of 0.67 as measured in NIPA. Because of a lack of price data in the CEX, I compute relative price indices from NIPA and find an elasticity of sub-

stitution around 1.7. These moments imply values for $\lambda = 1.01$, $\phi = 0.36$ and $\eta = 1.04$.

Firms. The labor share is calibrated to a standard value $\alpha = 1/3$. The elasticity of substitution between differentiated goods within a retail sector is set to $\epsilon = 6$ implying a markup of 20 percent. I calibrate the price stickiness parameters according to their expenditure-weighted median price change frequencies. Around 11.94% of basic goods change prices within a month compared to 6% for luxuries. I thus set $\theta_B = 0.69$ and $\theta_L = 0.83$ implying an economy-wide Calvo-parameter of $\theta = 0.74$ which is in line with standard calibrations. For the technology process I assume standard values for persistence $\rho_a = 0.9$ and volatility $\sigma_a = 0.008$ as employed in the literature.

Labor Market Frictions. In line with the literature (e.g. Gertler and Trigari (2009); Blanchard and Gali (2010); Shimer (2012)) I use observed average values in the postwar US economy for the steady-state employment rate N and the quarterly hiring rate x. The former has been around 95%, $N = 0.95$ and the latter around 70%, $x = 0.7$. These values imply a value for the separation rate $\delta = xU/((1-x)N) = 0.1228$ of around 12% per quarter which in turn implies that a fraction $U^0 = 1 - (1-\delta)N = 0.166$ of 16% of workers are looking for a job at the beginning of each quarter. The cost function requires calibration of the elasticity of costs to a change in the aggregate hiring rate, γ, and the coefficient Γ which governs the level of hiring costs. I calibrate the former to unity[39] and set the latter to $\Gamma = 0.1183$, implying a hiring cost of 1% of GDP.

Monetary Policy. I follow the literature (e.g. Christiano et al. (2010)) in setting the parameters for the generalized Taylor-Rule as $\phi_p = 1.5$, $\phi_y = 0.5/4$ and an interest rate smoothing parameter of $\rho_r = 0.9$. The monetary policy shock $\varepsilon_{r,t}$ has standard deviation $\sigma_\varepsilon = 0.05$.

6 Implications for Monetary Policy

In this section I present implications for the monetary policy trade-off between inflation and output stabilization taking into account heterogeneity in consumption elasticities and prices flexibility. First, monetary policy provides a larger stimulus of real output but at

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[39]Following footnote 36, given a Cobb-Douglas matching function $M(V_t, U_t^0) = V_t^{\varsigma}\left(U_t^0\right)^{1-\varsigma}$, this would imply that the relative contribution of vacancies to the matching process is equal to the contribution of unemployment, i.e $\varsigma = 0.5$. This is in line with the findings in the literature, see e.g. Yashiv (2006) andGertler and Trigari (2009).

the cost of disproportionately higher inflation compared to a standard New Keynesian model. Second, monetary policy is state dependent and faces a worsening trade-off over the business cycle. Third, I show that optimal monetary policy should rather target deviations of unemployment from its natural rate than real output.

6.1 Comparison to a Standard New Keynesian Model

The standard New Keynesian model relies on habit formation and other adjustment frictions to yield quantitatively realistic predictions like hump-shaped impulse responses to monetary policy shocks. My model is in its essence small-scale and does not incorporate any frictions besides labor adjustment costs to generate equilibrium unemployment. The only new element is the more complex preference structure. The goal of this section therefore is more modest in nature and aims at making qualitative statements about monetary policy transmission in a model with a more realistic preference structure.

Homogeneous Price Change Frequency

In order to build intuition, I first consider the response to a 25 basis point innovation of the Taylor rule disturbance under the case of homogenous price flexibility.[40] I compare a standard New Keynesian (NK) model to a New Keynesian model with non-homothetic preferences (NKN) and a model with both non-homothetic preferences and home-production (NKNH). Figure 8 shows the impulse responses.

In a Standard NK model with homothetic preferences consumption of both goods increases by the same amount (0.6%). Relative consumption does not change because under homotheticity demand only depends on relative prices. Since both sectors have the same price change frequency, relative prices do not change. Taken at face value, inflation increases somewhat more (by 1%) than real GDP (0.8%) and employment increases by 1.2%. Non-homotheticity adds surprisingly little to the model. Impulse responses look extremely similar with the exception of relative consumption.[41] As is implied by non-homotheticity, increased income leads to a disproportionate increase of luxury consumption.

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[40]This would translate into a 1% annualized increase in the nominal interest rate absent any endogenous feedback effects in the Taylor rule.

[41]Part of the reason is the shut-down of time-varying risk aversion as mentioned in section 4.2.

The response of real output is larger in the model with non-homothetic preferences and home-production. This is because of an additional channel of market demand for basic goods. As employment increases, general demand increases because of increased income similar to the NK and NKN model. However, since there are fewer unemployed to home-produce the basic good, there is additional demand to smooth basic consumption via market purchases. This leads to overall higher output. The additional demand channel also leads to additional price increases and leads to higher inflation.

The preference structure is able to capture the initial disproportionate increase in flexible price goods as people switch into employment and demand basic goods disproportionately more. Panel c) however qualifies this result. Without additional frictions that increase the persistence of the employment response, the initial increase is subsequently reserved. The (strong) decline in employment leads to increased home-production and thus a subsequent decrease in market demand for basic goods - to the degree that relative basic-to-luxury consumption turns negative.

Heterogeneous Price Change Frequency

The basic intuition under homogeneous price frictions caries over to the case of heterogeneous price flexibility. Under mild price heterogeneity, the NK model does not exhibit a "comovement problem", i.e. an expansionary monetary policy raises demand for both goods and production in both sectors increases. Impulse responses are quantitatively very similar to the case of homogeneous price flexibility.

Non-homothetic preferences lead to higher luxury consumption due to increased income. The response of necessities is initially flat but subsequently turns negative. This decline in market demand for necessities is due to the higher price change frequency in that sector. This allows for quicker and stronger price adjustment of basic goods producers which in turn curbs demand.

Adding home production leads to an initial positive increase in basic goods consumption as switches into employment lead to an increase in market demand for necessities. However, basic goods producers react to the increased demand by disproportionately increasing their prices. Compared to the homogeneous case, relative consumption is actually negative even on impact. This implies that the equilibrium price effects of the model outweigh the initial demand increase for necessities due to the preference struc-

ture. Compared to the NK model the initial price increase is about a third higher which in turn implies a disproportionate increase in luxury consumption.

Nominal wage rigidities that can increase the persistence of labor market responses and act as a friction on marginal cost are a promising candidate to resolve this issue. Retail producers set prices as a markup over expected future marginal cost. Wage rigidities prevent marginal cost in rising thus decreasing the incentive to increase retail prices. This in turn would lead to a larger increase in consumption of basic goods. On the household side, a slow rise in wages will decrease the initial employment response to more realistic levels and additionally induce persistence in the employment response. As argued in the last subsection, this additionally would help to correctly predict empirical patterns.[42]

6.2 State-Dependence of Monetary Policy

In order to investigate the state-dependence of monetary policy I simulate impulse responses to a monetary policy shock starting the economy outside of the steady state. In particular I investigate an initial state with a higher unemployment rate of 10% and compare it to impulse responses at the steady state unemployment rate of 5%. I define the generalized impulse response function (GIRF) of the vector of endogenous variables X_t as

$$GIRF(h) = \mathbb{E}\left(X_{t+h} \mid \mathcal{S}_{t-1}, ln\varepsilon_{r,t} = 0.0025\right) - \mathbb{E}\left(X_{t+h} \mid \mathcal{S}_{t-1}\right).$$

The impulse response function at horizon h in state $\mathcal{S}_{t-1}$ is the difference between the forecasts of the endogenous variables at time t (conditional on the realization of the policy shock) and the unconditional forecast in $t - 1$. In order to to examine state-dependence it is necessary to solve the model via perturbation of order higher than one so that the IRF depends upon the initial realization of the state $\mathcal{S}_{t-1}$, in which the shock hits.[43][44]

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[42]Obviously a lower initial employment response would lead to a reduced market demand for necessities, partially offsetting the correction implied by wage rigidities.

[43]See for example Andreasen et al. (2017); Basu and Bundick (2017) and Born and Pfeifer (2014) for an in-depth discussion. Higher order perturbation opens up the possibility of stochastic steady states due to the presence of uncertainty through second order terms in the state-space representation. I however continue to solve my model around the deterministic steady state. Also note, that the generalized impulse response functions may additionally depend on the sign and size of the shock, an issue that I abstract from in the following.

[44]In particular I draw a sequence of policy shocks from a standard normal distribution and simulate data out to horizon $H = 20$. I perform this simulation $N = 1000$ times and thereby construct $\mathbb{E}_{t-1}X_{t+h}$ for all forecast horizons. For each sequence of shocks I construct a counterpart sequence with the initial shock

Monetary Policy is less powerful and feeds more into prices if the unemployment rate is higher. Figure 10 shows the impulse responses to a 25 basis point in the Taylor rule disturbance. A state of higher unemployment with the same natural rate of unemployment requires more individuals switching into employment as evidenced by the larger increase in employment. This increase implies a larger increase in demand for basic goods. Panel a) however shows that the equilibrium consumption response of necessities is very similar to the one in steady state. This is because basic goods producers use the additional demand to further increase prices. Higher prices for necessities in turn lead to higher inflation of 0.3 percentage points, which translates into an annualized increase in inflation around 1.2 percentage points.[45] Panel h) shows that this is not accompanied by higher real GDP. Thus over the business cycle the same innovation to the Taylor Rule leads to a worsened trade-off between stimulus in GDP and inflation.

6.3 Optimal Monetary Policy

I assume that optimal monetary policy maximizes household welfare subject to the competitive equilibrium conditions.[46] In particular I consider the class of interest rate rules of the form

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_r} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\phi_p} \left(\frac{Y_t}{Y}\right)^{\phi_y} \left(\frac{U_t}{U}\right)^{\phi_u}\right]^{1-\rho_r} \varepsilon_{r,t} \tag{6.1}$$

where variables without a time subscript denote steady state values and perform a numerical search over the parameters $\{\phi_p, \phi_y, \phi_u\}$ for $\rho_r \in \{0, 0.9\}$. I require the monetary policy rule to guarantee uniqueness and maximize the lifetime utility of the representative household. As is standard for welfare analysis, I rely on a second-order approximation to the model.[47] Because of non-homothetic preferences it is not possible to construct a

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being a 25 basis point decline in the policy rate. Averaging over all N simulations yields the forecast $\mathbb{E}_t X_{t+h}$ conditional on the realization of the shock.

[45]Panel i) additionally indicates that even though the Taylor rule disturbance is expansionary, monetary policy reacts with interest rate increases to counteract increased inflation.

[46]I thus derive optimal policy from a distorted steady state. The distortions are price markups due to market power, labor market congestion due to future hiring cost entering contemporary hiring decisions and price dispersions amongst retail firms due to sticky prices. For optimal policy rules relative to an undistorted steady state (i.e. without market power and congestion externalities) it is immediately clear that pure inflation targeting yields the highest utility, because offsetting price dispersion as the remaining distortion requires price level stability. (see e.g. Galí (2010) and Faia (2008) for a debate on this point).

[47]I compute unconditional welfare and thus abstract from issues as regards the transition to the stochastic steady state.

consumption equivalent as a quantitative measure for expected welfare gains. As welfare itself is ordinal I restrict myself to direct comparison of different Taylor rules.

Optimal monetary policy follows a dual mandate in inflation and unemployment. I find that the optimal rule has coefficients $\phi_p = 2.5$, $\phi_y = 0$, $\phi_u = 0.037$ and $\rho_r = 0.9$. As is typical for a New Keynesian model, a stronger reaction to inflation leads to higher welfare.[48] Additionally figure 11a) shows that monetary policy should react to unemployment, although the coefficient and thus the potential welfare improvement is small. In general is never optimal for monetary policy to react to deviations of real GDP from its steady state level. These findings are in line with the literature.

More interestingly, a standard Taylor Rule that reacts to output yields suboptimal utility. This is particularly true if it doesn't also take unemployment into account. The optimal coefficient on unemployment for a standard Taylor Rule is $\phi_u = 0.153$ and thus larger than the coefficient for real output and an order of magnitude larger compared to the optimal policy rule. Figure 12 shows the reason in terms of Impulse Responses to a 1% positive technology shock. In a standard NK model, positive technology shocks lead to unemployment because of Calvo frictions. Those firms that cannot pass reduced marginal costs via reduced prices to their customers choose to lay off workers instead. In my model, this leads to (additional) deflationary pressure because unemployed workers start home producing necessities, thereby decreasing the demand for necessities and putting further pressure on prices. A monetary policy rule that also reacts to unemployment can thus stabilize inflation when stabilizing employment. Panel a) and b) show that optimal monetary policy counteracts the negative effect of technology shocks on unemployment and leads to (almost) pure intensive margin consumption adjustments. A Taylor rule that takes unemployment into account, tries to mimic this result.

7 Conclusion

In this paper I use expenditure data from the Consumption Expenditure Survey to study how consumption behavior influences the transmission of monetary policy. I show that consumption behavior due to intensive margin income increases differs from consump-

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[48]In fact, in line with the literature the optimal coefficient on inflation is unbound. I restrict ϕ_p to 2.5 as the bound of the parameter space that I search over.

tion behavior upon employment. While households consume more sticky price goods when their income increases, they spend more on employment-related flexible price goods upon employment. I use aggregate data to show that consumption of flexible price goods decreases during recessions pointing towards a relatively higher importance of extensive margin consumption for the macroeconomy. Additionally, empirical impulse responses to identified monetary policy shocks indicate that expansionary monetary policy succeeds in the raising employment but has little effects on earnings.

In the context of a multi-sector New Keynesian model that captures intensive and extensive margin consumption through non-homothetic preferences and home-production I analyze the consequences for monetary policy. Compared to a standard New Keynesian model, monetary policy is more effective in raising real output but at the cost of higher inflation. More importantly, state-dependence renders monetary policy less effective over the business cycle. When unemployment is high, monetary stimulus leads to a larger number of people switching back to employment. This creates additional market demand for flexible price goods which in equilibrium is almost solely absorbed in higher overall prices with little additional effect on real output. Finally I show, that optimal monetary policy follows a dual mandate in inflation and unemployment. Though the optimal reaction to unemployment is small, it becomes important for a typical Taylor Rule that also reacts to real output, because smoothing employment additionally helps stabilizing inflation and output.

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Figures

Figure 1: Correlation btw. different measures of price stickiness
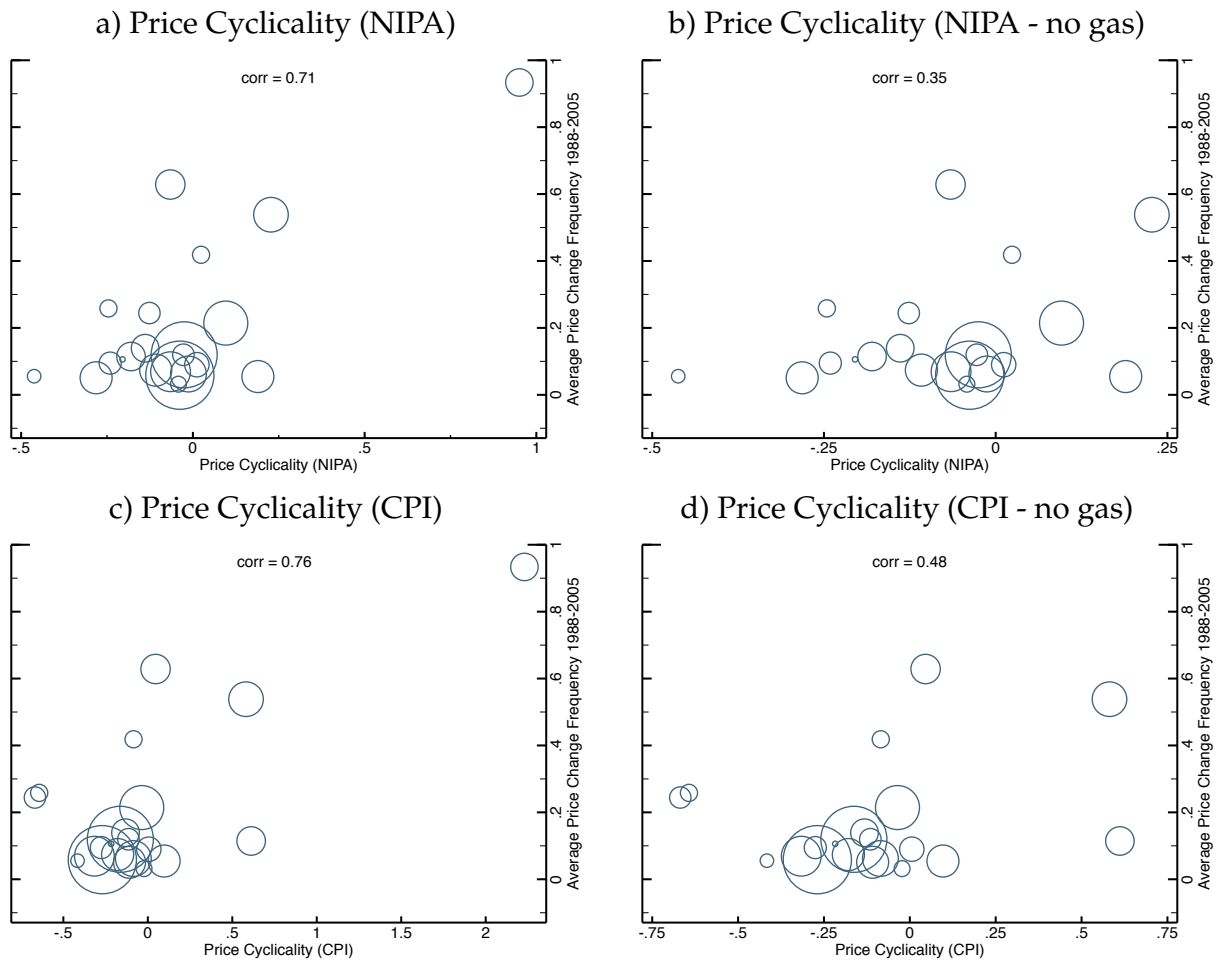

Using different price flexibility measures provides a good robustness check due to imperfect correlation

Average price change frequency refers to the (expenditure-weighted) monthly frequency of price changes over the period 1988-2005. It is obtained from data underlying the Consumer Price Index (CPI). Price cyclicality refers to a measure constructed by regressing log (hp-filtered) relative price indices (relative to the GDP deflator) on log (hp-filtered) real GDP. Price Indices are obtained from the national accounts (NIPA) or the CPI. Section 2.1 and Appendix A provide further details on the construction.

Each circle represents one consumption good as summarized in table (1). The size of each circle is proportional to the expenditure share of that good according to NIPA. Correlation refers to the weighted correlation between the average price change frequency and the respective price cyclicality measure. Panels b) and d) exclude gasoline.

Figure 2: Correlation btw. Intensive Margin Consumption & Price Stickiness

a) Price Change Frequency

b) Price Cyclicality
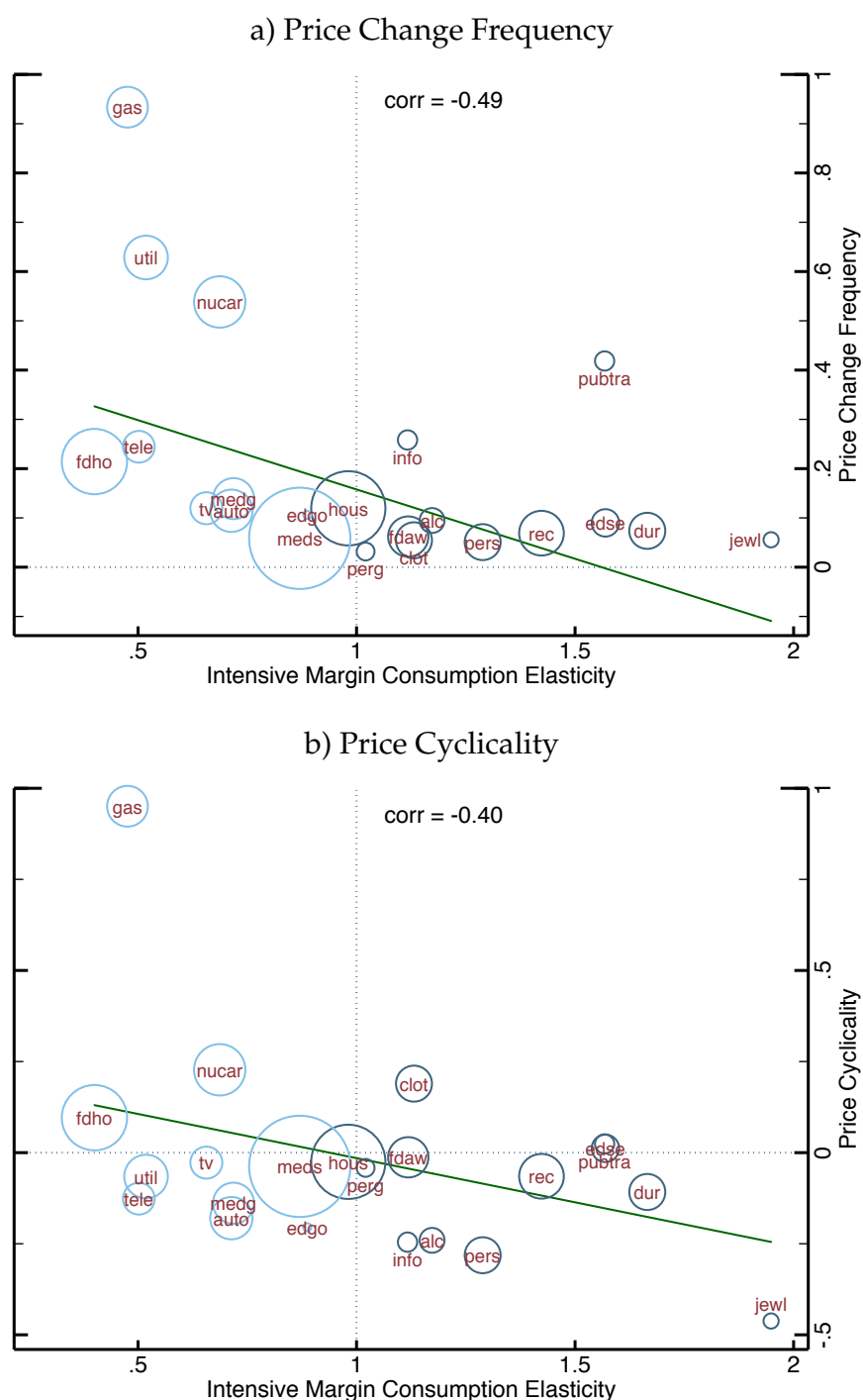
Households disproportionately spend intensive margin income increases on sticky price goods
Panel a) shows the negative correlation btw. Engel curve estimates and the average price change frequency 1988-2005. Panel b) shows the correlation with price cyclicality measured in NIPA. Each circle represents a different good. The size is proportional to the expenditure share in NIPA. Light blue circles indicate basic goods with Engel elasticities less than one, dark blue circles indicate luxuries with elasticities greater than one. Correlation refers to the weighted correlation. Abbreviations are explained in table 1.

Figure 3: Correlation btw. Extensive Margin Consumption & Price Stickiness

a) Price Change Frequency

b) Price Cyclicality
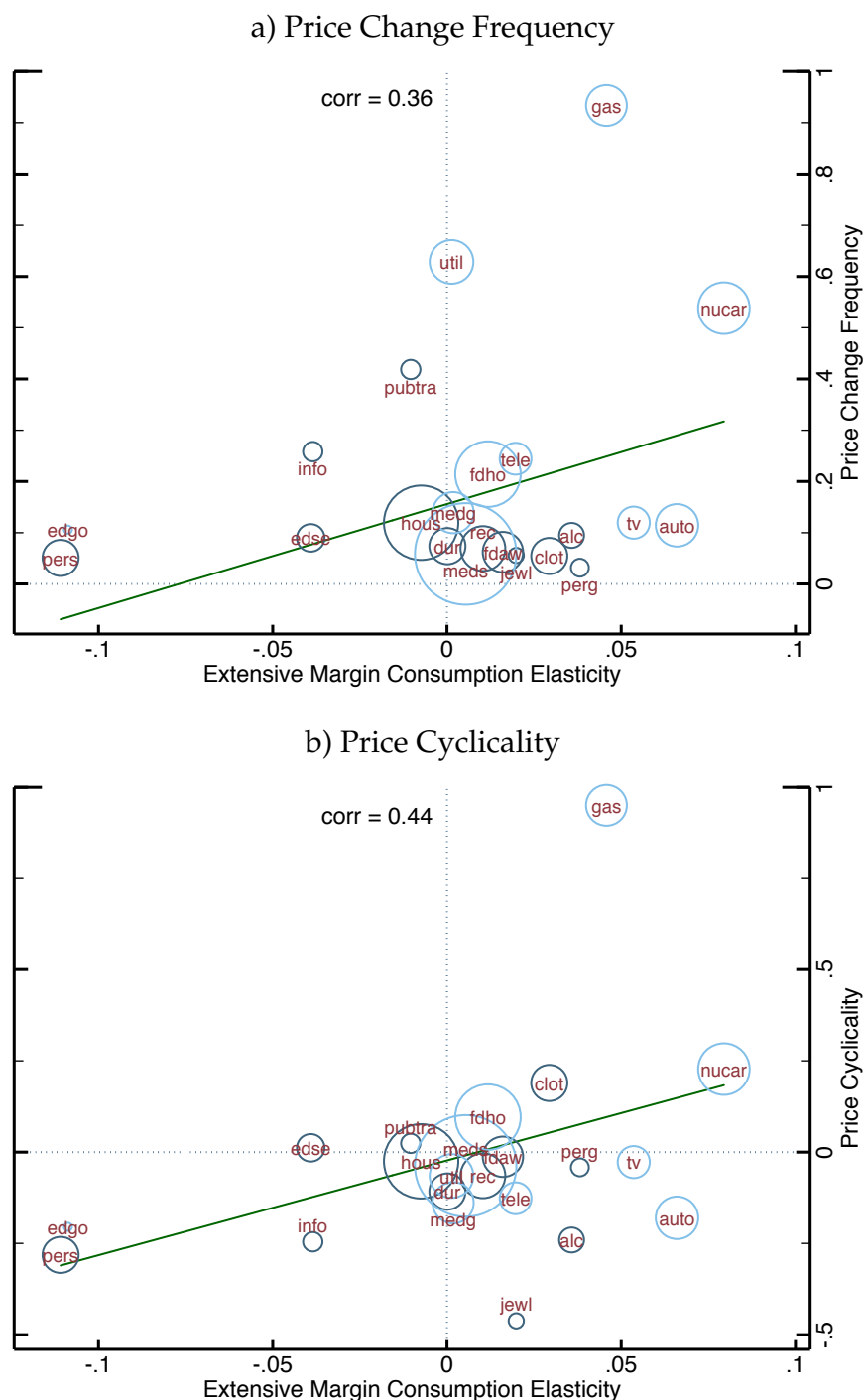
Upon employment households disproportionately consume flexible price goods
Panel a) shows the positive correlation btw. the average price change frequency 1988-2005 and a change in the number of earners within a household. Panel b) shows the correlation with price cyclicality measured in NIPA. Each circle represents a different good. The size is proportional to the expenditure share in NIPA. Light blue circles indicate basic goods with intensive margin elasticities less than one, dark blue circles indicate luxuries with intensive margin elasticities greater than one. Correlation refers to the weighted correlation. Abbreviations are explained in table 1.

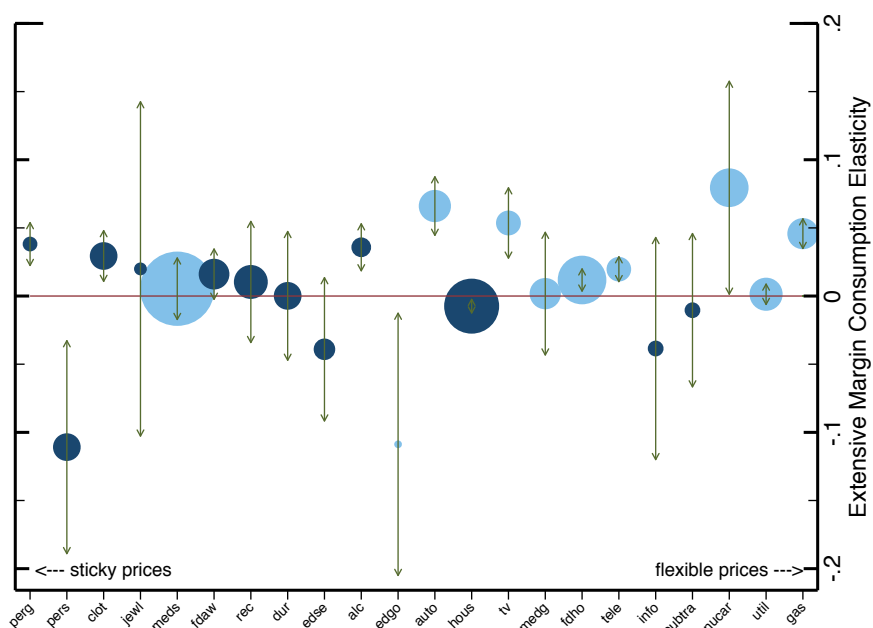**Figure 4:** **Statistical Significance of Extensive Margin Consumption Elasticities**

Extensive Margin Elasticities are mostly (statistically) significant for necessities
Each ball represents a different good. The size is proportional to the expenditure share in NIPA. Goods are ordered by their average price change frequency in ascending order. Light blue balls indicate basic goods with intensive margin elasticities less than one, dark blue balls indicate luxuries with intensive margin elasticities greater than one. Green arrows plot the 90% confidence intervals. Standard errors are clustered at the household level. Abbreviations are explained in table 1.

Figure 5: **Aggregate Expenditure-Weighted Price Change Frequency**
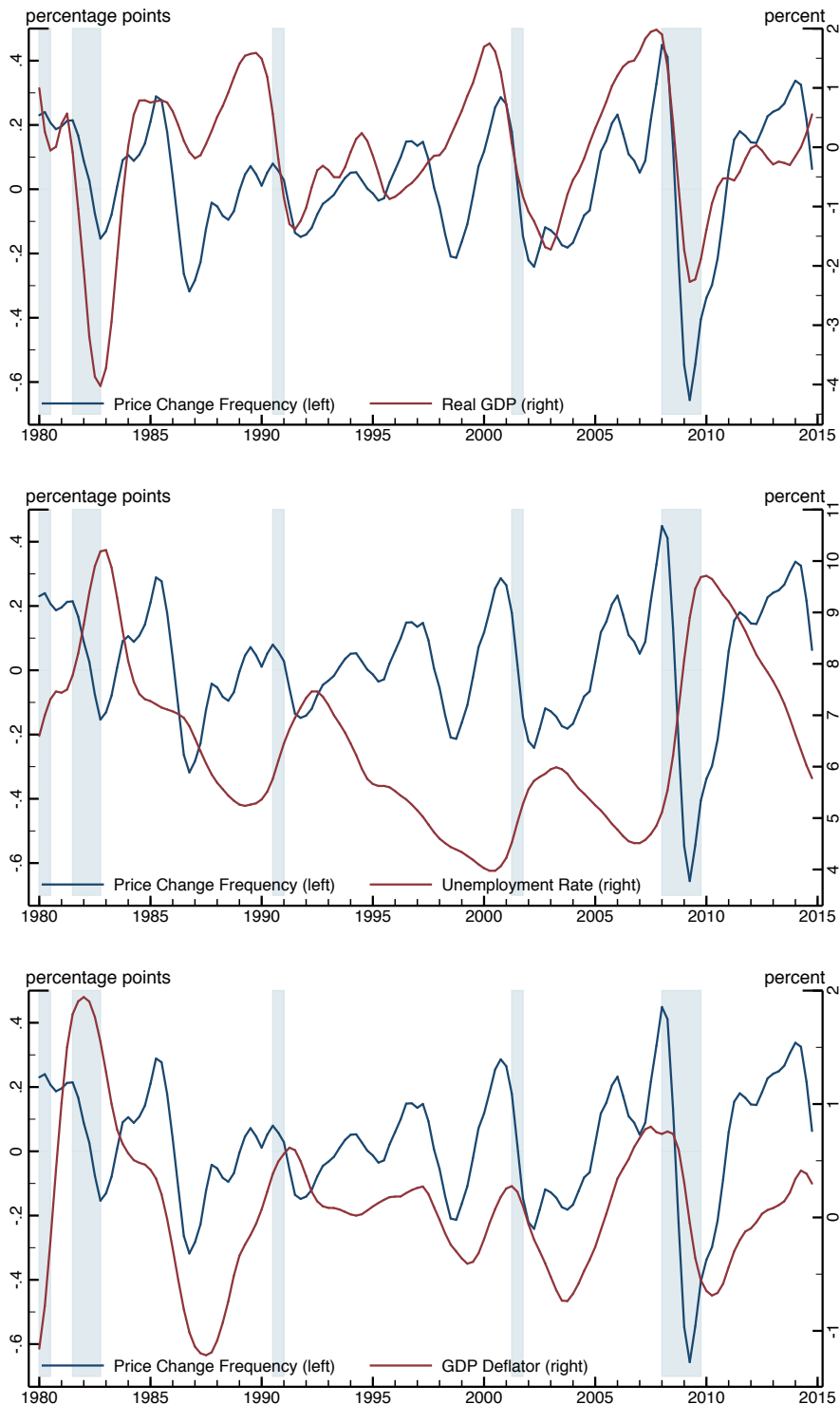
Consumption of flexible price goods comoves positively with the business cycle
Aggregate Price Change Frequency is constructed as an expenditure-weighted average of good-specific price change frequencies. Changes indicate changes in the underlying consumption composition. Shaded areas indicate recession periods according to NBER. Panel a) shows the positive comovement with (hp-filtered) real GDP. Panel b) shows negative comovement with the unemployment rate. Panel c) shows positive comovement with the GDP deflator.   49

Figure 6: Impulse Response of (Un-)Employment to a Monetary Policy Shock

a) Unemployment Rate

i) Contractionary Shock

ii) Expansionary Shock

b) Employment Rate

i) Contractionary Shock

ii) Expansionary Shock
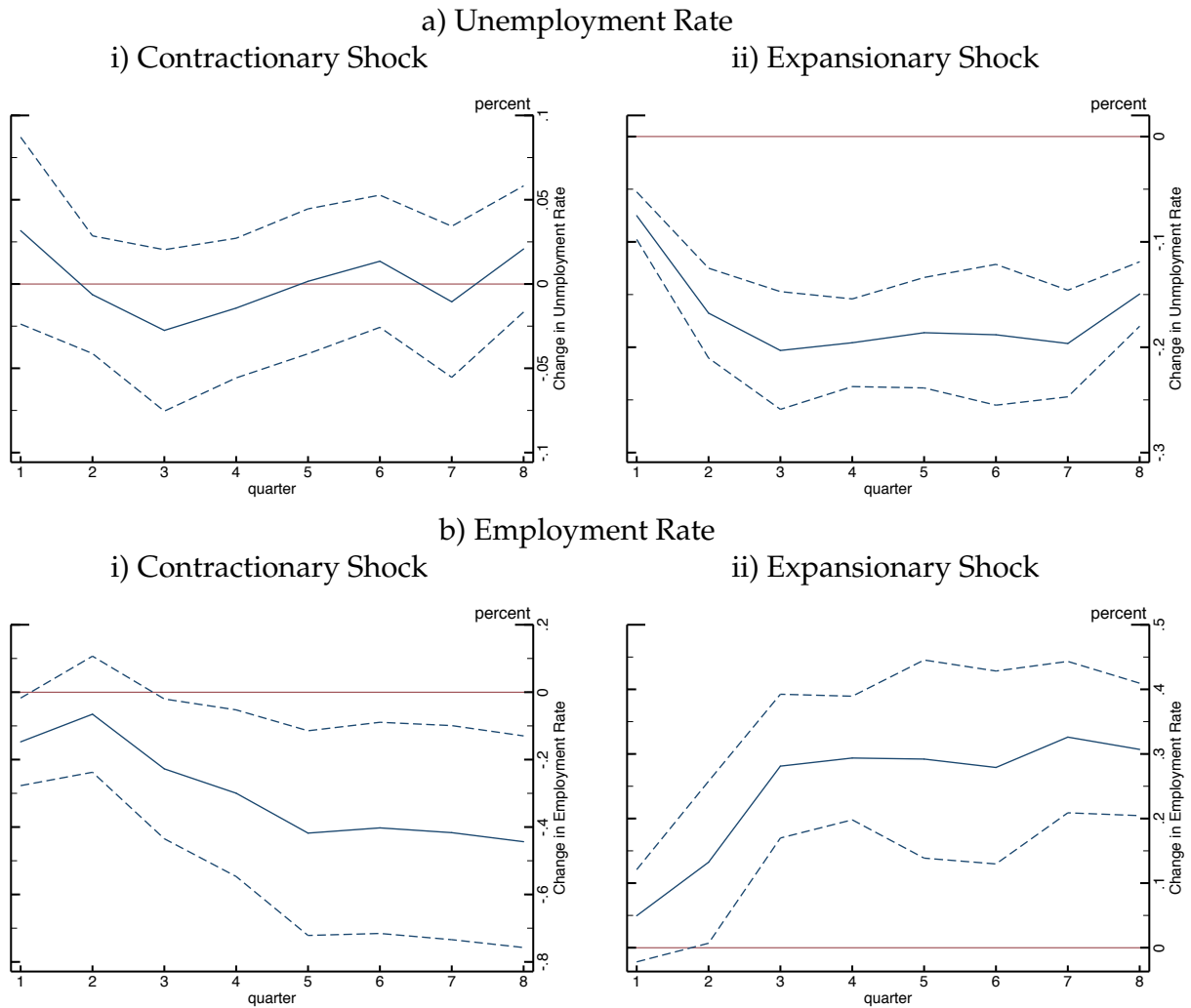
Monetary Policy decreases the unemployment rate by increasing employment
Impulse responses to a one standard deviation monetary policy shock. Shocks are identified through changes in the Federal Funds Rate within 60-minute windows around FOMC announcements. Dashed lines indicate 90% confidence intervals. Standard errors are clustered at the age-sex-education cohort level. Synthetic cohorts are constructed from the Current Population Survey. Unemployment rate refers to the within-cohort (population) weighted ratio of unemployed over labor force participants. Employment rate refers to the within-cohort (population) weighted ratio of employed over all working-age persons not disabled or retired.

Figure 7: Impulse-Response of Labor Earnings to a Monetary Policy Shock

a) Hourly Earnings

i) Contractionary Shock

ii) Expansionary Shock

b) Weekly Earnings

i) Contractionary Shock

ii) Expansionary Shock
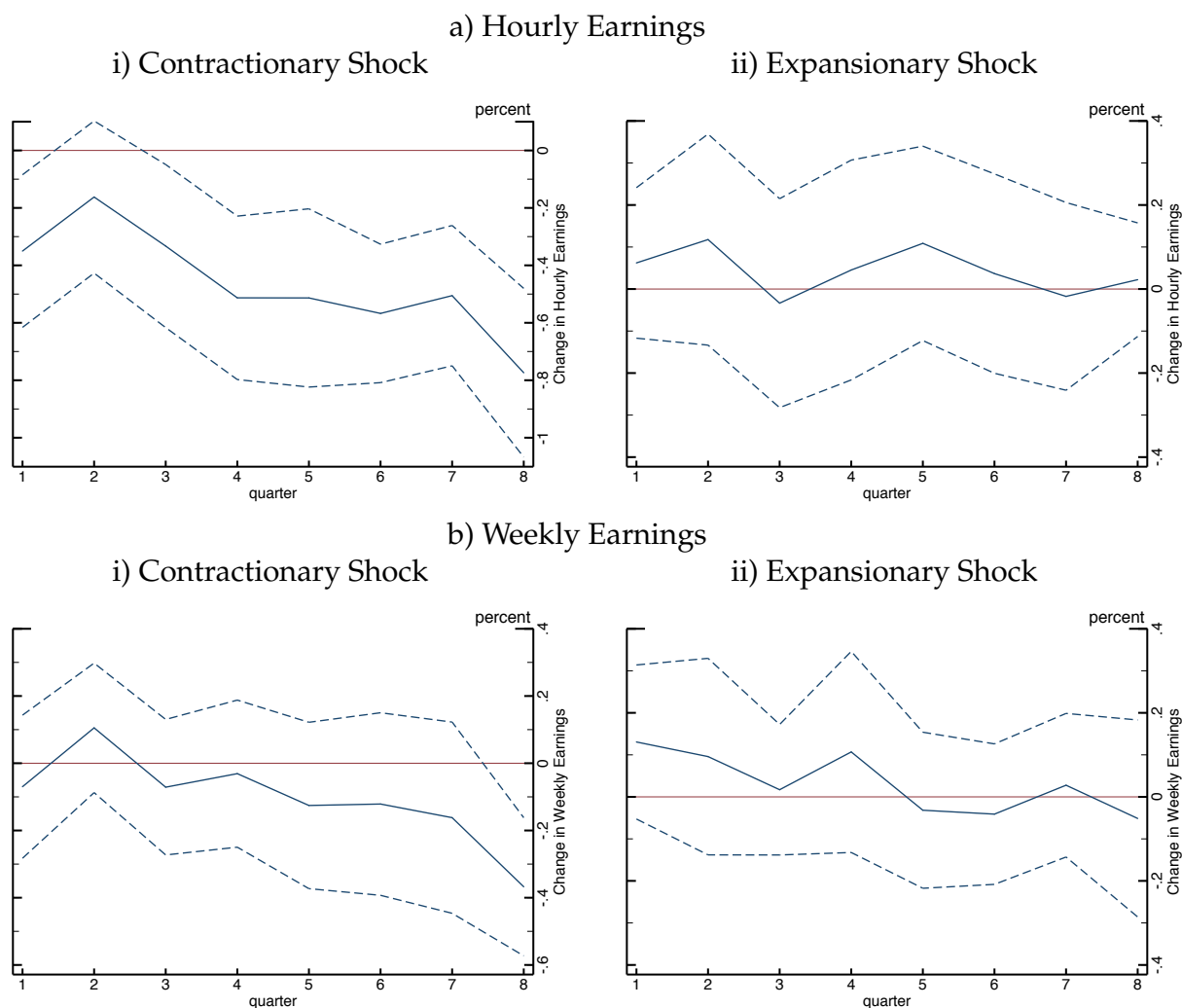
Monetary Policy has an immeasurable effect on labor income
Impulse responses of log real hourly earnings and log real weekly earnings to a one standard deviation monetary policy shock. Shocks are identified through changes in the Federal Funds Rate within 60-minute windows around FOMC announcements. Dashed lines indicate 90% confidence intervals. Standard errors are clustered at the age-sex-education cohort level. Synthetic cohorts are constructed from the Current Population Survey.

Figure 8: Impulse Responses to a monetary shock under homogeneous price flexibility

(a) Necessities

(b) Luxuries

(c) Necessities-to-Luxuries

(d) Price

(e) Employment

(f) Nominal GDP

(g) Inflation

(h) Real GDP

(i) Interest Rate

Legend:
- hom
- nonhom
- nonhom + hp
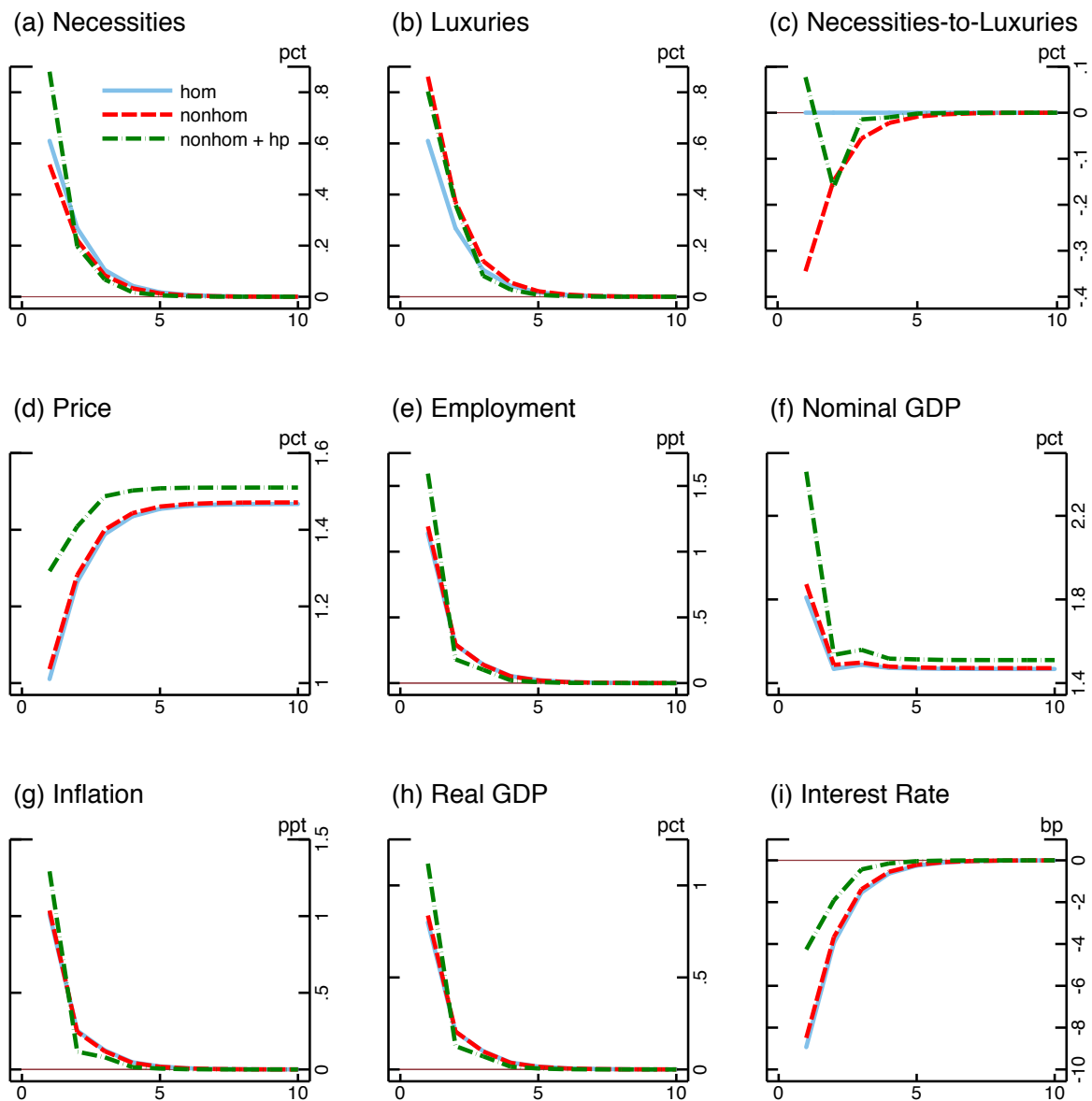
Non-homothetic preferences with home-production increase the strength of monetary policy
Impulse Responses to a 25 basis point innovation to the Taylor Rule, i.e. an annual increase in the nominal interest rate of 1% (absent endogenous feedback effects). Calvo price stickiness is assumed to be similar across necessities and luxuries ($\theta_B = \theta_L = 0.74$). Price refers to the price of necessities/luxuries. The light blue line shows IRFs for the standard New Keynesian (NK) model with homothetic preferences. The red dashed line shows IRFs for the NK model with non-homothetic preferences. The green dashed line shows IRFs for the model with non-homothetic preferences and home-production of necessities.

Figure 9: Impulse Responses to a monetary shock under heterogeneous price flexibility
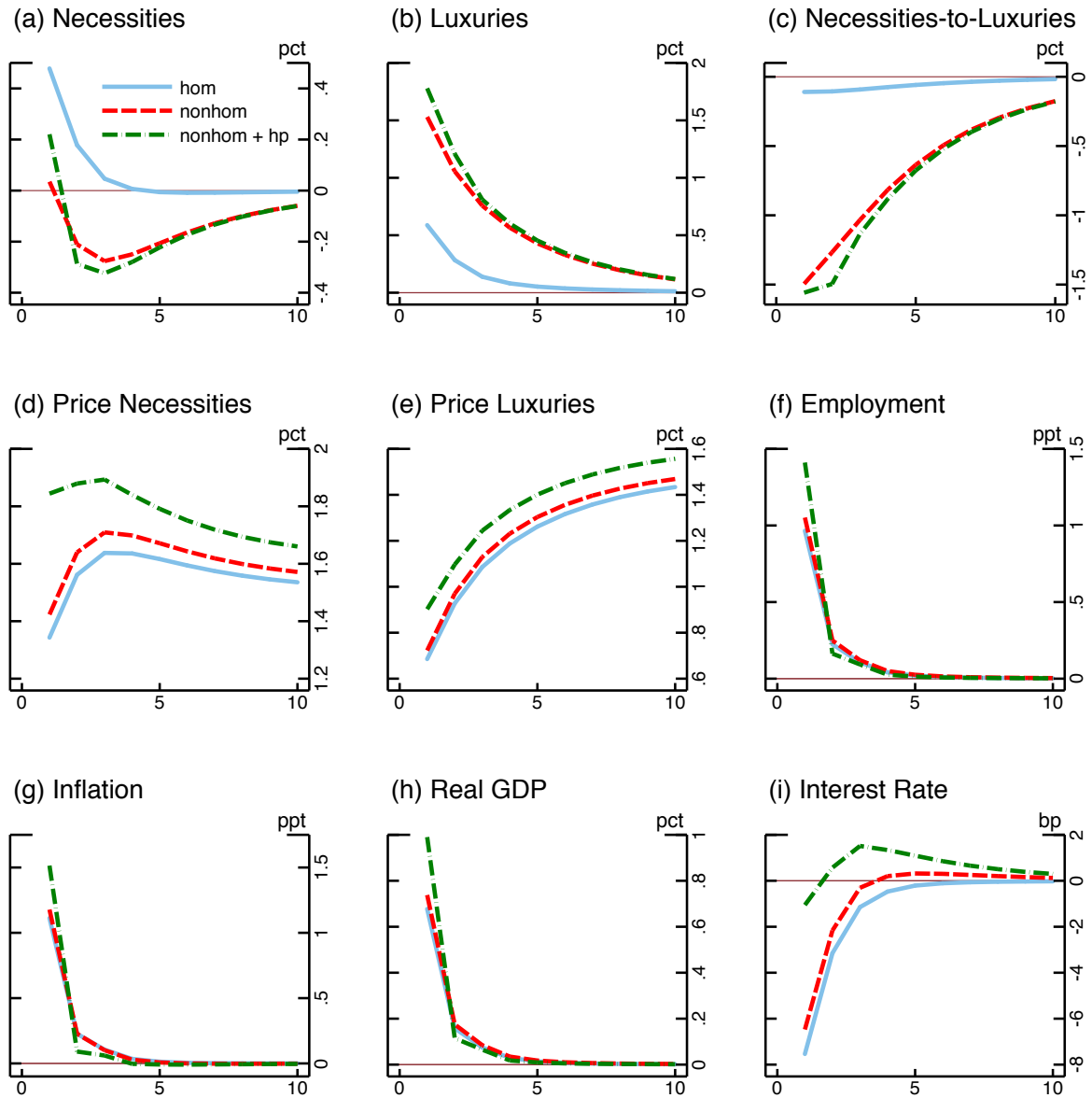
Higher demand for necessities feeds mostly into prices compared to homogeneous price flexibility

Impulse Responses to a 25 basis point innovation to the Taylor Rule, i.e. an annual increase in the nominal interest rate of 1% (absent endogenous feedback effects). Calvo price stickiness is heterogeneous across necessities ($\theta_B = 0.69$) and luxuries ($\theta_L = 0.83$). The light blue line shows IRFs for the standard New Keynesian (NK) model with homothetic preferences. The red dashed line shows IRFs for the NK model with non-homothetic preferences. The green dashed line shows IRFs for the model with non-homothetic preferences and home-production of necessities.

Figure 10: State-Dependence of Monetary Policy

(a) Necessities

(b) Luxuries

(c) Necessities-to-Luxuries

(d) Price Necessities

(e) Price Luxuries

(f) Employment

(g) Inflation

(h) Real GDP

(i) Interest Rate

Legend: u = 5% (solid line), u = 10% (dashed line)
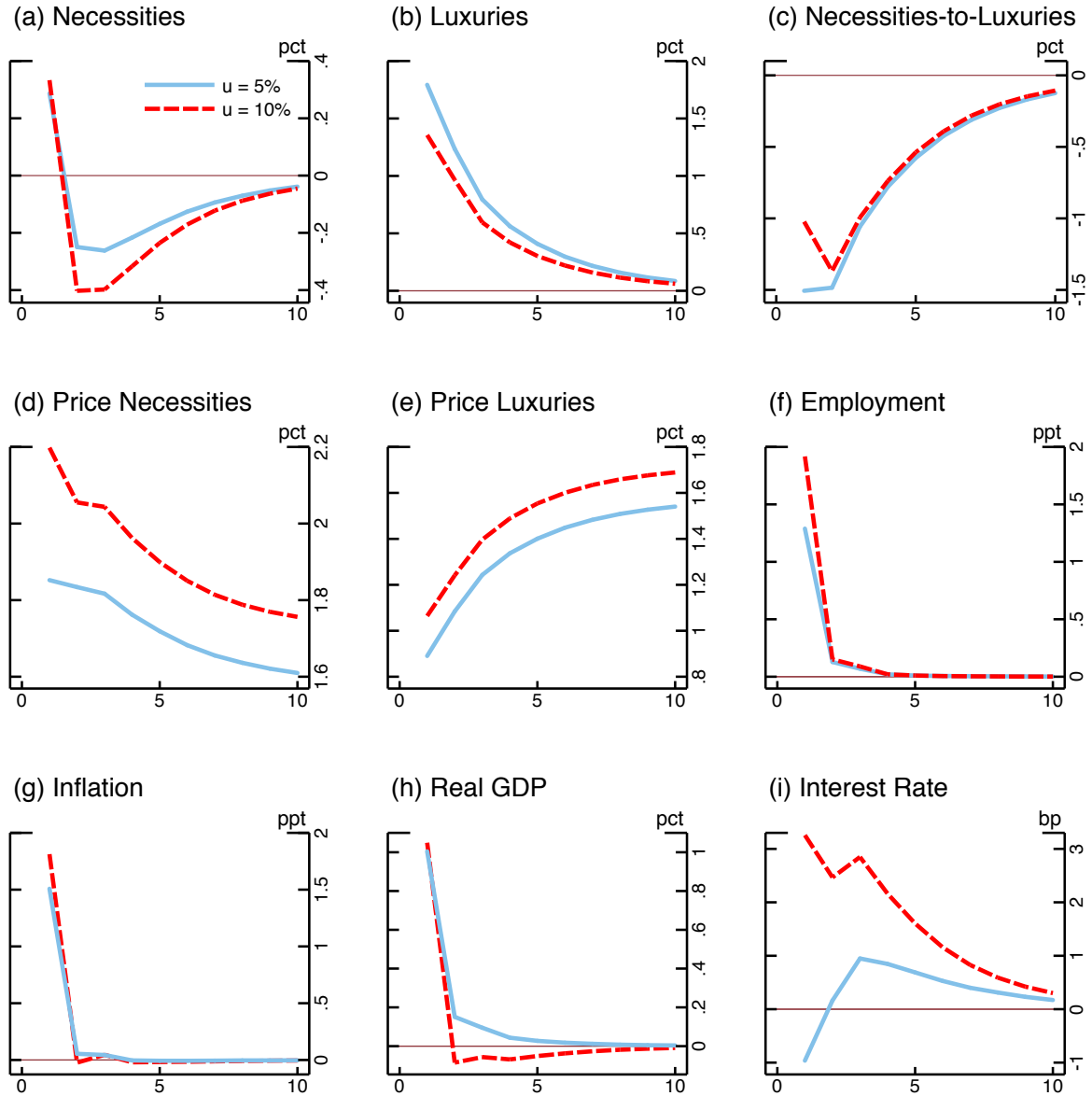
Higher unemployment leads to increased transmission into prices
Impulse Responses to a 25 basis point innovation to the Taylor Rule, i.e. an annual increase in the nominal interest rate of 1% (absent endogenous feedback effects). Calvo price stickiness is heterogeneous across necessities ($\theta_B = 0.69$) and luxuries ($\theta_L = 0.83$). The light blue line shows IRFs for the model with non-homotheticity and home-production at an unemployment rate of 5% (at steady state). The red dashed line shows IRFs at an unemployment rate of 10% (out of steady state).

Figure 11: Welfare under different Taylor Rule Coefficients

a) $\phi_y = 0$
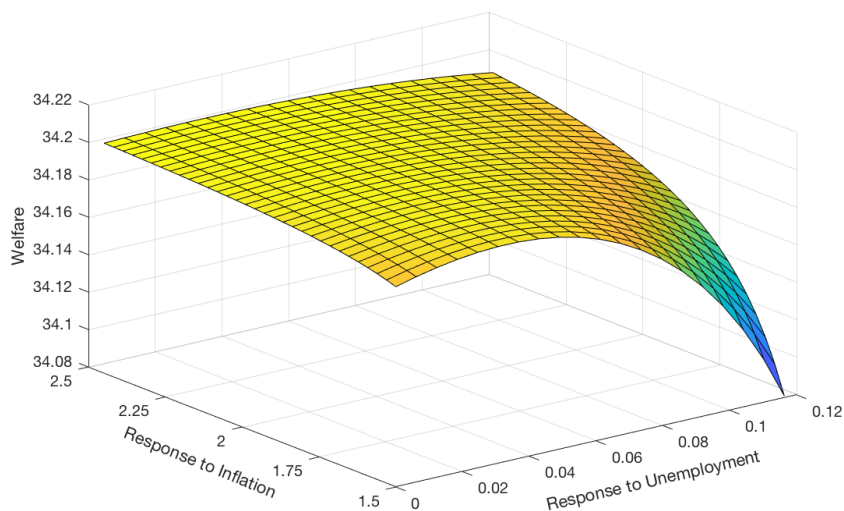
Optimal Monetary Policy follows a dual mandate in inflation and unemployment
Conditional welfare for different combinations of Taylor rule coefficients for inflation and unemployment (given $\rho_r = 0.9$ and $\phi_y = 0$). Taylor Rule takes the form given by equation (6.1). Optimal monetary policy is given by $\phi_p = 2.5$ and $\phi_u = 0.037$.

b) $\phi_y = 0.125$
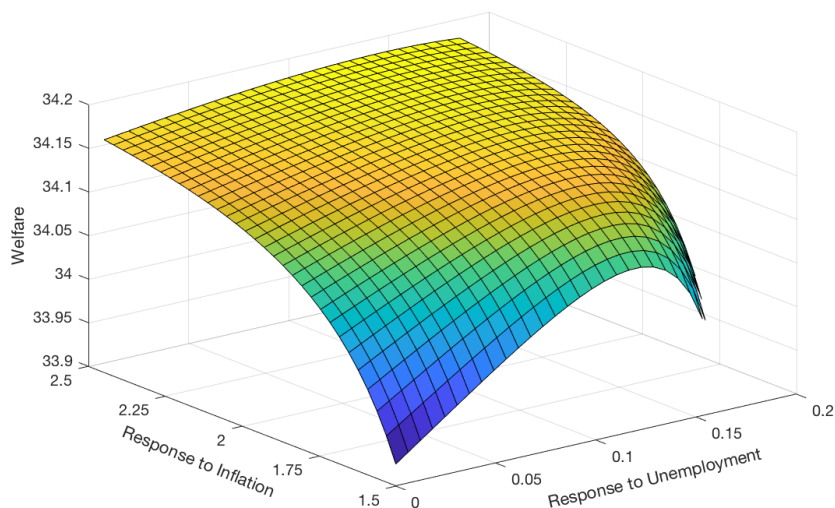
A standard Taylor Rule without consideration for unemployment is suboptimal
Conditional welfare for different combinations of Taylor rule coefficients for inflation and unemployment (given $\rho_r = 0.9$ and $\phi_y = 0.6/4$). Taylor Rule takes the form given by equation (6.1). Optimal monetary policy is given by $\phi_p = 2.5$ and $\phi_u = 0.153$.

Figure 12: Impulse Response to a Technology Shock
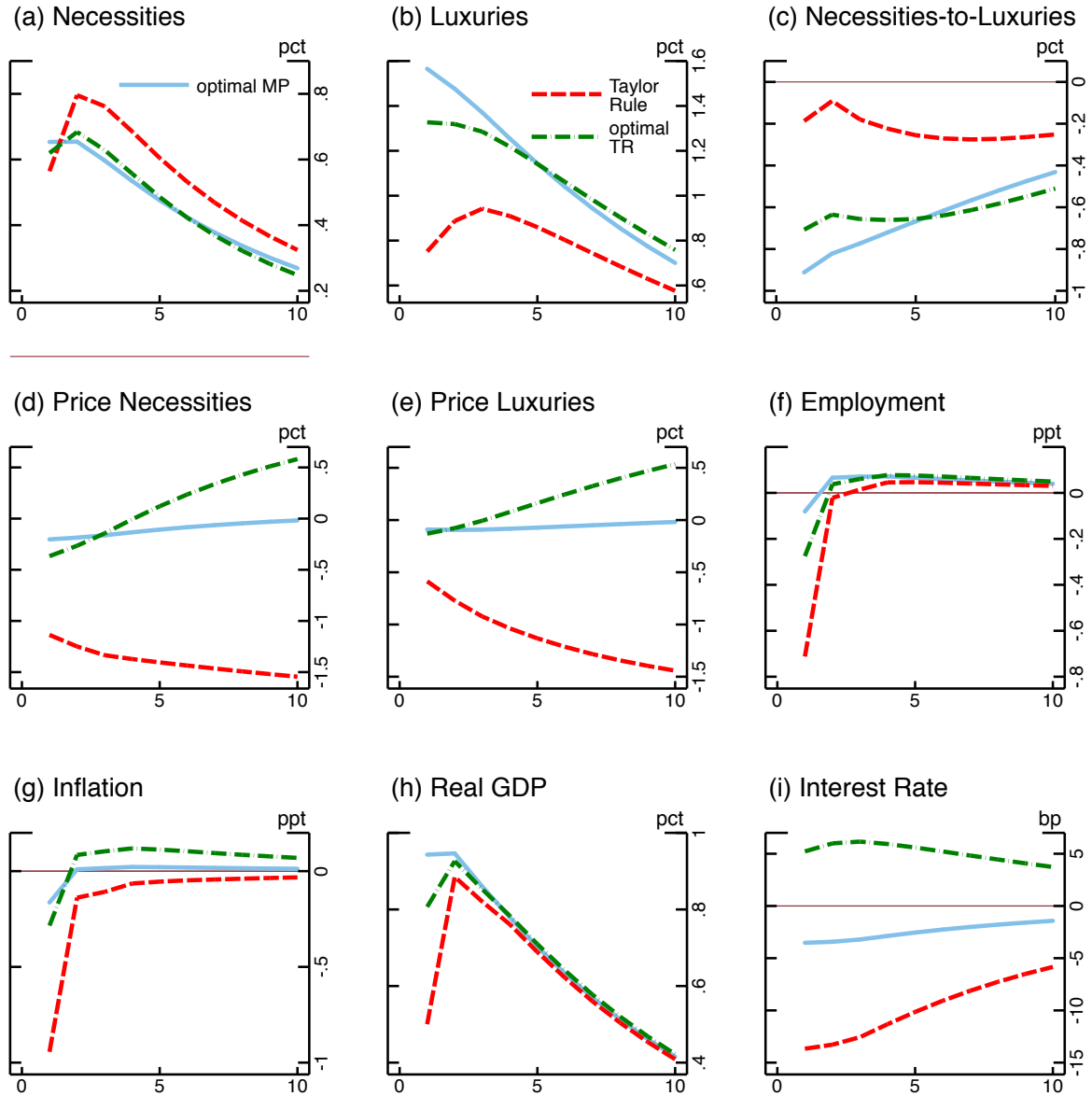
Optimal Monetary Policy stabilizes inflation by stabilizing employment
Impulse Responses to a 1% positive technology shock. Calvo price stickiness is heterogeneous across necessities ($\theta_B = 0.69$) and luxuries ($\theta_L = 0.83$). The light blue line shows IRFs under optimal monetary policy ($\phi_p = 2.5, \phi_y = 0, \phi_u = 0.037$). The red dashed line shows IRFs under a standard Taylor Rule ($\phi_p = 1.5, \phi_y = 0.125, \phi_u = 0$). The green dashed line shows IRFs under an optimized Taylor Rule ($\phi_p = 1.5, \phi_y = 0.125, \phi_u = 0.153$).

Tables

Table 1: Summary Statistics 1980-2016

Good	Abbr.	Expenditure Share				Price Freq.	Price Cycl.
		NIPA	CEX	Emp	Unemp		
Apparel	clot	4.21%	3.67%	3.71%	3.38%	.055	.189
Jewelry	jewl	0.75%	0.37%	0.39%	0.22%	.056	-.462
Housing	hous	17.92%	31.70%	31.70%	31.87%	.119	-.025
Utilities	util	3.54%	6.13%	5.86%	7.86%	.629	-.066
Durables	dur	4.23%	4.10%	4.23%	3.34%	.074	-.108
New & Used Cars	nucar	4.92%	4.13%	4.32%	2.80%	.538	.227
Gasoline	gas	3.10%	5.33%	5.40%	4.63%	.934	.951
Car Maintenance	auto	3.34%	4.92%	5.06%	3.80%	.114	-.180
Public Transport	pubtra	1.20%	1.06%	1.08%	0.99%	.419	.024
Educational Goods	edgo	0.12%	0.17%	0.17%	0.19%	.106	-.025
Educational Services	edse	2.44%	2.19%	2.32%	1.32%	.090	.012
Telephone Services	tele	1.87%	3.07%	2.97%	3.76%	.244	-.126
Information	info	1.21%	0.77%	0.79%	0.65%	.258	-.246
Medical Services	meds	19.10%	4.02%	4.09%	3.56%	.059	-.038
Medical Goods	medg	3.14%	0.53%	0.48%	0.85%	.139	-.139
TV & Audio	tv	1.91%	2.01%	1.99%	2.11%	.120	-.027
Recreation	rec	6.50%	3.88%	4.03%	2.80%	.069	-.065
Personal Goods	perg	1.04%	0.85%	0.86%	0.76%	.032	-.042
Personal Services	pers	4.20%	1.07%	1.06%	1.13%	.051	-.282
Food at Home	fdho	7.97%	14.00%	13.15%	19.84%	.214	.096
Food Away	fdaw	5.27%	4.89%	5.13%	3.33%	.062	-.013
Alcohol	alc	2.01%	1.15%	1.20%	0.82%	.095	-.241

Expenditures and the degree of price flexibility vary widely across goods
Abbr. refers to the abbreviated name of a goods category. NIPA expenditure shares are average expenditure shares from the national accounts over 1980-2016. CEX summarizes population weighted total expenditure shares according to the Consumption Expenditure Survey (CEX). Emp and Unemp report expenditures by employment status of the household head derived from the CEX. Price Frequency refers to the average monthly frequency of price changes over the period 1988-2005. Price Cyclicality refers to regression coefficients of a regression of log (hp-filtered) relative prices (relative to the GDP deflator) on log (hp-filtered) real GDP.

Table 2: Intensive and Extensive Margin Estimates

Good	Abbr.	Intensive Margin β_c^i		Extensive Margin β_c^e		
		Coef.	Std. Error	Coef.	Std. Error	p-value
Apparel	clot	1.131	.022	.0293	.0113	.009
Jewelry	jewl	1.949	.166	.0199	.0746	.790
Housing	hous	.981	.009	-.0074	.0030	.015
Utilities	util	.518	.009	.0013	.0045	.771
Durables	dur	1.665	.036	.0001	.0287	.997
New & Used Cars	nucar	.687	.043	.0795	.0475	.094
Gasoline	gas	.476	.010	.0458	.0066	.000
Car Maintenance	auto	.714	.013	.0660	.0131	.000
Public Transport	pubtra	1.568	.047	-.0103	.0342	.761
Educational Goods	edgo	.887	.056	-.1088	.0585	.063
Educational Services	edse	1.570	.053	-.0391	.0320	.221
Telephone Services	tele	.502	.011	.0197	.0056	.000
Information	info	1.117	.056	-.0385	.0500	.437
Medical Services	meds	.870	.022	.0054	.0137	.700
Medical Goods	medg	.719	.041	.0018	.0274	.948
TV & Audio	tv	.656	.018	.0536	.0157	.001
Recreation	rec	1.423	.036	.0103	.0270	.702
Personal Goods	perg	1.021	.018	.0381	.0096	.000
Personal Services	pers	1.289	.061	-.1109	.0475	.020
Food at Home	fdho	.400	.008	.0118	.0050	.018
Food Away	fdaw	1.118	.019	.0161	.0112	.152
Alcohol	alc	1.173	.030	.0358	.0105	.001

Intensive and Extensive Margin Consumption Elasticities vary widely
Abbr. refers to the abbreviated name of a goods category. Intensive Margin are the consumption elasticities derived from Engel curve estimation as described in section 2.2. Extensive Margin are the consumption elasticities in response to a change in the number of earners within the household. Std. Errors are clustered at the household level. P-Values are not shown for the intensive margin because all coefficients are highly statistically significant.

Table 3: Correlation btw. Intensive Margin Consumption & Price Stickiness

a) Average Price Change Frequency 1988-2005

	baseline	male heads	age 20-65	CEX share	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	-.837***	-.815***	-.848***	-.810***	-.745***	-1.09**
	[.200]	[.203]	[.196]	[.179]	[.198]	[.426]
correlation	-.485	-.474	-0.494	-.523	-.453	-.408

b) Median Price Change Frequency 1988-2005

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	-.731***	-.706***	-.743***	-.711***	-.645***	-.968***
	[.183]	[.195]	[.177]	[.154]	[.185]	[.331]
correlation	-.445	-.430	-.454	-.478	-.412	-.379

c) Price Cyclicality (NIPA) 1980-2016

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	-.666***	-.665***	-.673***	-.555***	-.625***	-.664*
	[.210]	[.209]	[.214]	[.174]	[.208]	[.373]
correlation	-.402	-.402	-.408	-.377	-.396	-.256

d) Price Cyclicality (CPI) 1980-2016

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	-.249***	-.246***	-.249***	-.212***	-.225***	-.243
	[0.070 ⏐	[.070]	[.067]	[.059]	[.068]	[.147]
correlation	-.345	-.341	.346	-.345	-.327	-.217

The negative correlation between intensive margin consumption elasticities and the good-specific price flexibility is a robust result

Each coefficient in the table represents the slope of a linear regression of the respective price flexibility measure on intensive margin elasticities. Correlation refers to the (NIPA) expenditure-weighted correlation between both. Columns present different specifications. Column (1) presents the baseline regression as plotted in figure 2. Column (2) restricts the sample to male household heads. Column (3) encompasses a bigger sample through a wider age range. Column (4) weights the correlation via expenditure shares from the CEX. Column (5) checks robustness when deflating CEX expenditure categories with good-specific price indices from the CPI. Column (6) employs a log specification for good-specific expenditures instead of relative household expenditures (left hand side variable). Table a) and b) present results for price change frequencies. Table c) and d) for price cyclicality measures using NIPA or CPI price indices respectively.

Table 4: Correlation btw. Extensive Margin Consumption & Price Stickiness

a) Average Price Change Frequency 1988-2005

	baseline	male heads	age 20-65	CEX share	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	.064*	.058*	.047*	.046*	.064*	.021
	[.033]	[.030]	[.023]	[.024]	[.033]	[.037]
correlation	.359	.354	.325	.359	.359	.121

b) Median Price Change Frequency 1988-2005

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(4)	(4)	(5)	(6)
beta	.058*	.054*	.044*	.041	.058*	.021
	[.033]	[.029]	[.024]	[.026]	[.033]	[.037]
correlation	.346	.347	.317	.335	.346	.123

c) Price Cyclicality (NIPA) 1980-2016

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	.075*	0.060	.056**	.046**	.075*	.028
	[.042]	[.035]	[.027]	[.019]	[.042]	[.020]
correlation	.441	.380	.401	.377	.441	.172

d) Price Cyclicality (CPI) 1980-2016

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	.031***	.027*	.026**	.026**	.031**	.023*
	[.014]	[.014]	[.011]	[.010]	[.014]	[.013]
correlation	.415	0.390	.429	.513	.415	.316

The positive correlation between extensive margin consumption elasticities and the good-specific price flexibility is a robust result

Each coefficient in the table represents the slope of a linear regression of the respective price flexibility measure on extensive margin elasticities. Correlation refers to the (NIPA) expenditure-weighted correlation between both. Columns present different specifications. Column (1) presents the baseline regression as plotted in figure 2. Column (2) restricts the sample to male household heads. Column (3) encompasses a bigger sample through a wider age range. Column (4) weights the correlation via expenditure shares from the CEX. Column (5) checks robustness when deflating CEX expenditure categories with good-specific price indices from the CPI. Column (6) employs a log specification for good-specific expenditures instead of relative household expenditures (left hand side variable). Table a) and b) present results for price change frequencies. Table c) and d) for price cyclicality measures using NIPA or CPI price indices respectively.

APPENDIX A - Data Cleaning

In this appendix I discuss my methodological approach to the data of the Consumption Expenditure Survey (CEX) and National Income and Products Account (NIPA) data for Personal Consumption Expenditures (PCE).

CEX Expenditure Aggregation

I obtain the Consumption Expenditure Survey (CEX) micro-data from two sources. For the waves 1980-1995 I rely on ASCII files from the Inter-university Consortium for Political and Social Research. For the 1996-2016 waves I directly gather the micro-data from the Bureau of Labor Statistics (BLS).

The expenditure data of the CEX is the main input for the construction of the Consumer Price Index (CPI). The CPI itself is an aggregate of 70 expenditure classes (EC) which are composed of groups of entry level items (ELI) that in turn are constructed from underlying narrow products, which are assigned a universal classification code (UCC). For example the expenditure class "Alcoholic beverages at home" (FW) is composed of ELIs "Beer and other at home" (FW011), "Distilled spirits at home" (FW021) and "Wine at home" (FW031). The ELI "Beer and other at home" in turn consists of UCCs "Beer and Alc at home" (200111) and "Non-alcoholic beer" (200112).

For the purposes of this paper I use the mtab-files containing monthly expenditure data at the UCC level. I aggregate these expenditures to the EC level and further aggregate consumption expenditures to the quarterly level. For the mapping between UCCs and ECs I rely on Appendix B of the "CPI Requirements of CE" by William Casey. Of the 70 ECs that feature in the computation of the CPI one can recover 52 categories. The CEX family files contain expenditures on food at home but not on detailed food items (ECs FA-FT). Furthermore some expenditure classes contain only very few items, are not continuously available or not available at all (ECs GB, GE, EC, HN). I further aggregate these 52 categories into 22 consumption goods based on a priori beliefs of similarity as well as to alleviate measurement error concerns and reduce noise in the data to allow for more precise estimation. Table (A.1) shows the mapping I employ. I confirm that all results also hold quantitatively at the EC level.

I make two additional adjustments to the data. For expenditure class HC "Owner's

equivalent rent of primary residence" I follow the literature (e.g. Alonso (2016) Aguiar and Bils (2015)) and diverge from the expenditure definition of the CEX. The CEX defines shelter for homeowners as the sum of out-of-pocket expenditures for maintenance, property taxes and interest payment on mortgages. Because the latter rather constitute a savings decision I exclude them from housing expenditures. In turn I include data on rental equivalence provided by the fmly-files.[49] Since rental equivalence is not available in the 1980-1981 wave, I impute it from the 1982-1983 wave by regressing rental equivalence on total household expenditure (instrumented with before-tax income), marital status, age, race, education and gender of the household head, family size and the number of earners. Because rental equivalence is also missing in the 1993-1994 waves I do the same for these years with data from 1995 and 1996.

Furthermore, Aguiar and Bils (2015) show that expenditures on food at home appear to be abnormally low between 1982 and 1987, supposedly due to the wording of the question in these years. I follow their recommendation and increase food at home expenditures by 11%.

Finally, I deflate all nominal consumption expenditures by the aggregate CPI research series[50], so that my estimation results have the interpretation of consumption elasticities as opposed to expenditure elasticities. As shown in section 3, all results are robust to deflating with good-specific price indices from the CPI.

CEX Sample Selection

Following the literature (e.g. Aguiar et al. (2013), Coibion et al. (2017), Alonso (2016)) I restrict the sample to ensure that the data is comparable over time. I restrict household heads to be aged between 25 and 55 and drop households with an age change of more than two years or a gender change of the household head. Since early waves of the CEX only surveyed urban households, I restrict the whole sample to urban households. I further drop households with incomplete income reports, before tax income of less than 100$ (in 1982 dollars) and expenditure observations for less than three month in each interview quarter. I finally require a household to be observed for all four interviews.

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[49]This is also consistent with the definition of owner's equivalent rent in NIPA, which uses the imputed rental equivalence for owned homes to account for opportunity costs.

[50]The CPI research series has the advantage of being consistently defined over the whole sample by accounting for definition changes of underlying goods categories.

I deflate all nominal variables (e.g. before and after tax income and total expenditure) with the aggregate CPI research series. Since I add the rental equivalence to housing expenditure for homeowners I also add them to before and after tax income.

For the Engel Curves estimation I further restrict the sample to households which do not observe a change in the number of earners or the family size to ensure that I am estimating intensive margin consumption elasticities.

For the extensive margin regressions I drop households with negative expenditures to be comparable to previous research, though results are robust to this choice. Additionally I do not consider households where the number of earners or the family size changes by more than one person, as there are a few outliers with 4-8 changes within a year which are very unlikely to constitute pure extensive margin adjustments.

NIPA PCE Mapping

I use NIPA data to calculate expenditure shares and price cyclicality measures. For expenditure shares I used the underlying detailed personal consumption expenditure table 2.4.5U. Table A.1 shows the mapping between PCE categories and consumption good categories that I use.

In order to calculate my good-specific price cyclicality measure I construct expenditure share weighted unique price indices, i.e. for each goods category that maps into multiple PCE categories I construct a unique Paasche Price Index for that category and then estimate price cyclicality as described in section 2.2.

CPI Price Cyclicality

In order to estimate price cyclicality for expenditure categories from the CPI I rely on the mapping shown in table A.1. Because of methodological changes over time some of the CPI series are not continuously available back until 1980. For price cyclicality estimates I rely on each series as given. For the robustness checks of good-specific expenditure deflation, I instead rely on the closest available substitute series if the original price index does not go back until 1980 (e.g. SAR for SERA for 1992 and earlier). Telephone services and Information are an exception with no appropriate substitute, so that I extrapolate each series with a quadratic trend.

Table A.1: Mapping btw. Consumption Categories & EC/PCE/CPI

Good	Abbr.	EC (CEX)	PCE Category	CPI
Apparel	clot	AA-AF	Clothing & Footwear	SAA
Jewelry	jewl	AG	Jewelry & Watches	SEAG
Housing	hous	HA-HD	Housing, Accommodations, Net HH Insurance	SAH1
Utilities	util	HE-HG	Fuel Oil & Other Fuels, Household Utilities	SAH2
Durables	dur	HH-HP	Furnishings & Durable HH Equipment HH Supplies/Maintenance, Flowers	SAH3
New & Used Cars	nucar	TA	New & Used Motor Vehicles, Motorcycles	SETA02
Gasoline	gas	TB	Gasoline & Other Motor Fuel	SETB
Car Maintenance	auto	TC-TF	Motor Vehicle (MV) Parts, Lubricants & Fluids MV Services, MV insurance	SAT1
Public Transport	pubtra	TG	Public Transportation	SETG
Educational Goods	edgo	EA	Educational Books	SEEA
Educational Services	edse	EB	Education Services, Childcare	SEEB
Telephone Services	tele	ED	Telephone Equip., Telecom. & Postal Services	SAE2
Information	info	EE	Info Processing Equip, Internet	SAE21
Medical Services	meds	MC-ME	Health Care/Insurance, Social Assistance	SAM2
Medical Goods	medg	MF, MG	Pharmaceutical & Other Medical Products Therapeutic Appliances	SAM1
TV & Audio	tv	RA	Video & Audio Equipment	SERA
Recreation	rec	RB-RG	Photo/Sport/Music Equip., Recreational Books, Sports vehicles (exc. Motorcycles) Games, Toys & Pets, Film supplies, Magazines	SAR
Personal Goods	perg	GC		SEGC
Personal Services	pers	GD	Legal/Accounting/Funeral/Clothing Services Financial Service Charges	SEGD
Food at Home	fdho	FH	Food & Nonalc. Beverages for off-premise cons. Food produced and consumed on Farms	SAF11
Food Away	fdaw	FV	Purchased meals and beverages (exc. alcohol) Food furnished to employees	SEFV
Alcohol	alc	FWX	Alcoholic Beverages, Alcohol in purchased meals	SAF116

Good refers to the categories of expenditures as defined in this paper. Abbr. refers to the abbreviated name. EC refers to the underlying expenditure classes that constitute an expenditure category. PCE category refers to the classification of products used by the national accounts for Personal Consumption Expenditures and is based on NIPA table 2.4.5U. CPI refers to the consumer price index used for robustness checks.
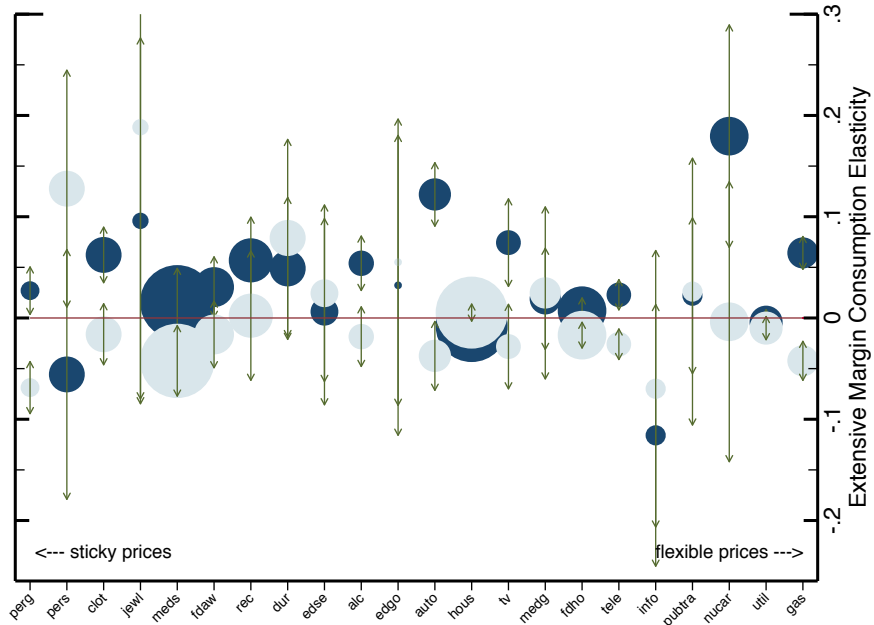
APPENDIX B - Further Robustness

Figure B.1: Correlation btw. Extensive Margin Consumption & Price Stickiness

a) Price Change Frequency

b) Price Cyclicality
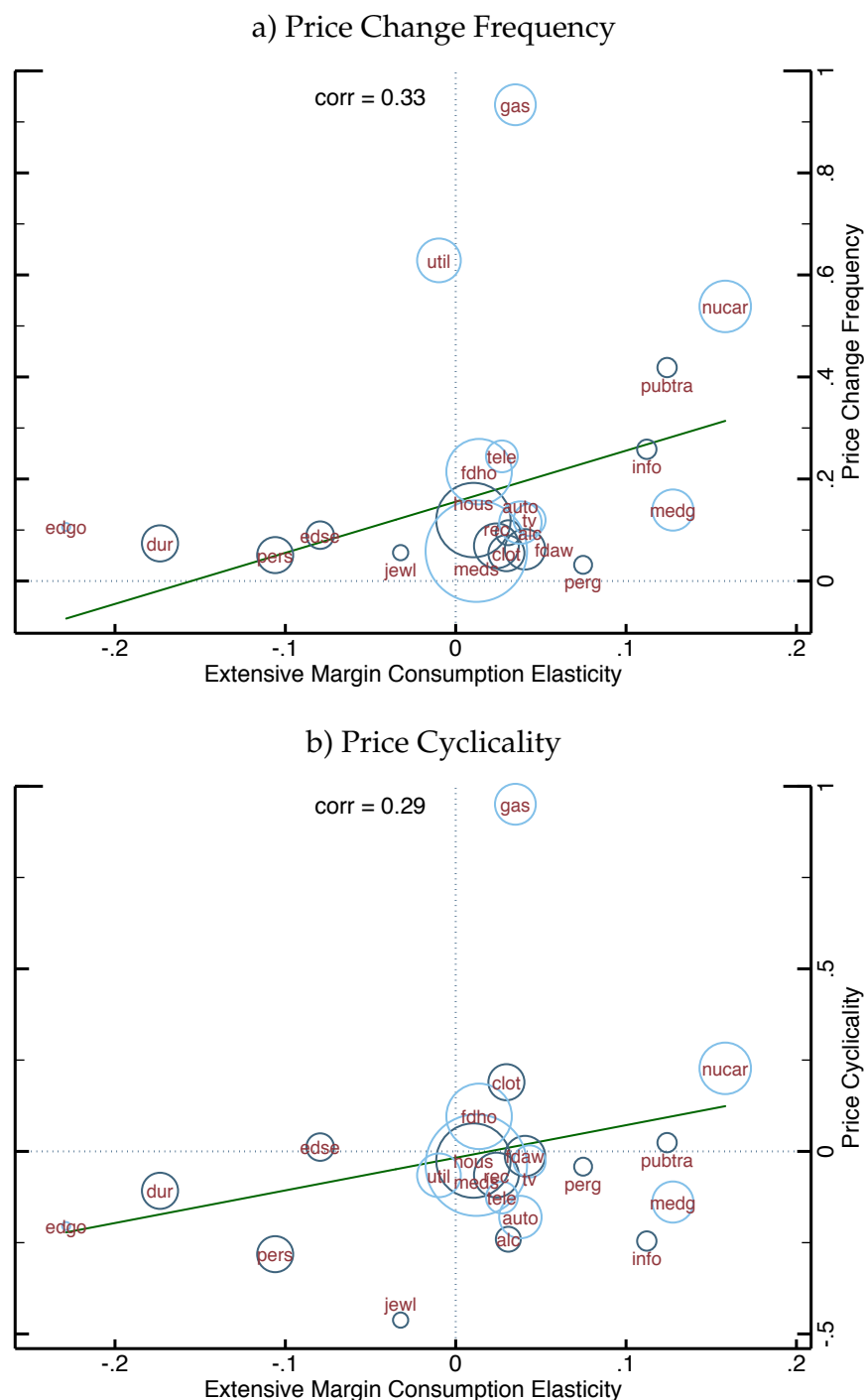
Extensive Margin Correlations are robust when using the employment status of the household head

Panel a) shows the positive correlation btw. the average price change frequency 1988-2005 and a change in the employment status of the household head. Panel b) shows the correlation with price cyclicality measured in NIPA. Each circle represents a different good. The size is proportional to the expenditure share in NIPA. Light blue circles indicate basic goods with intensive margin elasticities less than one, dark blue circles indicate luxuries with intensive margin elasticities greater than one. Correlation refers to the weighted correlation.

Figure B.2: Symmetry of Extensive Margin Consumption Elasticities

Extensive Margin Consumption Responses are fairly symmetric to employment and unemployment

Dark blue balls indicate consumption responses upon employment. Light blue balls indicate consumption responses when a household member becomes unemployed. Goods are ordered by their average price change frequency in ascending order. Green arrows indicate 90% confidence intervals. Standard errors are clustered at the household level.

Table B.1: Correlation btw. Extensive Margin Consumption & Price Stickiness

a) Average Price Change Frequency 1988-2005

	baseline	male heads	age 20-65	CEX share	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	.107	.129*	.100	.066	.107	.014
	[.076]	[.071]	[.075]	[.052]	[.076]	[.058]
correlation	.328	.318	.348	.267	.328	.057

b) Median Price Change Frequency 1988-2005

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	.108	.132*	.101	.066	.108	.013
	[.074]	[.069]	[.072]	[.054]	[.074]	[.057]
correlation	.345	.342	.367	.275	.345	.054

c) Price Cyclicality (NIPA) 1980-2016

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	.089	.166	.053	.058	.089	.046
	[.069]	[.116]	[.049]	[.041]	[.069]	[.028]
correlation	.281	.426	.189	.245	.281	.193

d) Price Cyclicality (CPI) 1980-2016

	baseline	male heads	age 20-65	CEX shares	EC deflator	log
	(1)	(2)	(3)	(4)	(5)	(6)
beta	.029	.036*	.023	.022	.029	0.030**
	[.024]	[.021]	[.026]	[.015]	[.024]	[.014]
correlation	.209	.211	.192	.221	.209	.299

Extensive margin results using the employment status of the household head are robust
Each coefficient in the table represents the slope of a linear regression of the respective price flexibility measure on extensive margin elasticities as measured by the employment status of the household head. Correlation refers to the (NIPA) expenditure-weighted correlation between both. Columns present different specifications. Column (1) presents the baseline regression as plotted in figure 2. Column (2) restricts the sample to male household heads. Column (3) encompasses a bigger sample through a wider age range. Column (4) weights the correlation via expenditure shares from the CEX. Column (5) checks robustness when deflating CEX expenditure categories with good-specific price indices from the CPI. Column (6) employs a log specification for good-specific expenditures instead of relative household expenditures (left hand side variable). Table a) and b) present results for price change frequencies. Table c) and d) for price cyclicality measures using NIPA or CPI price indices respectively.

APPENDIX C - Calibration

This appendix section describes how I calibrate the preference parameters of the non-homothetic utility function: λ, ϕ, η.

I use as three target moments: i) the expenditure share of basic goods, ii) the relative expenditure (income) elasticity of basic market goods and luxuries and iii) the price elasticity of substitution between basic market goods and luxury goods. Because the utility is time-separable one can think of the household problem as a two-stage budgeting procedure where the decision between consumption and savings (first step) is separate from the intra-temporal consumption allocation (second step). The second step describes the marginal rate of substitution between basic market goods and luxuries and yields FOC (4.8). The budget constraint in turn is given by $P_B X_B + P_L C_L = C$, where C is total consumption and in steady state given by $C = Y^n - P_B G H$. Rearranging (4.8) for C_L and using the resulting expression in the budget constraint then yields the budget share for basic market goods as the first moment:

$$\frac{P_B X_B}{C} = \left(1 + \left(\frac{P_L}{P_B} \right)^{1 - \frac{1}{\phi}} C_B^{\frac{\rho + \lambda - 1}{\phi}} \eta^{\frac{1}{\phi}} X_B^{\frac{1 - \rho - \phi}{\phi}} \right)^{-1}$$

which calibrates η for given values of λ and ϕ.

Using the FOC (4.8) in the budget constraint furthermore defines an implicit function $h(X_B, C_L, C)$ in the quantity of market goods, luxuries and total consumption. Using the implicit function theorem to calculate both partial derivatives $\partial X_B / \partial C$ and $\partial C_L / \partial C$ and thus the respective the expenditure elasticity allows the computation of the relative expenditure elasticities as

$$\frac{\frac{\partial log X_B}{\partial log C}}{\frac{\partial log C_L}{\partial log C}} = \frac{1 + \frac{\phi}{1-\rho} \left(\frac{P_L}{P_B} \right)^{\frac{\rho}{1-\rho}} \eta^{\frac{1}{\rho-1}} C_B^{\frac{1-\rho-\lambda}{1-\rho}} C_L^{\frac{\phi+\rho-1}{1-\rho}}}{1 + \left(\frac{P_L}{P_B} \right)^{1-\frac{1}{\phi}} \eta^{\frac{1}{\phi}} \left(C_B^{\frac{\lambda+\rho(1-\phi)-1}{\phi}} X_B^{\frac{(1-\phi)(1-\rho)}{\phi}} \frac{\lambda+\rho-1}{\phi} - \frac{1-\rho}{\phi} C_B^{\frac{\lambda+\rho-1}{\phi}} X_B^{\frac{1-\rho-\phi}{\phi}} \right)} \frac{S_L}{S_B}$$

where $S_B = P_B X_B / C$ and $S_L = P_L C_L / C$ are the respective budget share.

The calculation of the elasticity of substitution (EoS) between basic market goods and luxury goods is somewhat more involved. Using the definition of Allen et al. (1938) the

EoS between two goods a and b given a utility function $x = f(a,b)$ is given by

$$EoS \equiv \frac{\frac{a}{b}d\left(\frac{b}{a}\right)}{\frac{1}{MRS}dMRS} = \frac{f_a f_b (a f_a + b f_b)}{ab \left[2 f_a f_b f_{ab} - f_a^2 f_{bb} - f_{aa} f_b^2\right]}$$

where $MRS = f_a(a,b)/f_b(a,b)$ is the marginal rate of substitution between goods a and b. Since my model embeds home-production within the utility function and good b therefore enters utility $f(a, g(b))$ only indirectly through home-production function $g(b)$, the Allen-elasticity of substitution modifies to

$$EoS \equiv \frac{f_a f_b (a f_a + b f_b)}{ab \left[f_a f_{ab} f_b g_b - f_a^2 f_{bb} g_b - f_a^2 f_b g_{bb} - f_{aa} f_b^2 g_b^2 + f_a f_{ab} f_b g_b^2\right]}.$$

Since f is given by (4.2) and g by (4.3) with $a = C_L$ and $b = X_B$ we can derive the elasticity of substitution as

$$EoS = \frac{\frac{1}{X_B} + \frac{1}{QC_L}}{\frac{\lambda}{X_B} + \frac{\phi}{QC_L} - \frac{1-\rho}{X_B}\left[\left(\frac{X_B}{C_B}\right)^\rho - 1\right]}$$

where $Q = P_L/P_B$.