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Economics

2019

Essays on the Real Effects of Monetary Policy

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Princeton, NJ : Princeton University

<http://arks.princeton.edu/ark:/88435/dsp01jh343w16n>

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ESSAYS ON THE REAL EFFECTS OF MONETARY POLICY

MICHAEL DOBREW

A DISSERTATION

PRESENTED TO THE FACULTY

OF PRINCETON UNIVERSITY

IN CANDIDACY FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

RECOMMENDED FOR ACCEPTANCE

BY THE DEPARTMENT OF ECONOMICS

ADVISOR: ATIF MIAN

JUNE 2019

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Abstract:

In this dissertation I investigate the question of how monetary policy affects the real economy. Each chapter looks at a different component of the macroeconomy.

In the first chapter I study how empirically observed consumption behavior influences monetary policy transmission into output and prices. I show that extensive margin changes in employment status lead households to consume disproportionately more flexible price goods. In contrast to that, intensive margin changes of permanent income prompt households to consume more sticky prices goods. In a multi-sector New Keynesian model with labor market frictions, non-homothetic preferences and home-production I argue that monetary policy - even if solely interested in price stability - should take into account developments in the labor market and optimally follows a dual mandate in inflation and employment stabilization.

In the second chapter I study labor market responses to monetary policy shocks using individual-level microdata. In particular I distinguish between intensive margin responses of hourly wages and hours worked and extensive margin responses of changes in labor market status. I find that expansionary monetary policy shocks have little effects on hourly wages and hours worked and thus do not influence the intensive margin. However, they have significant extensive margin effects through increasing employment and labor force participation.

In the third chapter I empirically investigate how monetary policy during the financial crisis affected firm investment and firm financial outcomes. To that end I examine the floating-rate channel of firm bond-financing and study how the unexpected reduction of policy rates at the onset of the crisis differentially affected firms depending on whether they issued floating-rate or fixed-rate coupon bonds before the crisis. I show that “treated” floating-rate issuers reduced real investment less than fixed-rate issuers but otherwise had little differences in financial outcomes.

Acknowledgments:

Obtaining a doctoral degree from a university like Princeton is as big as it gets. While I often felt like a failure, by any normal and objective measure this constitutes a grand success. As any success, this one had many fathers.

First and foremost I am indebted to my advisors Atif Mian, Oleg Itskhoki and Mark Aguiar. From Atif I have learned the most important lesson at this stage of my life: to take responsibility for my own decisions. I thank him for trusting in me and my abilities when I myself haven't done so and apologize for not having been able to repay that trust to the degree I would have liked to. I thank Oleg for his never-ending enthusiasm for anything related to economics. Whenever I think back to his lectures and seminar participations, I always see pure, raw and contagious excitement. I thank Mark for transpiring the spirit of not taking ourselves and the things we are engaged with more seriously than needed. This has often helped me put things into perspective.

There are many more people I need to thank and to my shame I cannot do proper justice to all of them. First, I want to thank my mom and my dad. They had to bear the brunt of my ups and downs during my time at Princeton and this PhD is as much their's as it is mine. In particular, without my dad I would have been lost many more times than I'm comfortable admitting. I also want to thank my wider family, in particular Лела Сребка, Чичо Колъо, Бате Русе и Баба Злата for being unconditionally there for me. I'm sorely indebted to Oli and Franzi who hosted me way too many times and anchored me more often than they themselves are aware of. The same goes for family Csernak. I also want to thank three very special girls - Mila, Minjoung and Jasmin - all of which have supported me through different phases of the PhD and without which I would have had to carry more at each stage than I could have handled by myself. The same goes for my friends Jakob, Julius and David Cho. I have to apologize to Lao Yang for wasting so many opportunities for

meaningful conversations but am extraordinarily grateful to have met an old soul like hers. I want to thank Ahn Sehyoun, Paul Ho, Donghwa Shin and Dima Mukhin for being amazing office mates and for many insightful discussions over countless lunches. It's not an understatement to say that the bulk of my knowledge gained at Princeton derives from these discussions. I also want to thank my Russian office mates Andrei and Denis for bringing in the fun and a slight feeling of home. Lastly, I want to thank my Berlin friends who have always taken an interest in my progress.

While the connection to my PhD is not immediately apparent, I also want to thank my former soccer coaches. In particular I'm sorely indebted to Horst Hauschild, Dieter Hahn, Helmut Schieck and Ronny Müller. Each one of them has taught me a different aspect of the game and life in general. During my PhD I have looked back countless times to the example they've set and found old and new lessons and consolations over and over again. They have planted and watered the seed that is still growing.

Finally, I can not thank Laura Hedden enough. She is the rock in the surf, the calm amidst the storm of existential problems. A true gem hidden in the Princeton administration. I think no PhD in economics at Princeton would be possible without her - certainly not mine. Thank you!

To everybody who supported and taught me on my way.

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Chapter 1

(Dis-)Aggregate Consumption and Monetary Policy

1.1 Introduction

The consumption response to income changes is of interest to economists and policy makers alike. If consumption is very responsive, stimulus policy can be very effective in raising demand. The natural concern is, that higher demand comes at the cost of higher prices. This trade-off between transmission into quantities and prices is of particular concern to monetary policy with its prime mandate of price stability. Consumption elasticities however 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 because they stimulate consumption of a different set of goods. This is true especially if there is a systematic relationship between consumption elasticities and price change frequencies that differs across the intensive and extensive margin.

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. In order to theoretically assess the implications for monetary policy I finally build a multi-sector New Keynesian model with non-homothetic preferences, home-production and labor market frictions.

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, recreational services or 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 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. Overall a switch of a household member into employment increases consumption of necessities by almost 3% with little changes in luxury consumption. 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. Additionally using household demographics controls allows me to capture predictably changes like switching from college to employment but remaining in the household. 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 composition. 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 a relatively more important role for extensive margin consumption elasticities as increases in unemployment lead to lower consumption of flexible price necessities.

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 necessities 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 employment status.

I use my model to derive three results. First, monetary policy is more effective in raising output but also raises prices more 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 worse in my model. A 25 basis point innovation to a typical Taylor Rule increases inflation by 0.4 percentage points more compared to a standard New Keynesian model but real GDP rises only by 0.3 percentage points more.

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 in an out-of-steady-state economy with a higher unemployment rate of 10%. In the latter economy monetary policy has a stronger impact on employment due to the larger deviation of unemployment from its natural rate. However, because this increased transition into employment decreases home production the representative family increases market demand for necessities. Producers of necessities react to this demand increase almost solely by increasing prices without

producing additional quantities of necessities. The stimulus overall leads to 1% higher inflation (annualized) with negligible additional effects on real output.

Third, I show that optimal monetary policy follows a dual mandate in inflation and unemployment. I compute welfare and do a numerical search for the optimal response coefficients to inflation, real output and unemployment of a typical Taylor rule with interest rate smoothing. Despite imposing the Hosios condition which renders labor market frictions unimportant, I find that optimal monetary policy should react to unemployment deviations from its natural rate. However, as is standard in the New Keynesian literature, the response coefficient to inflation maintains its superior importance and is an order of magnitude larger than the response coefficient to unemployment.

Related Literature

This chapter 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 While I do not focus on the particular source of income changes, I contribute to the literature by explicitly distinguishing between

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

changes at the intensive and extensive margin. Closest in spirit to my chapter 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 chapter also relates to the literature on household production. Benhabib et al. (1991) 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 chapter is most closely related to Nevo and Wong (2015). They show that shopping time behavior changed during the Great Recession towards larger sized, more generic and on-sale goods. My extensive margin estimates are consistent with a shift away from home production of necessities. I additionally show that market purchases tend to happen in rather flexible price goods. I theoretically embed these results via a home-production function. The main innovation comes from allowing only a subset of goods (necessities) to be home-produced, whereas the literature only considers substitutability for the whole 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 however mixed. 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 is more powerful 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 state-dependence arising from the household side and propose extensive margin consumption of flexible price goods as a potential mechanism for the varying effectiveness of monetary policy over the business cycle.³⁴

Lastly, this chapter relates to a vast literature on New Keynesian (NK) DSGE models. I contribute to this literature by implementing a more complex preference structure with non-homothetic preferences that nests household production. This structure allows to capture 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 of the NK model have been studied amongst others by Barsky et al. (2003, 2007) and Bils, Klenow and Kryvtsov (2003). They show that NK models with heterogeneous pricing frictions counterfactually predict negative sectoral output comovement in response to a monetary policy shock.⁶

²Eichenbaum 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 shocks, expansionary monetary policy is less effective due to lower gains of refinancing compared to the earlier cycle of interest rate cuts.

³There 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.

⁴The 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.

⁵This approach differs from the usual search and matching approach by i) only implicitly modeling 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.

⁶The literature has cast this “comovement puzzle” in a model with flexible price durable and sticky price nondurable consumption. A number of mechanisms have been suggested as a resolution that usually rely on a combination of habit formation (Huang et al. (2013)), wage rigidity (Cenesiz and Guimarães (2013)) or labor market frictions (Di Pace and Hertweck (2016)). In general any mechanism that inhibits demand or marginal cost is capable of overturning the comovement result. Cantelmo and Melina (2018) instead argue that heterogeneous pricing frictions crucially rely on inclusion of housing as a durable good.

The chapter proceeds as follows. The next section describes the data and estimation methodology. Section 1.3 documents the difference between intensive and extensive margin consumption behavior. Section 1.4 introduces non-homothetic preferences and home-production into a New Keynesian model. Section 1.5 describes the calibration. Section 1.6 shows the model implications for monetary policy and Section 1.7 concludes.

1.2 Measuring Intensive and Extensive Margin Consumption Elasticities

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

1.2.1 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 consecutive quarters.⁷ 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

⁷In practice households are interviewed for up to five consecutive quarters, but the first interview is solely used for pre-sampling purposes and is not available for analysis.

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. The appendix 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 43000 household observations for the intensive margin estimates and 14264 households with a change in the number of earners for estimating extensive margin elasticities. Table 1.1 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. However, the CEX under-samples some good categories because it relies on out-of-pocket expenditures. This is most pronounced for medical services (4% in the CEX 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.

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 sales-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 1988-2005.⁸

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 change 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. To construct a unique price change frequency for housing I weight renter's and owner's rent with their respective expenditure share from NIPA.⁹

⁸While 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.

⁹In 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.

The second measure relies on the cyclical nature of good-specific price indices. In particular, following [Bils et al. \(2013\)](#) I estimate

$$\log\left(\frac{P_{ct}}{P_t}\right) = \alpha + \beta \cdot \log\left(\frac{Y_t}{P_t}\right) + \nu_t \quad (1.1)$$

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 over the business cycle (relative to the overall price level) 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.¹⁰

Using different measures of price flexibility provides a good robustness check. Table 1.1 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 1.1. 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 cyclicity only slightly above average. Excluding gasoline and utilities jointly yields correlations around 0.5.¹¹

¹⁰I also check that different filtering methods for the price cyclicity measure, such as the band-pass filter of [Baxter-King](#) and [Christiano-Fitzgerald](#) as well as quadratic and cubic detrending, do not substantially alter my results.

¹¹The correlation between average and median price change frequencies (not shown) for the pooled period 1988-2005 is 0.99. 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.

1.2.2 Econometric Methodology

Estimating Intensive Margin Consumption responses

In order to estimate intensive margin consumption responses to increased income 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.¹² I gauge income elasticities for each good c via the following regression:

$$y_{cht} = \alpha_{ct} + \alpha_{ch} + \beta_c^i \cdot \log(C_{ht}) + \gamma_c X_{ht} + \nu_{cht} \quad (1.2)$$

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.¹³ I undertake the following steps to assure that β_c^i indeed measures an intensive margin consumption response due to increased income. First, household fixed effects ensure that unobserved, time-invariant 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.

¹²As 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 globally log-linear 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 is nevertheless a sufficiently good approximation.

¹³As 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. Furthermore, current household income is only available in the first and fourth interview of the CEX.

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 the absence of any extensive margin adjustments.

One complication in the estimation of (1.2) 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: $\tilde{y}_{cht} = y_{cht}/\bar{y}_{ct}$.¹⁴

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 lead to potentially biased estimates. A standard technique therefore 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 (1.2) by instrumenting $\log(C_{ht})$ with total expenditures from the first interview. This strategy exploits the fact that total expenditures are based on permanent income and hence are strongly correlated over time thereby satisfying the relevance condition.¹⁵

Finally, (relative) prices do not enter the estimation of equation (1.2). To the degree that relative price movements are common across all households, they are absorbed by time fixed effects. However, recent research has shown that households potentially face different relative prices based on shopping behavior and quality choices.¹⁶ Due to the lack of household level price data in the CEX, I therefore rely

¹⁴Because of concerns that households with large deviations may influence the estimation I check and report results for the log-specification as well.

¹⁵Additionally, all results are robust to instrumenting with labor income, total before- or after-tax income and using total expenditures and income as joint instruments.

¹⁶See e.g. Kaplan and Schulhofer-Wohl (2017) and Nevo and Wong (2015).

on the additional identifying assumption that relative price movements are common across households.

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:

$$y_{cht} = \alpha_{ch} + \alpha_{ct} + \beta_c^e \cdot \# \text{Earners}_{ht} + \gamma_c X_{ht} + \nu_{cht} \quad (1.3)$$

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 is the semi-elasticity β_c^e which 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 (1.3) I implicitly assume that consumption responses upon employment are

symmetric to those upon unemployment. Appendix table 1.12 shows that elasticities are indeed fairly symmetric.

For robustness checks I also rely on the employment status of the household head (Appendix B). I define employment as an indicator that equals one if the household head worked a positive number of weeks in the 12 month prior to the interview. However, the CEX only asks information on the employment status in the first and fourth interview. This implies a considerably lower sample size (2614 households) and makes the number of earners (14264 households) 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

$$\text{Elasticity}_c = \alpha + \beta \cdot \text{Price Flexibility}_c + \nu \quad (1.4)$$

where $\text{Elasticity}_c \in \{\beta_c^i, \beta_c^e\}$ is the good-specific intensive or extensive margin elasticities estimated from (1.2) and (1.3) respectively. *Price Flexibility*_c in turn is either the monthly price change frequency or the price cyclicalities of good *c*.

1.3 Empirical Results

In this section I establish three main empirical facts: (i) households disproportionately increase consumption of sticky price goods, when their income increases at the intensive margin (ii) upon employment households disproportionately increase consumption of flexible price goods and (iii) these effects estimated from micro-level data are visible and do not wash out at the aggregate level.

Intensive Margin Consumption Response

Intensive margin consumption elasticities vary widely. Table 1.2 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.¹⁷

Households disproportionately spend intensive margin income increases on goods with sticky prices. Panel a) of figure 1.2 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 circles) have a lower average price change frequency of 8 percent per month compared to 18 percent for necessities (light blue circles).¹⁸ Excluding public transportation as an obvious outlier raises the correlation to -0.55.¹⁹

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 cyclicalities as a price flexibility measure. Excluding gasoline still yields a comparably negative correlation of -0.36.

¹⁷I exclude tobacco from all regressions as it constitutes the only inferior good with a negative elasticity.

¹⁸These 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.

¹⁹Besides 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.

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 1.3 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) even 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 indices 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 1.3 shows that using the median instead of the average price change frequency yields very similar results. Panel d) furthermore confirms that measuring price cyclicalities via CPI price indices yields similar results to using price indices from NIPA.

Extensive Margin Consumption Response

Extensive margin consumption elasticities exhibit pronounced heterogeneity. Table 1.2 shows that household expenditures increase the most for purchases of new and used cars (.079), vehicle maintenance (.066), gasoline (.046) and TV (.054) after a household member switches into employment. 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 a household member switches into employment, households disproportionately increase consumption of goods with more flexible prices. Panel a) of figure 1.3 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 cyclical 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. Figure 1.3 shows that the four goods with the highest extensive margin elasticity are all necessities. Additionally, all consumption elasticities for necessities are positive, except for educational goods with a negligible expenditure share of 0.2%. The average extensive margin elasticity for necessities is 3% but close to zero for luxuries.²⁰ Figure 1.4 provides a graphical representation on the statistical significance of the estimates. Whereas six out of nine elasticities for necessities are statistically significant (treating housing as a near-unit elastic good), only four out of eleven coefficients for luxuries are significant. Setting the elasticities to zero for insignificant estimates (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 cyclical 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 1.4 shows 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

²⁰The 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% for a sample of people aged 50 or above. However, they focus on the Great Recession which unlikely constitutes a representative time period.

but weak correlations around 0.15 for the price change measure and around 0.2-0.3 for the price cyclicality measure. Appendix table 1.7 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.²¹ A much more plausible interpretation would be, that educational and personal expenditures are necessary to increase the likelihood of employment and are cut back once a job opportunity arises.

Aggregate Evidence

I construct a measure of the aggregate, economy-wide 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 in aggregate price flexibility 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.²²

²¹Additionally, 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.

²²Vavra (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 consumption-based counterpart that indicates in which direction consumption patterns affect economy-wide price stickiness over the business cycle.

The household level evidence from the previous two sections is reflected in the aggregate level as well. Panel a) of figure 1.5 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.²³ 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 (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.

²³The 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.

1.4 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 derive implications for monetary policy transmission.

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 necessity 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 consumption of necessities 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 necessities having more flexible prices. In order to produce, retail firms rely on a (single) intermediate good from intermediate firms as a production input.²⁴ Intermediate

²⁴This 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.

firms are perfectly competitive and recruit workers in a frictional labor market.²⁵ 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 period-by-period Nash bargaining which directly takes place between individual household members and intermediate firms.

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

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{V(C_{Nt}, C_{Lt})^{1-\sigma}}{1-\sigma} - \chi \frac{N_t^{1+\varphi}}{1+\varphi} \right) \quad (1.5)$$

where V_t is an intra-temporal consumption aggregator of necessary and luxury consumption, C_{Nt} 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,²⁶ 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 (addilog) specification of the form

$$V(C_{Nt}, C_{Lt}) = \left(C_{Nt}^{1-\lambda} + \frac{\eta(1-\lambda)}{1-\phi} C_{Lt}^{1-\phi} \right)^{1/(1-\lambda)} \quad (1.6)$$

²⁵The 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 also subject to labor market frictions.

²⁶More 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.

where λ and ϕ are curvature parameters and η governs the relative expenditure share. 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).²⁷ The specification nests a standard homothetic CES aggregator as a special case for $\lambda = \phi$, which would imply that relative consumption between necessities and luxuries depends only on relative prices. For $\lambda \neq \phi$ preferences are non-homothetic and appendix C shows how the parameters are related to the intra-temporal elasticity of substitution, income elasticities and expenditures shares.²⁸

I assume that luxury consumption can only be obtained through market purchases of luxury goods (i.e. formally $C_{Lt} = X_{Lt}$). Consumption of necessities however can either be obtained through market purchases of necessities, X_{Nt} , or through home-production by unemployed household members.²⁹ Necessary consumption is thus an aggregate with assumed functional form

$$C_{Nt} = (X_{Nt}^\rho + \psi(1 - N_t)^\rho)^{1/\rho} \quad (1.7)$$

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

²⁷Further 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).

²⁸A 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 Bertolotti, Etro and Simonovska (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.

²⁹At least two arguments provide justification for assuming this particular technology of home production. First, it is ex ante reasonable to assume that households are only able to home-produce necessities like food at home or health care. Luxuries like watches or household durables are luxurious goods precisely because they are associated with higher social status and imperfect access. Second, empirical evidence from the American Time Use Survey suggests that most of the time at home is spent on the production of necessities.

obtain both goods only through market purchases. For $\psi > 0$ households home-produce some necessities. Implicit in the above formulation is the assumption that all unemployed members automatically devote their time to the home-production of necessities.

Employment N_t evolves over time according to

$$N_t = (1 - \delta)N_{t-1} + x_t U_t^0 \quad (1.8)$$

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

$$U_t^0 = 1 - N_{t-1} + \delta N_{t-1} = 1 - (1 - \delta)N_{t-1}. \quad (1.9)$$

Equation (1.8) implies that current hires become immediately productive.³⁰ I assume that unemployed members passively search for work and hence don't explicitly model a labor market participation decision. 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

³⁰This 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.

$$P_{Nt}X_{Nt} + P_{Lt}C_{Lt} + Q_tB_t = \int_0^1 W_t(j)n_t(j)dj + B_{t-1} + \Phi_t + T_t \quad (1.10)$$

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 firm³¹, $\Phi_t = \sum_s \Phi_{st}$ denotes the sum of sectoral profits Φ_{st} remitted by retail firms in sector $s \in \{B, L\}$ and T_t are lump-sum taxes. As usual, the household faces a solvency condition which prevents it from engaging in Ponzi schemes.

Using (1.6) directly in the household objective function (1.5) 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_{Nt} and C_{Lt} yields an expression for the marginal rate of substitution between necessary and luxury consumption given by

$$\frac{\partial V_t / \partial C_{Nt}}{\partial V_t / \partial C_{Lt}} = \frac{\mu_{2t}}{\mu_{1t}} \frac{1}{P_{Lt}} = \frac{C_{Nt}^{-\lambda}}{\eta C_{Lt}^{-\phi}}. \quad (1.11)$$

The FOC for market purchases of necessities, X_{Nt} combined with the FOC for consumption of necessities, C_{Nt} , yields

$$\frac{P_{Nt}}{P_{Lt}} = \left(\frac{X_{Nt}}{C_{Nt}} \right)^{\rho-1} \frac{C_{Nt}^{-\lambda}}{\eta C_{Lt}^{-\phi}} \quad (1.12)$$

and the inter-temporal optimality condition is given by

$$Q_t = \beta E_t \left\{ \frac{\mu_{1t+1}}{\mu_{1t}} \right\} = \beta E_t \left\{ \left(\frac{V(C_{Nt+1}, C_{Lt+1})}{V(C_{Nt}, C_{Lt})} \right)^{\lambda-\sigma} \left(\frac{C_{Lt+1}}{C_{Lt}} \right)^{-\phi} \frac{P_{Lt}}{P_{Lt+1}} \right\}. \quad (1.13)$$

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

³¹As shown below, in equilibrium each employed member receives the same wage $W_t(j) = W_t$ so that $\int_0^1 W_t(j)n_t(j)dj = W_t N_t$

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

$$MRS_t = \frac{P_{Lt}}{\eta C_{Lt}^{-\phi}} \left[\chi N_t^\varphi V(C_{Nt}, C_{Lt})^{\sigma-\lambda} + C_{Nt}^{-\lambda} \psi \left(\frac{1 - N_t}{C_{Nt}} \right)^{\rho-1} \right] \quad (1.14)$$

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 producing necessary consumption at home.

Retail Firms

There is a separate retail sector for necessary and luxury goods. Output of sector $s \in \{N, L\}$ is determined by the aggregation technology $Y_{st} = [\int Y_{st}(j)^{(\epsilon-1)/\epsilon} d(j)]^{\epsilon/(\epsilon-1)}$, where ϵ is equal across sectors and measures the elasticity of substitution between individually differentiated goods. This implies 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 $P_{st} = [\int P_{st}(j)^{1-\epsilon} dj]^{1/(1-\epsilon)}$.

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 $\Phi_{st,t+k}(j) = P_{st}(j)Y_{st,t+k}(j) - P_{t+k}^I M_{st,t+k}(j)$.³² The firm thus chooses its price to

³² $Y_{st,t+k}(j) = (P_{st}(j)/P_{st+k})^{-\epsilon} Y_{st+k}$ 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.

maximize

$$E_t \sum_{k=0}^{\infty} \theta_s^k Q_{t,t+k} Y_{t,t+k}(j) [P_{st}(j) - P_{t+k}^I]$$

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 marginal cost of a typical New Keynesian model.

The optimal price given by the first order condition is

$$P_{st}^*(j) = \frac{\epsilon}{\epsilon - 1} E_t \left\{ \frac{\sum_{k=0}^{\infty} \theta_s^k Q_{t,t+k} Y_{st+k} P_{st+k}^{\epsilon} P_{t+k}^I}{\sum_{k=0}^{\infty} \theta_s^k Q_{t,t+k} Y_{st+k} P_{st+k}^{\epsilon}} \right\}. \quad (1.15)$$

The price level in sector s is given by

$$P_{st} = [\theta_s P_{st-1}^{1-\epsilon} + (1 - \theta_s) P_{st}^{*1-\epsilon}]^{\frac{1}{1-\epsilon}}. \quad (1.16)$$

since all retail firms in a given sector reset to the same price, i.e. the right hand side in equation (1.15) does not depend on j .

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

$$Y_t^I(i) = A_t N_t(i)^{1-\alpha} \quad (1.17)$$

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 to

$$N_t(i) = (1 - \delta)N_{t-1}(i) + H_t(i) \quad (1.18)$$

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 necessity and assumed to be exogenous.³³ 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 form³⁴

$$G_t = G(x_t) = \Gamma x_t^\gamma. \quad (1.19)$$

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

³³Since hiring cost are small in the 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.

³⁴Note 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 $\gamma \equiv \frac{1-\varsigma}{\varsigma}$.

described by the condition³⁵

$$MRPN_t(i) = W_t(i) + P_{Nt}G_t - (1 - \delta)E_t \{Q_{t,t+1}P_{Nt+1}G_{t+1}\} \quad (1.20)$$

where $MRPN_t(i) \equiv P_t^I(1 - \alpha)A_tN_t(i)^{-\alpha}$ is the nominal marginal revenue product of labor, which equals the cost of a marginal worker. The latter depends on the nominal wage, hiring costs and discounted savings of future hiring costs.

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

$$S_t^H(i) = W_t(i) - MRS_t + (1 - \delta)E_t \{Q_{t,t+1}S_{t+1}^H(i)\} \quad (1.21)$$

where MRS_t is the household's marginal disutility of labor market effort given by the right hand side of (1.14).

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

$$S_t^F(i) = MRPN_t(i) - W_t(i) + (1 - \delta)E_t \{Q_{t,t+1}S_{t+1}^F(i)\}. \quad (1.22)$$

³⁵The corresponding nominal profit function that the intermediate firm maximizes is $\Phi_t^I(i) = E_t \{ \sum_k Q_{t,t+k} (P_{t+k}^I Y_{t+k}^I(i) - W_{t+k}(i)N_{t+k}(i) - P_{Nt+k}G_{t+k}H_{t+k}(i)) \}$ subject to (1.18).

Together with (1.20) this implies $S_t^F(i) = P_{Nt}G_t$ 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

$$\xi S_t^H(i) = (1 - \xi) S_t^F(i). \quad (1.23)$$

Together with (1.21) and (1.22) this implies the associated nominal wage

$$W_t(i) = \xi MRS_t + (1 - \xi) MRPN_t(i). \quad (1.24)$$

Using (1.20) 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 (1.20) further yields

$$P_{Nt}G_t - (1 - \delta)E_t \{Q_{t,t+1}P_{Nt+1}G_{t+1}\} = \xi(MRPN_t - MRS_t) \quad (1.25)$$

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

Monetary & Fiscal Policy

The government runs a period-by-period balanced budget 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

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\rho_r} \left[\left(\frac{\Pi_t}{\Pi} \right)^{\phi_p} \left(\frac{Y_t}{Y} \right)^{\phi_y} \right]^{1-\rho_r} \varepsilon_{r,t} \quad (1.26)$$

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 $0 \leq \rho_r < 1$, whereas $\phi_y \geq 0$ indicates the responsiveness of monetary policy to aggregate output growth while $\phi_p \geq 1$ governs the responsiveness of the monetary authority to economy wide inflation.

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

$$P_t = \frac{P_{Nt}Y_{Nt} + P_{Lt}Y_{Lt}}{P_N Y_{Nt} + P_L Y_{Lt}}. \quad (1.27)$$

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

Market Clearing

Market Clearing of the intermediate goods market requires that demand for intermediate goods across both retail sectors equals supply from intermediate firms:

$$\sum_{s \in \{N, L\}} \int_0^1 M_{st}(i) di = \int_0^1 Y_t^I(j) dj. \quad (1.28)$$

The left hand side is given by the relationship between retail output 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 .³⁶ Because hiring cost are paid in terms of the necessity, market clearing in the retail sector for necessary goods is given by

$$Y_{Nt} = X_{Nt} + H_t G_t \quad (1.29)$$

while market clearing for the luxury good is simply

$$Y_{Lt} = C_{Lt}. \quad (1.30)$$

The right hand side of (1.28) is described by the production technology of intermediate firms

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

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.

³⁶These price dispersions are zero in steady state and up to a first order approximation outside of the steady state.

Equilibrium Definition

A stationary competitive equilibrium is a set of endogenous stationary processes $\{X_{Nt}, C_{Lt}, N_t, Q_t, P_{Nt}, P_{Lt}, P_t^I, A_t, Y_t^I, G_t, x_t, W_t, P_t, R_t, \Pi_t, Y_t\}_t$ and exogenous processes $\{\varepsilon_{at}, \varepsilon_{rt}\}_t$ satisfying equations (1.6)-(1.8), (1.11)-(1.14), (1.16), (1.19), (1.20), (1.26)-(1.30).

1.5 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 $\{\rho_r, \phi_p, \phi_y, \sigma_\varepsilon^2\}$. Table (1.7) gives an overview of the calibration which I discuss in detail in the following. The period is taken to be a quarter.

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 is determined by equation (1.25) for a given values of ξ and ψ and is equal to 0.39.

I calibrate $\{\lambda, \eta, \phi\}$ jointly by targeting i) the expenditure share of necessities, ii) the relative income elasticities of necessities and luxuries and iii) the elasticity of substitution between necessities and luxuries. Appendix C provides details on the analytical expressions for each. The expenditure share of necessities 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 substitution around 1.7. These moments imply values for $\lambda = 1.01$, $\phi = 0.36$ and $\eta = 1.04$.

The elasticity of substitution towards necessities upon employment is around 3% as evinced in section (1.3), implying $\rho = 2/3$. The consumption weight ψ on home production is of crucial importance for the simulation results because it determines how valuable employment at home is. Calibrating ψ requires measuring the difference between consumption and market purchases of necessities. Under the assumption that one hour of work at home exhibits the same productivity as one hour of work in the labor market, one could empirically measure the differences between consumption and market purchases of necessities by comparing the time spent on producing necessities at home to the time spent working. Data from the American Time Use Survey implies that the typical American works 40 hours per week and spends an additional minimum of 10 hours (and more closely 15-20 hours) per week producing or consuming necessities at home.³⁷ Calibrating ψ to the minimum implies a value of 0.15 and higher values would strengthen the results presented in the next section.

Firms. The labor share is calibrated to a standard value of $\alpha = 1/3$. 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 necessary goods change their prices within a month compared to only 6% for luxuries. I thus set $\theta_N = 0.69$ and $\theta_L = 0.83$ implying a typical economy-wide Calvo-parameter of $\theta = 0.74$ 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 real business cycle literature.

³⁷Most time at home is spend on television (more than two hours per day) which certainly constitutes consumption of a necessity but not necessarily production in the sense of expending effort. Consequently, home “production” can also be understood to incorporate a leisure component.

Labor Market Frictions. In line with the literature (e.g. Gertler and Trigari (2009); Blanchard and Gali (2010); Shimer (2012a)) 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%, $x = 0.7$. This implies a 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 hiring 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 unity³⁸ and set the latter to $\Gamma = 0.1183$, implying an aggregate hiring cost of 1% of GDP. Finally, I assume that the Hosios condition holds and set the worker bargaining power ξ to the standard value of 0.5.

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 $\sigma_\varepsilon = 0.05$.

1.6 Implications for Monetary Policy

In this section I present implications for monetary policy taking into account heterogeneity in consumption elasticities and prices flexibility. First, compared to a standard New Keynesian model monetary policy leads to stronger increases in output due to an additional demand channel arising from home production. However, because the additional demand occurs for goods with more flexible prices the relative trade-off between inflation and output stimulus is generally worse. Second, monetary policy

³⁸Following footnote 34, given a Cobb-Douglas matching function $M(V_t, U_t^0) = V_t^\xi (U_t^0)^{1-\xi}$, this would imply that the relative contribution of vacancies to the matching process is equal to the contribution of unemployment, i.e $\xi = 0.5$. This is in line with the findings in the literature, see e.g. Yashiv (2006) and Gertler and Trigari (2009).

is state dependent and becomes less powerful, i.e. translates more into prices, the deeper the recession. Third, I show that optimal monetary policy follows a dual mandate and should react to both inflation and deviations of unemployment from its natural rate.

1.6.1 Comparison to a Standard New Keynesian Model

To yield quantitatively realistic predictions like hump-shaped impulse responses to monetary policy shocks, the standard New Keynesian model relies on additional features like habit formation and other adjustment frictions. My model is in its essence small-scale and does not incorporate any frictions.³⁹ The only true new element is its 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 Flexibility

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 homogeneous 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 1.6 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 demand under homotheticity only depends on relative prices. Relative prices in turn don't change since both sectors have the same price change frequency. Taken at face value, inflation increases somewhat more (by 1%) than real GDP (0.8%)

³⁹Except for labor adjustment costs to generate unemployment, which allows to investigate state-dependence of monetary policy.

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

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 in luxury consumption.

Monetary policy leads to stronger increases in output in a model with non-homothetic preferences and home-production. The reason is the existence of an additional demand channel. Expansionary monetary policy leads to increases in employment but simultaneously yields a reduction in home-produced necessities due to the fewer number of available unemployed household members. Because the representative family wants to smooth consumption of necessities, it is increasing market demand for necessities to substitute for the fall in consumption. Producers of necessities use this additional demand to increase their prices which also leads to higher inflation compared to the standard New Keynesian model.

The preference structure is overall able to capture the initial disproportionate increase in necessary goods as people switch into employment and increase their market demand for necessities. However, due to the assumed Nash bargaining of wages this effect subsides quickly as shown in panel c). Introducing nominal wage rigidities could improve the quantitative results in three ways: First, the initial response in market demand for necessities would be more pronounced because intermediate firms would have stronger incentives to hire workers if wages remain low. Second, rigid wages would reduce the overall intensive margin consumption effects because income increases are less strong. Third, the employment effect would be longer lasting due to the more gradual adjustment of wages which in turn would lead to longer-lasting effects for the demand for necessities.

⁴¹Part of the reason is the shut-down of time-varying risk aversion as mentioned in section 1.4.

Heterogeneous Price Flexibility

The basic intuition under homogeneous price frictions carries 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 producers of necessities to adjust their prices quicker and more strongly which in turn curbs demand.

Adding home production leads to an initial positive increase in market demand for necessities which compensates for reduced home production as unemployed household members switch into employment. However, producers of necessities 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 structure. Compared to the NK model the initial price increase is about a third higher which in turn implies a disproportionate increase in luxury consumption, which contradicts the evidence in the empirical section.

1.6.2 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

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

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 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.^{42,43}

Monetary Policy is less powerful and feeds more into prices if the unemployment rate is higher. Figure 1.8 shows the impulse responses to a 25 basis point innovation 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 in turn implies a stronger increase in market demand for necessities. Panel a) however shows that the equilibrium consumption response of necessities is very similar to the one in steady state. This is because producers of necessities use the additional demand to further increase their prices. Higher prices for necessities in turn lead to higher inflation. Compared to IRFs in steady state, the expansionary policy shock leads to 0.3 percentage point higher inflation that is not accompanied by higher real GDP. Thus the same innovation to the

⁴²Higher 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. However, I continue to solve my model around the deterministic steady state. Additionally, the generalized impulse response functions may depend on the sign and size of the shock. I abstract from this issue in the following.

⁴³In 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 being a 25 basis point decline in the policy rate. Averaging over all N simulations yields the forecast $\mathbb{E}_tX_{t+h}$ conditional on the realization of the shock.

Taylor Rule leads to a worsened trade-off between stimulus into GDP and inflation. This worsening trade-off implies that policy makers should aim at providing an early stimulus when signs of a worsening economy arise.

1.6.3 Optimal Monetary Policy

In order to gauge normative implications for monetary policy assume that optimal policy maximizes household welfare subject to the competitive equilibrium conditions.⁴⁴ In particular I consider the class of interest rate rules of the form

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\rho_r} \left[\left(\frac{\Pi_t}{\Pi} \right)^{\phi_p} \left(\frac{Y_t}{Y} \right)^{\phi_y} \left(\frac{U_t}{U} \right)^{\phi_u} \right]^{1-\rho_r} \varepsilon_{r,t} \quad (1.31)$$

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 and compute conditional welfare for each parameter configuration thereby accounting for the transition paths from the initial deterministic to the stochastic steady state.

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.⁴⁵ Figure 1.9a) shows that monetary policy should additionally react to unemployment, although the coefficient and thus the potential welfare improvement

⁴⁴I 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).

⁴⁵In 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.

is small. In general it is never optimal for monetary policy to react to deviations of real GDP from its steady state level. These findings differ when compared to the standard New Keynesian model as shown in figure 1.9b).

Figure 1.10 shows the reason for a dual mandate 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.

1.7 Conclusion

In this chapter 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 consumption 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.

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 disproportionately 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 albeit for flexible price goods. In general equilibrium this is almost solely absorbed through price increases by producers of necessities and leads to overall higher prices with little additional effects for real output. Finally I show, that optimal monetary policy follows a dual mandate in inflation and unemployment because smoothing changes in employment additionally helps stabilizing inflation and output.

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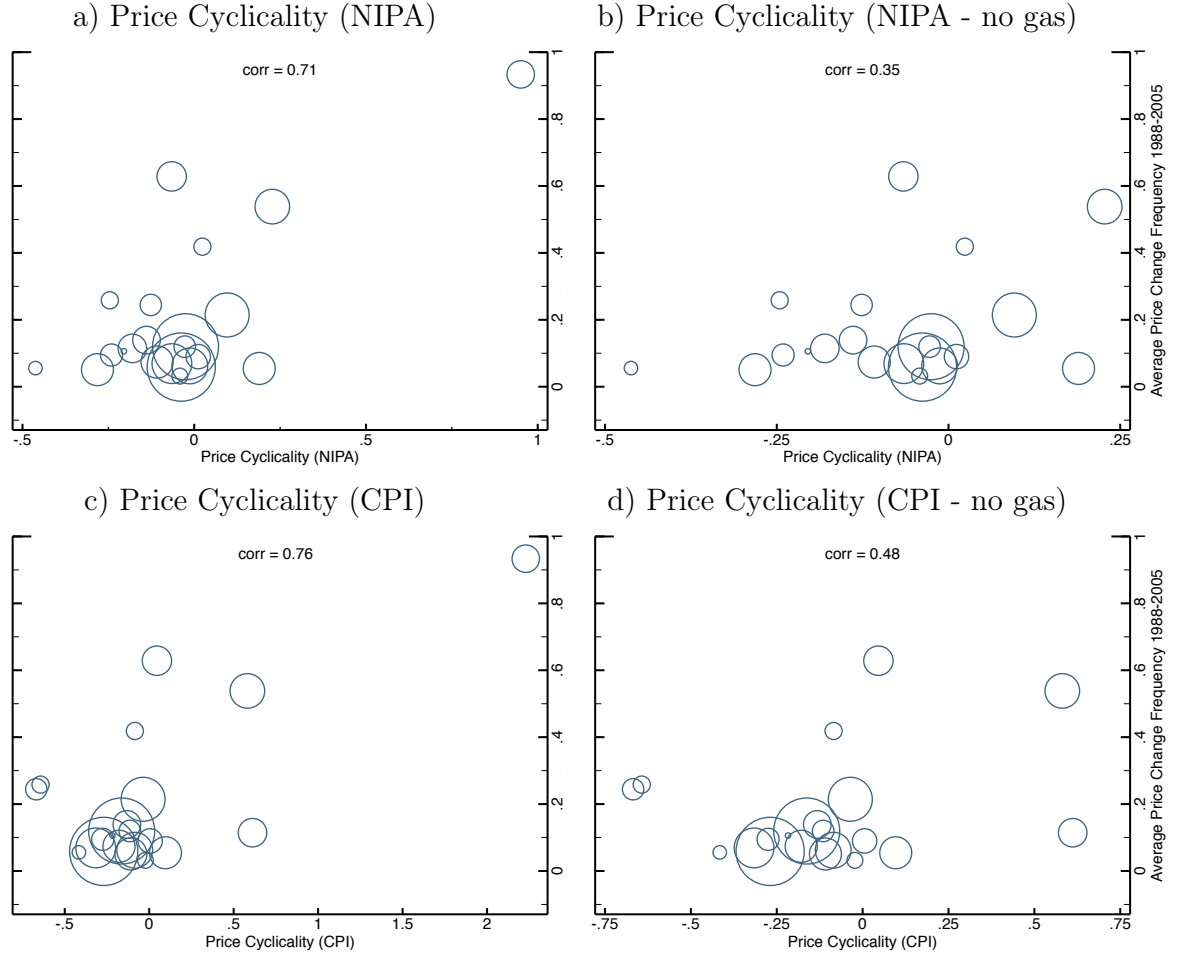
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Figures

Figure 1.1: Correlation between different measures of price stickiness

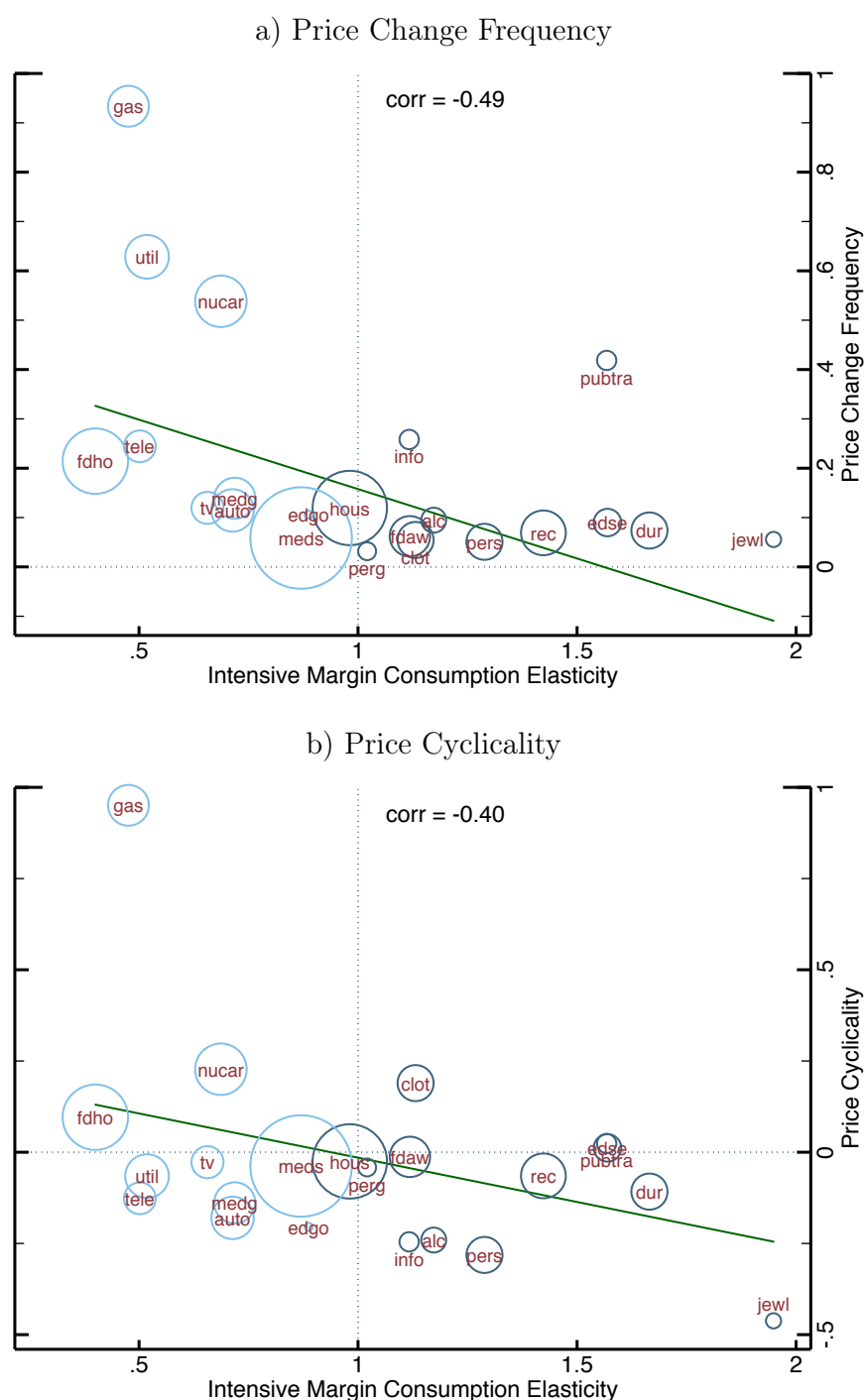


Using different price flexibility measures provides a good robustness check due to imperfect correlation

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 cyclicalities 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 1.2.1 and Appendix A provide further details on the construction.

Each circle represents one consumption good as summarized in table (1.1). 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 cyclicalities measure. Panels b) and d) exclude gasoline.

Figure 1.2: Correlation between Intensive Margin Consumption & Price Stickiness



Households disproportionately spend intensive margin income increases on sticky price goods

Panel a) shows the negative correlation between Engel curve estimates and the average price change frequency 1988-2005. Panel b) shows the correlation with price cyclicity measured in NIPA. Each circle represents a different good. The size is proportional to the expenditure share in NIPA. Light blue circles indicate necessities 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 1.1.

a) Price Change Frequency

corr = 0.36

Extensive Margin Consumption Elasticity

Price Change Frequency

b) Price Cyclicity

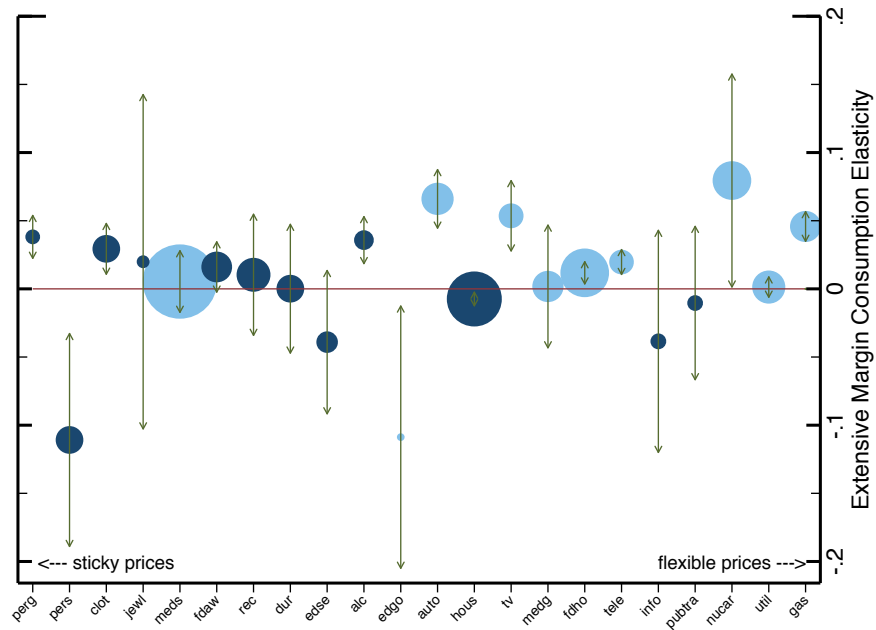
corr = 0.44

Extensive Margin Consumption Elasticity

Price Cyclicity

52

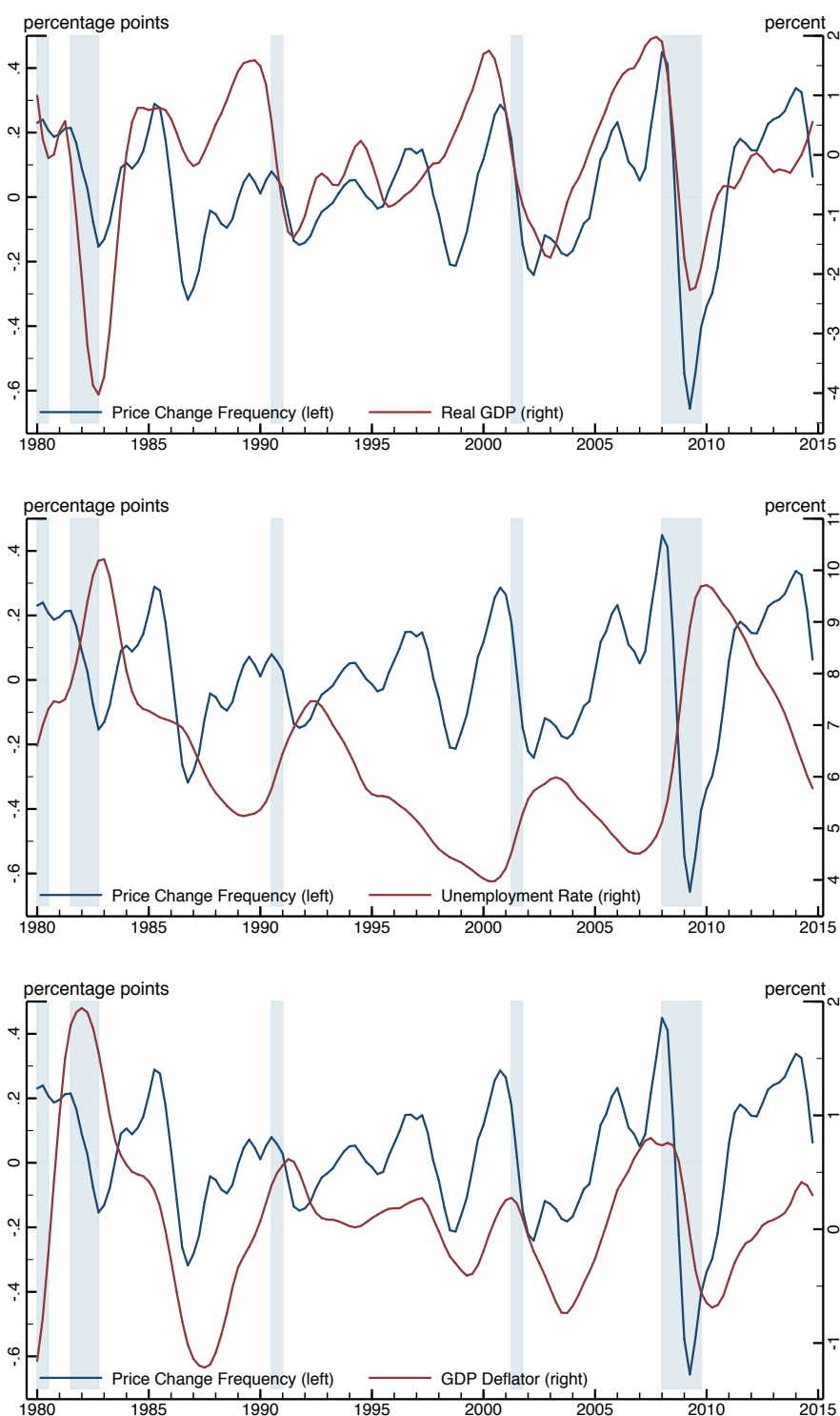
Figure 1.4: Statistical Significance of Extensive Margin Consumption Elasticities



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 necessities, dark blue balls indicate luxuries. Green arrows plot the 90% confidence intervals. Standard errors are clustered at the household level. Abbreviations are explained in table 1.1.

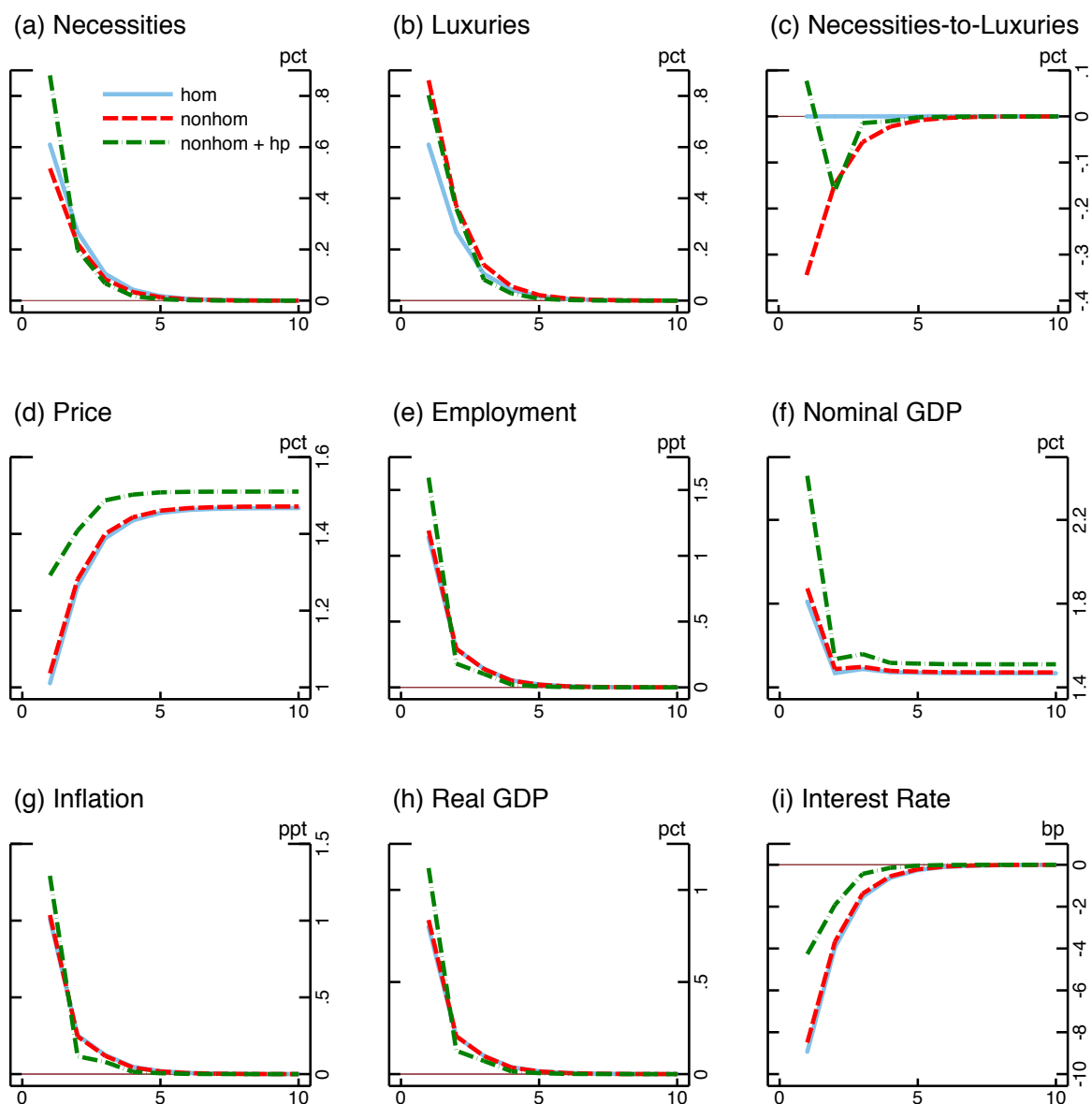
Figure 1.5: Aggregate Expenditure-Weighted Price Change Frequency



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.

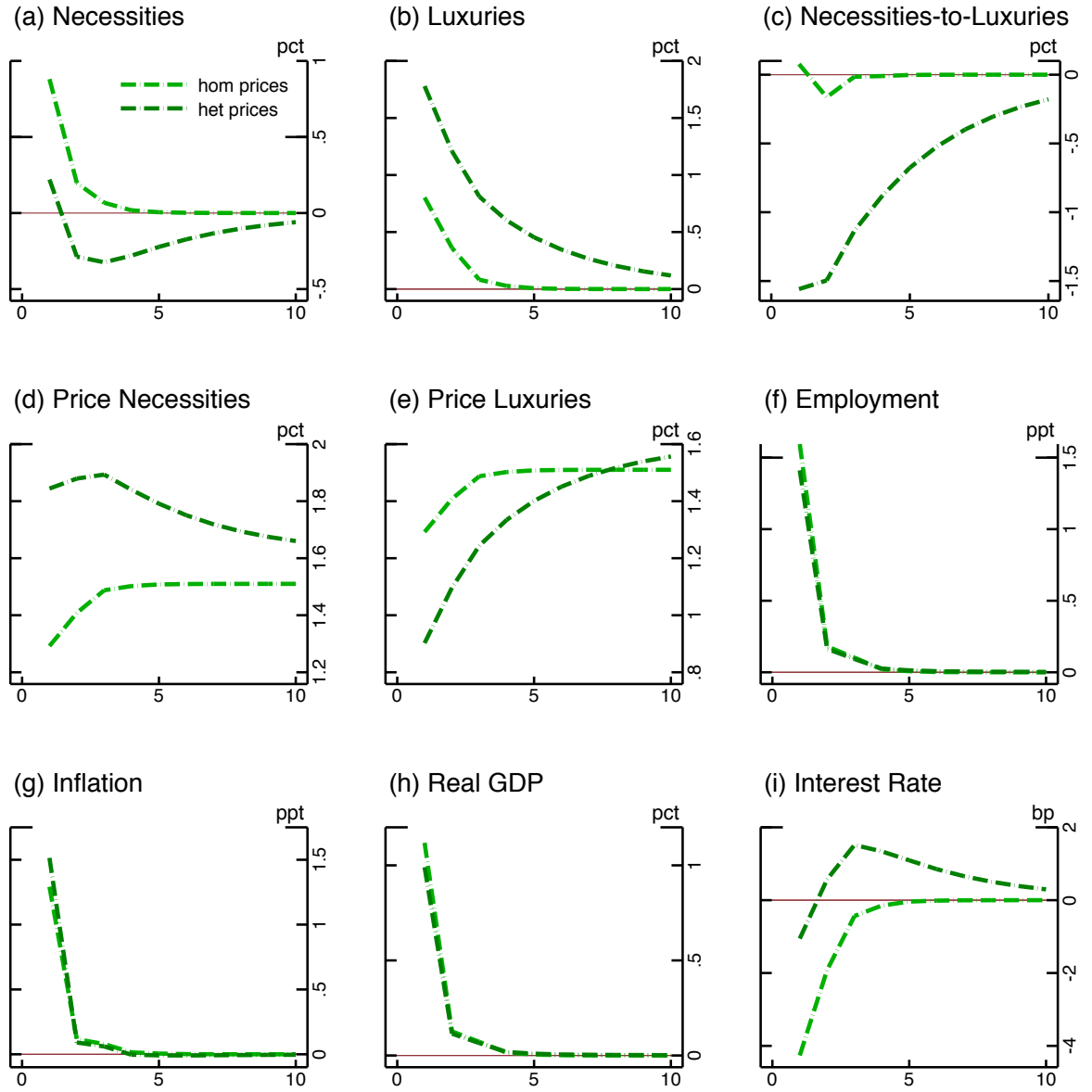
Figure 1.6: Impulse Responses to a monetary shock under homogeneous price flexibility



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 the same across necessities and luxuries ($\theta_N = \theta_L = 0.74$). Panel a) refers to market demand for necessities. 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.

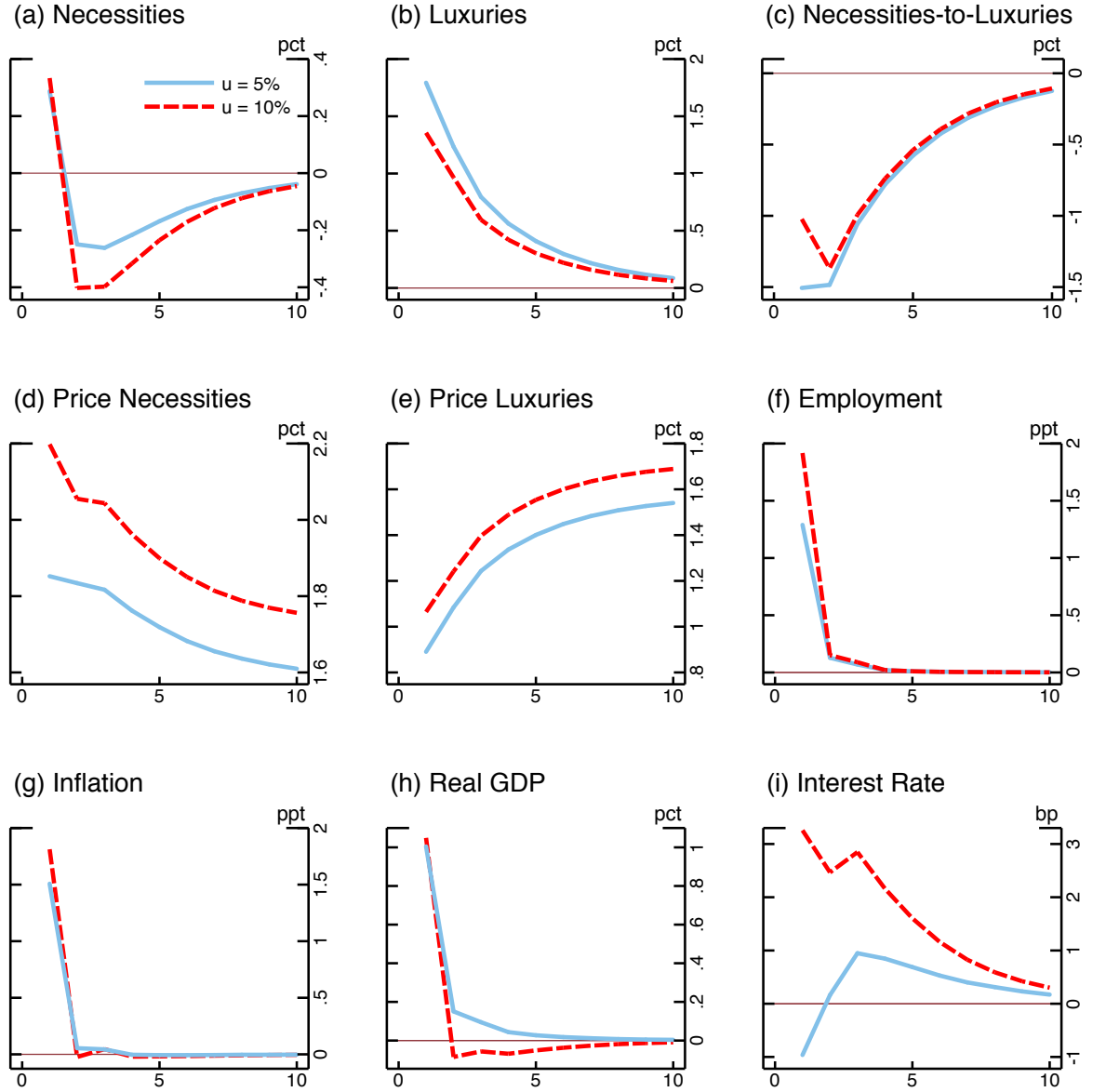
Figure 1.7: Impulse Responses to a monetary shock under heterogeneous price flexibility



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). The light green line shows IRFs for the model with non-homothetic preferences and home-production of necessities but with homogeneous degrees of price stickiness ($\theta_N = \theta_L = 0.74$). The dark green line shows IRFs for the same model when Calvo price stickiness is heterogeneous across necessities ($\theta_N = 0.69$) and luxuries ($\theta_L = 0.83$).

Figure 1.8: State-Dependence of Monetary Policy

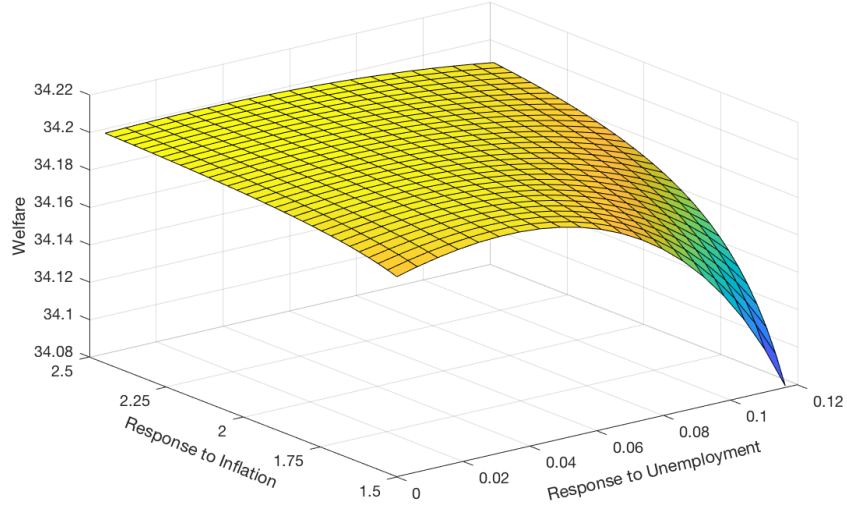


Higher unemployment leads to increased transmission into prices

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 ($\theta_N = 0.69$) and luxuries ($\theta_L = 0.83$). The light blue line shows IRFs for the model with non-homotheticity and home-production at a steady state unemployment rate of 5%. The red dashed line shows IRFs for the same model at an out-of steady state unemployment rate of 10%.

Figure 1.9: Welfare Comparison: Extended vs. Standard New Keynesian Model

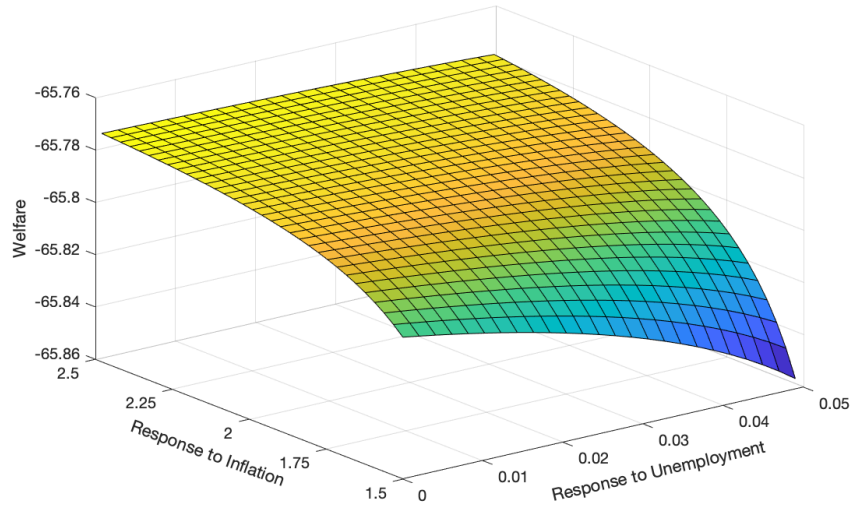
a) Extended Model



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 $\phi_y = 0$) in the model with non-homothetic preferences and home-production of necessities. Taylor Rule takes the form given by equation (1.31). Optimal monetary policy is given by $\phi_p = 2.5$ and $\phi_u = 0.037$.

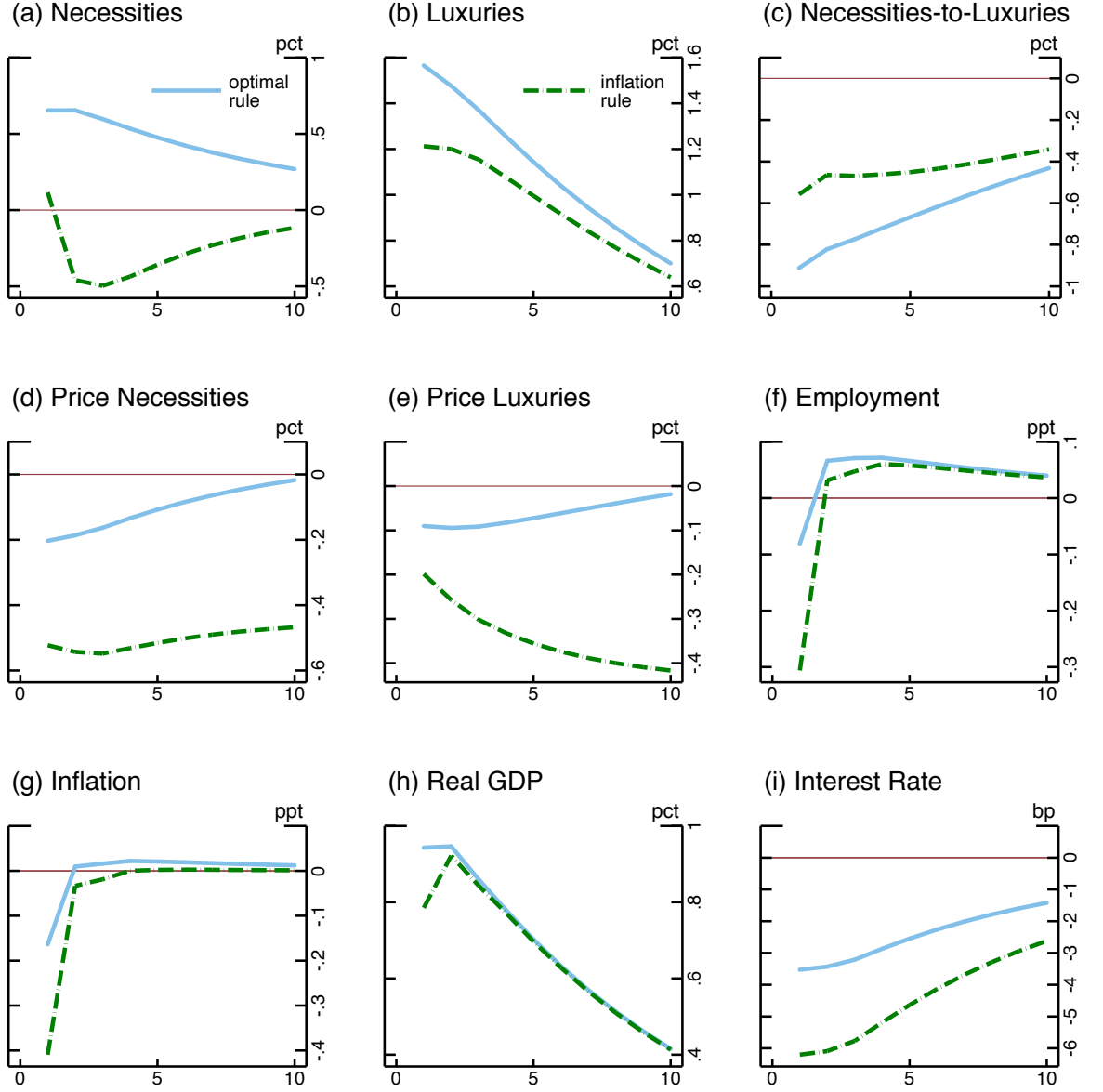
b) Standard New Keynesian Model



Optimal Monetary Policy in a New Keynesian Model solely targets inflation

Conditional welfare for different combinations of Taylor rule coefficients for inflation and unemployment under the Standard New Keynesian model. Taylor Rule takes the form given by equation (1.31). Optimal monetary policy is given by $\phi_p = 2.5$ and $\phi_u = 0$.

Figure 1.10: Impulse Response to a Technology Shock



Optimal Monetary Policy stabilizes inflation by stabilizing employment

Impulse Responses to a 1% positive technology shock in the model with non-homothetic preferences and home-production of necessities. Calvo price stickiness is heterogeneous across necessities ($\theta_N = 0.69$) 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 green dashed line shows IRFs under a pure inflation targeting Taylor Rule ($\phi_p = 1.5, \phi_y = 0, \phi_u = 0$).

Tables

Table 1.1: Summary Statistics 1980-2016

Good	Abbr.	Expenditure Share				Price	Price
		NIPA	CEX	Emp	Unemp	Freq.	Cycl.
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 Cyclical 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 1.2: 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 1.2. 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 1.3: Correlation btw. Intensive Margin Consumption & Price Stickiness

a) Average Price Change Frequency 1988-2005						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX share (4)	EC deflator (5)	log (6)
beta	-.837*** [.200]	-.815*** [.203]	-.848*** [.196]	-.810*** [.179]	-.745*** [.198]	-1.09** [.426]
correlation	-.485	-.474	-0.494	-.523	-.453	-.408
b) Median Price Change Frequency 1988-2005						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	-.731*** [.183]	-.706*** [.195]	-.743*** [.177]	-.711*** [.154]	-.645*** [.185]	-.968*** [.331]
correlation	-.445	-.430	-.454	-.478	-.412	-.379
c) Price Cyclicalities (NIPA) 1980-2016						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	-.666*** [.210]	-.665*** [.209]	-.673*** [.214]	-.555*** [.174]	-.625*** [.208]	-.664* [.373]
correlation	-.402	-.402	-.408	-.377	-.396	-.256
d) Price Cyclicalities (CPI) 1980-2016						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	-.249*** [0.070]	-.246*** [.070]	-.249*** [.067]	-.212*** [.059]	-.225*** [.068]	-.243 [.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 1.2. 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 cyclicalities measures using NIPA or CPI price indices respectively.

Table 1.4: Correlation btw. Extensive Margin Consumption & Price Stickiness

a) Average Price Change Frequency 1988-2005						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX share (4)	EC deflator (5)	log (6)
beta	.064* [.033]	.058* [.030]	.047* [.023]	.046* [.024]	.064* [.033]	.021 [.037]
correlation	.359	.354	.325	.359	.359	.121
b) Median Price Change Frequency 1988-2005						
	baseline (1)	male heads (2)	age 20-65 (4)	CEX shares (4)	EC deflator (5)	log (6)
beta	.058* [.033]	.054* [.029]	.044* [.024]	.041 [.026]	.058* [.033]	.021 [.037]
correlation	.346	.347	.317	.335	.346	.123
c) Price Cyclicalities (NIPA) 1980-2016						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	.075* [.042]	0.060 [.035]	.056** [.027]	.046** [.019]	.075* [.042]	.028 [.020]
correlation	.441	.380	.401	.377	.441	.172
d) Price Cyclicalities (CPI) 1980-2016						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	.031*** [.014]	.027* [.014]	.026** [.011]	.026** [.010]	.031** [.014]	.023* [.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 1.3. 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 cyclicalities measures using NIPA or CPI price indices respectively.

Table 1.5: Calibration

Parameter	Value	Description
β	0.99	Discount Factor
σ	1	Intertemporal Elasticity of Substitution (EoS)
φ	5	
χ	0.39	
λ	1.01	Relative Price Elasticity
ϕ	0.36	Relative Expenditure Elasticity
η	1.04	Expenditure Share of Necessities
ψ	0.15	Consumption weight on Home Production
ρ	2/3	EoS between Necessities and Home Production
ϵ	6	Demand Elasticity
θ_N	0.69	Price Change Frequency Necessities
θ_L	0.83	Price Change Frequency Luxuries
α	0.33	Labor Income Share
δ	0.1228	Separation Rate
γ	1	Matching Function Equivalence
ξ	0.5	Bargaining Power
Γ	0.1183	Hiring Cost
ρ_r	0.9	Monetary Policy Inertia
ϕ_p	1.5	Inflation Response
ϕ_y	0.5/4	Output Response
σ_ϵ^2	0.0025	Monetary Policy Volatility
ρ_a	0.9	Productivity Persistence
σ_a^2	0.008	Productivity Volatility

Calibration of a New Keynesian model with non-homothetic preferences and home production

This table lists the values assigned to each model parameter and its description. From top to bottom the blocks in the table describe standard preference parameters, the non-homothetic utility parameters, the home-production technology for necessities, the retail firm sector, the labor market, the Taylor Rule and the parametrization of monetary and technology shocks.

Appendix

1.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 product categories, 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 chapter 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 (1.6) shows the mapping I employ. I confirm that all results are quantitatively similar 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.⁴⁶ 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.

⁴⁶This 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.

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% for these years only.

Finally, I deflate all nominal consumption expenditures by the aggregate CPI research series⁴⁷, so that my estimation results have the interpretation of consumption elasticities as opposed to expenditure elasticities. As shown in section 1.3, 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.

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.

⁴⁷The CPI research series has the advantage of being consistently defined over the whole sample period by accounting for definition changes of underlying goods categories.

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 cyclical measures. For expenditure shares I used the underlying detailed personal consumption expenditure table 2.4.5U. Table 1.6 shows the mapping between PCE categories and consumption good categories that I use.

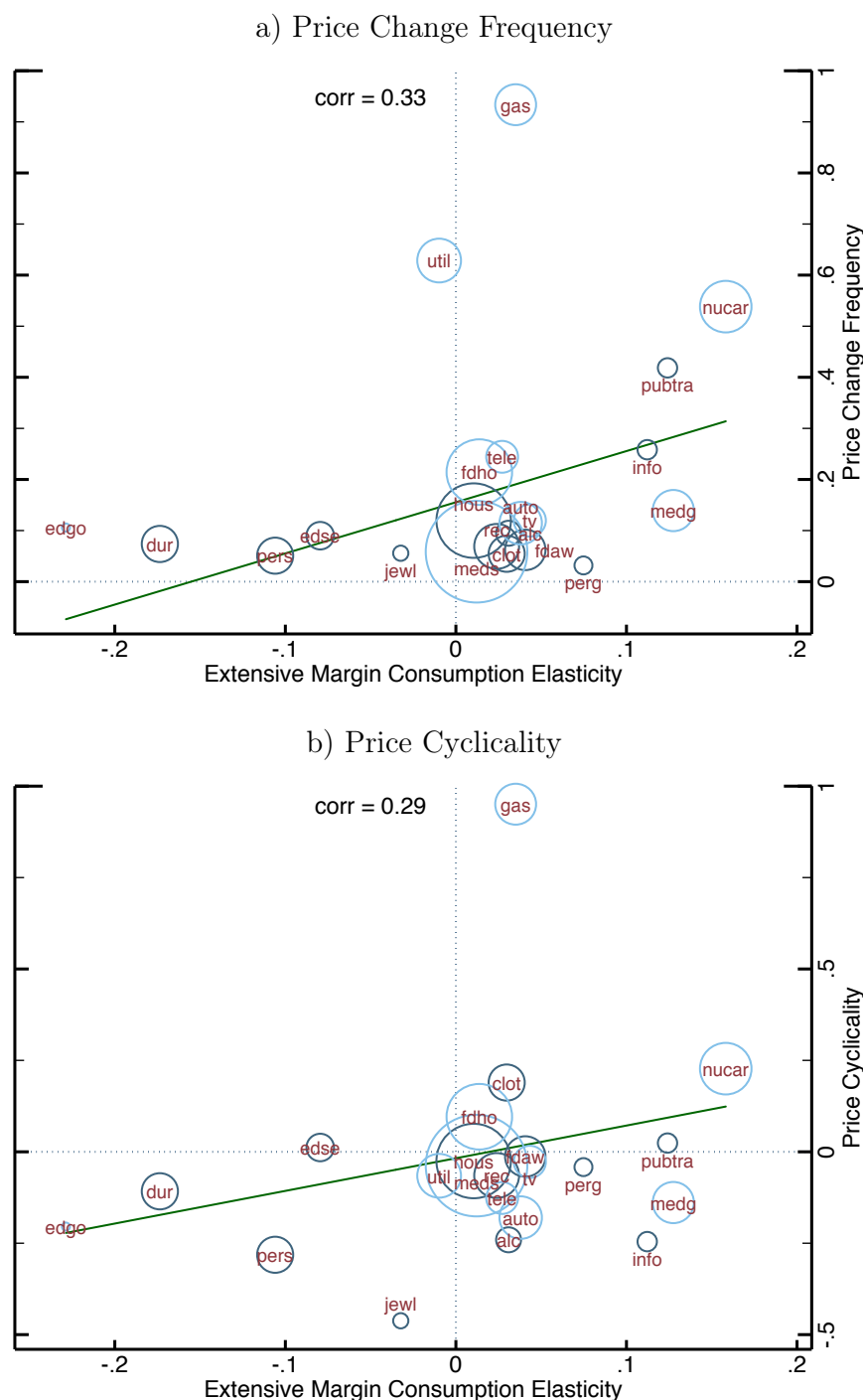
In order to calculate my good-specific price cyclical measure I construct expenditure share weighted unique price indices, i.e. for each goods category that maps into multiple PCE categories I construct a unique Paasche Price Index for that category and then estimate price cyclical as described in section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

CPI Price Cyclical

In order to estimate price cyclical for expenditure categories from the CPI I rely on the mapping shown in table 1.6. Because of methodological changes over time some of the CPI series are not continuously available back until 1980. For price cyclical 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.

1.B Further Robustness

Figure 1.11: Correlation between Extensive Margin Consumption & Price Stickiness



Extensive Margin Correlations are robust when using the employment status of the household head

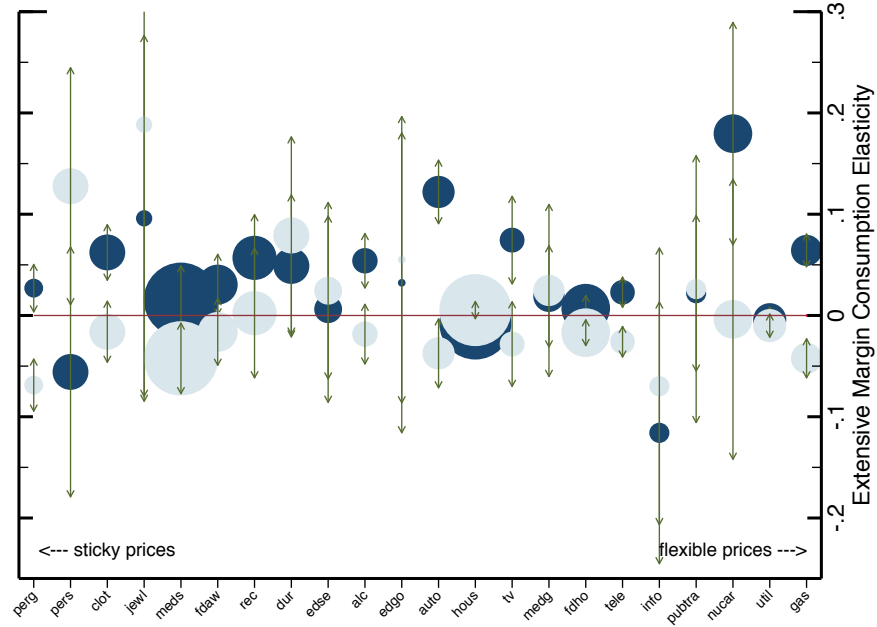
Panel a) shows the positive correlation between the average price change frequency 1988-2005 and a change in the employment status of the household head. Panel b) shows the correlation with price cyclicity measured in NIPA. Each circle represents a different good. The size is proportional to the expenditure share in NIPA. Light blue circles indicate necessities, dark blue circles indicate luxuries. Correlation refers to the weighted correlation.

Table 1.6: 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 chapter. 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.

Figure 1.12: 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 1.7: Correlation between Extensive Margin Consumption & Price Stickiness

a) Average Price Change Frequency 1988-2005						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX share (4)	EC deflator (5)	log (6)
beta	.107 [.076]	.129* [.071]	.100 [.075]	.066 [.052]	.107 [.076]	.014 [.058]
correlation	.328	.318	.348	.267	.328	.057
b) Median Price Change Frequency 1988-2005						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	.108 [.074]	.132* [.069]	.101 [.072]	.066 [.054]	.108 [.074]	.013 [.057]
correlation	.345	.342	.367	.275	.345	.054
c) Price Cyclicity (NIPA) 1980-2016						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	.089 [.069]	.166 [.116]	.053 [.049]	.058 [.041]	.089 [.069]	.046 [.028]
correlation	.281	.426	.189	.245	.281	.193
d) Price Cyclicity (CPI) 1980-2016						
	baseline (1)	male heads (2)	age 20-65 (3)	CEX shares (4)	EC deflator (5)	log (6)
beta	.029 [.024]	.036* [.021]	.023 [.026]	.022 [.015]	.029 [.024]	0.030** [.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 1.2. 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 cyclicity measures using NIPA or CPI price indices respectively.

1.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 necessities, ii) the relative expenditure (income) elasticity of necessities and luxuries and iii) the price elasticity of substitution between necessary 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 market demand for necessities and luxuries and yields FOC (1.12). The budget constraint in turn is given by $P_N X_N + P_L C_L = C$, where C is total consumption and in steady state given by $C = Y^n - P_N GH$. Rearranging (1.12) 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:

$$\frac{P_N X_N}{C} = \left(1 + \left(\frac{P_L}{P_N} \right)^{1-\frac{1}{\phi}} C_N^{\frac{\rho+\lambda-1}{\phi}} \eta^{\frac{1}{\phi}} X_N^{\frac{1-\rho-\phi}{\phi}} \right)^{-1}$$

which calibrates η for given values of λ and ϕ .

Using the FOC (1.12) in the budget constraint furthermore defines an implicit function $h(X_N, C_L, C)$ in the quantity of market goods, luxuries and total consumption. Using the implicit function theorem to calculate both partial derivatives $\partial X_N / \partial C$ and $\partial C_L / \partial C$ and thus the respective the expenditure elasticity allows the computation of the relative expenditure elasticities as

$$\frac{\frac{\partial \log X_N}{\partial \log C}}{\frac{\partial \log C_L}{\partial \log C}} = \frac{1 + \frac{\phi}{1-\rho} \left(\frac{P_L}{P_N} \right)^{\frac{\rho}{1-\rho}} \eta^{\frac{1}{\rho-1}} C_N^{\frac{1-\rho-\lambda}{1-\rho}} C_L^{\frac{\phi+\rho-1}{1-\rho}}}{1 + \left(\frac{P_L}{P_N} \right)^{1-\frac{1}{\phi}} \eta^{\frac{1}{\phi}} \left(C_N^{\frac{\lambda+\rho(1-\phi)-1}{\phi}} X_N^{\frac{(1-\phi)(1-\rho)}{\phi}} \frac{\lambda+\rho-1}{\phi} - \frac{1-\rho}{\phi} C_N^{\frac{\lambda+\rho-1}{\phi}} X_N^{\frac{1-\rho-\phi}{\phi}} \right)} \frac{S_L}{S_N}$$

where $S_N = P_N X_N / C$ 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

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

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

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

Since f is given by (1.6) and g by (1.7) with $a = C_L$ and $b = X_N$ we can derive the elasticity of substitution as

$$EoS = \frac{\frac{1}{X_N} + \frac{1}{Q C_L}}{\frac{\lambda}{X_N} + \frac{\phi}{Q C_L} - \frac{1-\rho}{X_N} \left[\left(\frac{X_N}{C_N} \right)^\rho - 1 \right]}$$

where $Q = P_L/P_N$.

Chapter 2

Monetary Policy through Intensive and Extensive Margin Labor Adjustments

2.1 Introduction

Macroeconomists usually rely on New Keynesian models to study the real effects of monetary policy. New Keynesian models are able to generate real effects by introducing nominal rigidities on prices or wages into otherwise standard real business cycle models. However, the low persistence of impulse responses of inflation and output to monetary policy shocks in these models have led to the search for endogenous amplification mechanisms that close the gap between model and data.

Particular emphasis was put on integrating labor market frictions in the spirit of search and matching models into the New Keynesian framework. While the augmented models differ in their specifics a common feature among most of them is the explicit distinction between intensive and extensive margin labor adjustments. Firms in these models are able to react to economic shocks either via adjustment

in hours worked or potential renegotiations of the real wage (intensive margin) or through hiring and firing of workers (extensive margin). While the literature shows the ability of these models to improve the fit of impulse responses to inflation and output, investigating the empirical fit of intensive and extensive margin responses themselves to identified policy shocks is an oddly neglected issue and often treated as a free modeling dimension.

Empirical investigations on the effects of monetary policy on US labor markets are surprisingly scarce as emphasized by Christiano et al. (2016). The existing analyses usually rely on aggregate data on unemployment rates, aggregate hours worked and a real wage index. Structural vector autoregressions (SVAR) or Factor augmented vector autoregressions (FAVAR) constitute the commonly employed estimation framework and monetary policy shocks are often identified through Cholesky Factorization by ordering the Federal Funds rate as the last variable in a typical VAR.

This chapter improves upon the literature by studying the labor market effects of monetary policy through individual level data. Using individual level data allows to explicitly distinguish between intensive and extensive margin labor market responses. Data on labor market outcomes comes from the Current Population Survey (CPS), a dwelling-based survey conducted since the 1940s. The CPS initially interviews individuals for 4 consecutive months, temporarily drops from the survey for 8 months and collects information a year after the start of the first interview for another 4 consecutive months. This sampling scheme, while far from perfect, allows to construct short individual-level panels to study impulse responses of monetary policy on a disaggregated level.

The CPS allows to explicitly study intensive margin labor responses in hours worked and real hourly wages as well as extensive margin responses in the change of labor force status of an individual. The peculiarities of the CPS survey design warrant some adjustments however since wage information is only collected at each time before

the individual temporarily or permanently leaves the sample. In order to compute real wage changes I therefore construct an aggregate real wage index. The advantage of the CPS as opposed to aggregate data is, that it allows to purge composition-bias by controlling for worker demographics, in particular for age, education and skill-level. The wage index is then naturally defined as the averaged residuals from a regression of individual wages on individual-level characteristics.

In order to ensure exogenous identification of monetary policy shocks I rely on high-frequency changes in the Federal Funds Futures around tight windows of FOMC announcements. These shocks are largely uncorrelated and on average zero and have been widely used in the literature. Using exogenously identified shocks allows to avoid modeling joint dynamics of endogenous variables in a VAR. Instead I rely on autoregressive distributive lag models to estimate impulse response of monetary policy shocks.

The main finding of this chapter is, that monetary policy works almost exclusively through extensive margin labor adjustments. A one standard deviation expansionary monetary policy shock increases the probability of employment by 15 percentage points after 8 quarters. This result is mostly driven by unemployed workers finding a new job as the probability of entering the labor force increases by only 3 percentage points. The data shows signs of asymmetric effects of monetary policy as contractionary shocks reduce the probability of employment by around 4 percentage points.

Monetary policy shows little effects on intensive margin labor market outcomes. Impulse responses of hourly real wages to both expansionary and contractionary shocks are entirely flat and statistically insignificant. 95 percent confidence intervals indicate that wages highly likely change less than 0.2 percent even after 8 quarters. Impulse responses of usual hours worked show counterintuitive increases to contractionary shocks but reductions to expansionary shocks. While statistically significant these effects are economically negligible. A one standard deviation contractionary

shock increases hours worked by at most 30 minutes. This implies a change of less than 1 percent compared to the average working week of 40 hours. Expansionary shocks have even more muted effects and imply a peak absolute response of at most 20 minutes. Impulse responses for real weekly earnings which combine changes in hours worked and hourly wages confirm that monetary policy has little effect at the intensive labor margin.

Related Literature

This chapter relates to three main strands of the literature. The early Real Business Cycle literature usually models the labor market as a frictionless Walrasian market in total aggregate hours worked and thus only features an intensive margin. New Keynesian models aimed at explaining real effects of monetary policy through the introduction of wage or price rigidities but maintained the assumption of Walrasian labor markets. In these models expansionary policy stimulates consumption and thereby leads to increases in labor demand which in turn raises wages. Since wages are the largest cost component of marginal cost and because firms set prices as a markup over marginal cost, monetary policy shocks counterfactually imply quick transmission into prices which is at odds with empirical estimates that show rather sluggish price adjustments.

Early models like Walsh (2003, 2005) and Trigari (2006) tried to overcome this shortcoming by integrating search and matching frictions through a separate intermediate goods sector. While this explicitly introduced intensive and extensive margins of labor adjustments, the introduction of a separate firm sector effectively separated labor market and price setting frictions. Impulse responses to monetary policy shocks were quite similar to standard models because employment was subject to adjustment costs and took time to adjust leaving the hours margin and thus marginal costs the only margin to be able to adjust to short run fluctuations.

A second vintage of models like Thomas (2011), Sveen, Weinke (2009), Clerc (2015) modeled labor adjustment and pricing frictions at the same (representative) firm and thus explicitly allowed for the interaction of both frictions. These models fall into two categories depending on whether they assume rigid real wages or not. Without real wage rigidities adjusting labor at the intensive margin is costly for firms, which thus resort to the extensive margin to respond to unexpected short-run fluctuations. When real wage rigidities are assumed instead, adjustment at the intensive margin is comparably cheaper and firms respond to short-run fluctuations via adjusting hours. While this yields realistic inflation responses due to near-constant marginal costs it does not fit the evidence on labor market adjustments.

Gauging the degree of wage rigidities is also closely related to estimating the cyclicity of real wages. At least since Keynes (2018) real wage rigidities have been argued to constitute important adjustment frictions to short-run fluctuations. While aggregate real wages indeed appear to be acyclical, Bils (1985) and Solon et al. (1994) have forcefully argued that this acyclicity cloudes substantial procyclicality at the individual level due to composition bias. Because low-skilled workers with below average earnings potential enter unemployment during booms, aggregate wages appear acyclical even if underlying individual wages are strongly procyclical. Subsequent research like Daly and Hobijn (2016) and Haefke et al. (2013) has thus investigated the different dynamics of wages for incumbents and new hires.

Lastly, there is a large literature on the appropriate identification of monetary policy shocks. The bulk of this literature relies on VARs (e.g. Christiano et al. (1999), Bernanke and Mihov (1998) and Bernanke et al. (2005)) with different identification approaches, most often Cholesky-Factorization by ordering the Federal Funds Rate last and thus assuming that monetary policy has no contemporaneous effect. Romer and Romer (2004) employ a narrative method by using historical records of FOMC meetings to isolate the innovations to these interest rate changes that are orthogonal

to the Federal Reserve’s information set. Kuttner (2001) and Gürkaynak et al. (2005) were the first to rely on high-frequency identification through changes in Federal Funds futures as a measure of unexpected policy surprises. Subsequently this approach has been fruitfully applied to a wide range of topic, e.g. asset price movements (Gorodnichenko and Weber (2016)), long-term bond yields (Swanson and Williams (2014); Swanson (2017)) and consumption (Wong (2015)). To the best of my knowledge this chapter is the first to use high-frequency identified policy shocks to study their labor market effects.

The chapter proceeds as follows. Section 2.2 describes the data. Section 2.3 describes the construction of a composition-bias corrected aggregate real wage index and the estimation methodology. Section 2.4 shows the empirical impulse responses for intensive and extensive margin labor outcomes and section 2.5 concludes.

2.2 Data Description

The empirical analysis in this chapter relies on two data sources. I combine high-frequency identified monetary policy shocks with individual level data on labor market outcomes from the Current Population Survey. This section describes each dataset in turn.

Identified Monetary Policy Shocks

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

The Federal Reserve announces changes of the Federal Funds 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 Federal Funds futures in a narrow window around these FOMC announcements as a measure of unanticipated changes in the Federal Funds 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 Federal Funds futures rate Δ^+ minutes after the FOMC press release. Following the literature I consider both a tight 30 minute and a wide 60 minute window around the FOMC announcement that starts $\Delta^- = 15$ minutes before the announcement and ends $\Delta^+ = 15/45$ minutes after. D is the number of days in the month of the announcement and $D/(D - t)$ is an adjustment term.¹ The identifying assumption for exogeneity is that during the narrow window around the announcement there are no other relevant shocks (e.g. financial, news or risk premium shocks) moving the Federal Funds futures rate.

Figure 1 shows the time series of daily shocks to the federal funds rate. Expansionary shocks are somewhat larger in magnitude and are observed more often than contractionary shocks. Reassuringly the series does not seem to exhibit any autocorrelation thereby strengthening the case for truly exogenously identified shocks. To get a quarterly measure of monetary policy shocks I sum the identified shocks as

¹This adjustment term takes into account that a Federal Funds 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.

in Wong (2015). Table 1 summarizes both monthly and quarterly shocks. 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 quarterly shock of 48 basis points occurred in the fourth quarter of 1991.

Labor Market Data

I use data from the Current Population Survey (CPS), which is a long-standing, nationally representative survey that has been conducted by the Census Bureau since 1940. It is the key information source for monitoring new developments in the US labor market. For this study I rely on the Basic Monthly files starting in 1990 to match the data availability of high-frequency identified monetary policy shocks and end the sample in 2007 to avoid concerns about the zero lower bound.

Importantly for this study, the CPS provides monthly individual-level data on labor force status, working hours, earnings and demographics on about 45000 households containing approximately 94000 persons aged 15 years and older. This micro-data can be used cross-sectionally or to construct short individual-level panels. To understand the type of information contained in each of these short panels it is useful to review the CPS survey structure. The CPS is a dwelling-based survey² in which households are included for a total of 16 months. Over this period, individual household members are interviewed monthly for the first four months, not interviewed for the next eight months, and then interviewed monthly again for the remaining four months before being retired from the sample. Table 2 provides an illustration of this structure. The rationale for this survey design is to provide a cost-efficient method for monitoring year-on-year changes in labor market developments and to reduce the survey burden on households.

²Dwelling-based implies that individuals that change residency are subsequently dropped from the survey.

The regular monthly surveys collect very basic information about labor market status. Earnings information along with other details of jobs are collected twice during a household survey tenure, once in survey month 4 and again in survey month 16. Individuals in survey month 4 and 16 are usually referred to as the outgoing rotation group (ORG) since they temporarily or permanently leave the survey. The literature usually constructs short panels from those survey months only, the so-called merged ORG panel. Earnings and job information are collected only for individuals who are employed at the time of the interview. As opposed to previous research, I do not restrict attention to the merged outgoing rotation group but instead use the full set of observations instead.

One concern about the use of the CPS for tracking individuals over time is that the sample may not be representative of the population. Since the CPS is dwelling based, when individuals change residences they are dropped from the sample and the new occupants of the unit are interviewed. While this does not alter the cross-sectional representativeness of the CPS, it can potentially interfere with representativeness of the individual-based short panels. This is true especially if moving is related to the variables being analyzed. However, work by Nekarda (2009) and Kim et al. (2009) that carefully corrects for this type of sample attrition finds that the biases introduced are empirically modest. Thus, I use the raw, matched CPS data as the basis for my analysis.

To construct the sample of interest I aggregate the basic monthly files to the quarterly level. I further restrict attention to people aged 25-65 and not related to the agricultural or armed forces sector. However, I include both male and female workers to get a representative sample for the private, non-agricultural workforce.

The main outcome variables of interest are hours worked and hourly wages earned at the intensive margin and the probability of employment and labor force participation at the extensive margin. The wage series employed here is hourly earnings

for hourly workers and weekly earnings divided by usual weekly hours for weekly workers. For weekly workers who report that their hours vary I use hours worked last week. To construct a time-consistent wage series across all periods I impute wages for top-coded weekly earnings by assuming a log-normal cross-sectional distribution for earnings following Schmitt (2003). Additionally, I trim the data for values below \$1 and above \$100 per hour in constant 2002 dollars and exclude overtime, tip and commission earnings for hourly paid earnings.

2.3 Econometric Methodology

The specifics of the CPS survey design preclude estimating individual level wage changes in response to monetary policy shocks because wages are observed only twice during the interview sample and both observations are 12 month apart. However, looking at aggregate wage responses is not sufficient either as the literature has long since at least Bils (1985) recognized the composition bias of aggregate variables. During upturns low-skilled workers earning less than average wages enter the labor market and render the aggregate wage less pro-cyclical than individual level wages. This is commonly referred to as the composition-bias of aggregate data. In order to use the CPS to estimate responses of real wages to monetary policy shocks but avoid confounding such changes with changes in the composition of the labor force, I construct a composition-bias corrected wage series first and then describe the econometric methodology to estimate empirical impulse responses to the identified monetary policy shocks.

Constructing a composition-bias corrected wage series

Taking into account individual heterogeneity, the wage w_{it} of worker i at time t can be thought of as depending on worker i 's individual characteristics and on a residual

that potentially depends on aggregate conditions:

$$\log w_{it} = \beta \cdot x_i + \log \hat{w}_{it}$$

Vector x_i represents time-invariant or deterministically time-dependent individual characteristics like gender or age and $\hat{w}_{it}$ is the residual wage orthogonal to these characteristics.

The standard approach in the micro-literature on composition bias follows Bils (1985) and uses first differences in wages to purge the unobserved individual heterogeneity. However, this approach is not possible with the CPS given the data limitations on observed wages. Instead I follow Haefke et al. (2013) and proxy x_i by a vector of observables: gender, race, marital status, education and a fourth order polynomial in experience. These variables explain part of the idiosyncratic variation in wages.

I regress log wages on observable worker characteristics and construct the residual. The residual itself constitutes the composition-bias corrected wages. Since interest lies in estimating the impulse responses of wages to monetary policy shocks, I average these residuals by quarter. Such averaging can potentially be done for different subgroups of the population, e.g. newly hires. The wage index for subgroup j , $\hat{w}_{jt}$, then relates to the average wage of that group of workers, w_{jt} , as follows:

$$\log \hat{w}_{jt} = \log w_{jt} - \beta \cdot (x_{jt} - \bar{x}_j)$$

where x_{jt} is the average of the vector of observable characteristics for the subgroup of workers in each quarter and $\bar{x}_j$ denotes the sample average x_j . Even though the individual worker's characteristics x_i might be time-invariant, the average characteristics for a group of workers x_{jt} may be varying because the composition of the group might change.

Estimating labor market responses to monetary policy

I employ an autoregressive distributed lag model in order to estimate responses of labor market outcomes to identified monetary policy shocks. I use the individual level data constructed from the CPS together with the identified monetary policy shocks and estimate impulse responses via regressions of the form:

$$\Delta y_{it} = \alpha_i + \sum_{k=1}^K \beta_k \cdot \epsilon_{t-k}^- + \sum_{k=1}^K \gamma_k \cdot \epsilon_{t-k}^+ + \lambda_{s(t)} + \nu_{it} \quad (2.1)$$

where Δy_{it} is the change for individual i in quarter t . At the intensive margin this is either the change of (i) usual hours worked, (ii) log real hourly wages or (iii) log real weekly earnings. At the extensive margin instead of looking at changes, I use indicators for being employed or in the labor force. The interpretation then is that of changes in the probability of employment or the probability of entering the labor force. The difference between the two directly implies changes in the probability of unemployment. α_i are individual fixed effects included in hours and extensive margin regressions, $\lambda_{s(t)}$ 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

$$\frac{\partial y_{it+k}}{\partial \epsilon_t^-} = \sum_{k=1}^T \frac{\partial \Delta y_{it+k}}{\partial \epsilon_t^-} = \sum_{k=1}^T \beta_k \quad (2.2)$$

whereas the elasticity for a contractionary shock is given by

$$\frac{\partial y_{it+k}}{\partial \epsilon_t^+} = \sum_{k=1}^T \frac{\partial \Delta y_{it+k}}{\partial \epsilon_t^+} = \sum_{k=1}^T \gamma_k. \quad (2.3)$$

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.

2.4 Empirical Results

2.4.1 No Intensive Margin Effects

Monetary policy has statistically significant but negligible economic effects on usual hours worked. Figure 2.5 shows the impulse responses to a one standard deviation monetary policy shock. Somewhat surprisingly usual hours worked rise in response to contractionary shocks but decrease in response to expansionary shocks. While statistically significant these effects are economically rather negligible. A one standard deviation contractionary shock leads to an increase of 0.3 hours (20 minutes) worked on impact and reaches a peak of 0.6 hours (40 minutes) after 4 to 5 quarters before reverting. Since the number of average usual hours worked in the sample is around 40 hours, the peak response of hours worked is around 1%. Expansionary shocks have overall more muted effects. The response on impact is a mere 0.1 hours (6 minutes) less worked and the peak response after around 6 quarters is 0.25 hours (15 minutes). Both types of shocks show a pronounced hump-shaped profile although this is less visible for expansionary shocks. Though theory predicts that contractionary shocks should decrease consumer demand through a multitude of transmission channels and thereby ultimately decrease firms' labor demand, the opposite seems to be true in the empirical impulse responses. A potential explanation is discussed below when looking at the extensive margin responses.

Hourly real wages do not seem to change after monetary policy shock. Figure 2.5 shows mostly flat impulse responses for both contractionary and expansionary shocks. While contractionary shocks initially decrease hourly real wages by around 0.2% this decrease is mostly statistically insignificant, the response after 2 quarters being the exception. Expansionary shocks on the other hand do not show any statistically or economically significant effect at any horizon. As opposed to hours worked the confidence bands are visibly larger due to the reduced sample size. This issue is amplified for contractionary shocks as they are observed less frequently than expansionary shocks. However, even more precise estimates would yield a maximum absolute response of 0.4% after 10 quarters.

The results on hours worked and real hourly wages imply that intensive margin labor responses are overall negligible. Figure 2.5 reinforces this result by plotting the impulse responses for real weekly earnings. Since weekly earnings are a combination of hours worked and hourly wages the impulse responses closely resemble the responses of hourly real wages and show few if any significant effects.

2.4.2 Pronounced Extensive Margin Effects

Monetary policy has significant effects at the extensive margin. Figure 2.5 shows that on impact the probability of being employed drops by two percentage points. This probability subsequently decreases further to its trough of about 4 percentage points after 7 quarters. Interestingly, the probability of employment turns positive after 10 quarters. Since employment is defined as working a job, a lower probability of employment can either mean an increase in unemployment or an increase in the number of people that are out of the labor force. However, both possibilities imply that contractionary monetary policy shocks lead to significant adjustments through laying off workers. The counterintuitive increase in usual hours worked, though small, implies that these lay-offs are partially compensated through increased hours for the

remaining employed workers. Overall the results correctly imply that aggregate labor falls in response to contractionary shocks.

Expansionary shocks have even stronger economic effects and additionally point towards asymmetries of monetary policy effects on extensive margin outcomes. The impulse responses show a pronounced hump-shaped profile with the probability of being employed after 4 quarters increasing by 8 percentage points. After two years the response reaches a peak at a 14 percentage point increased probability for an individual to have found worked if previously unemployed or out of the labor force. This magnitude is 6 times larger in absolute terms than the effects of contractionary shocks. Point estimates for both contractionary and expansionary shocks are extremely tightly estimated due to the large sample size.

Contractionary policy shocks lower the probability of entering the labor force as shown in figure 2.5. For the first 5 quarter the probability is around 0.5 percentage points lower but interestingly turns positive afterwards. Mechanically changes in the probability of employment together with changes in the probability of entering the labor force imply changes in the unemployment rate. Empirically, the labor force participation increases after 5 quarters but the probability of employment remains subdued until 8 quarters after a contractionary shock. Both facts together imply that the probability of being unemployed reaches its peak after around 8 quarters before reverting back.

The probability of entering the labor force after an expansionary policy shock shows the same hump-shaped response as the probability of employment. However, absolute magnitudes are a lot smaller. After 4 quarters the probability of labor force entrance is around 2 percentage points higher and reaches its peak of 3 percentage points after 8 quarters. This together with a 15 percentage point higher probability of employment implies that the bulk of the employment effects of expansionary policy comes from unemployed workers finding a job.

2.5 Conclusion

This chapter empirically investigates the labor market effects of monetary policy shocks. I show that expansionary monetary policy works exclusively through the extensive margin by increasing the probability of employment and to a lesser degree labor force participation. Contractionary shocks show the opposite effects but are less powerful pointing to potential asymmetries in the effects of policy shocks. As opposed to the extensive margin however monetary policy shows no effects at the intensive margin. While usual hours worked counterintuitively increase after contractionary shocks and decrease after expansionary shocks these effects are economically negligible. Impulse responses of hourly real wages are entirely flat and show no reaction at all.

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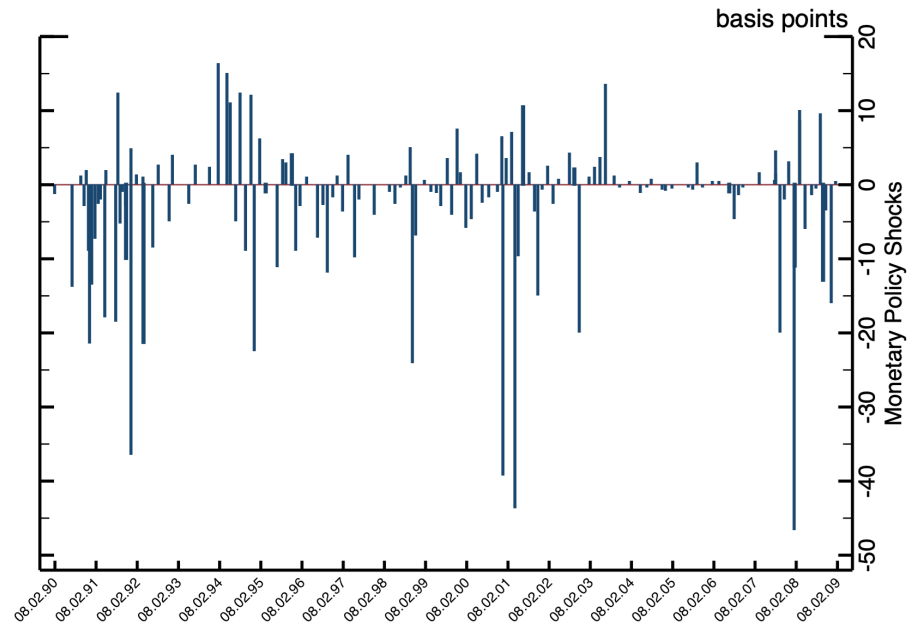
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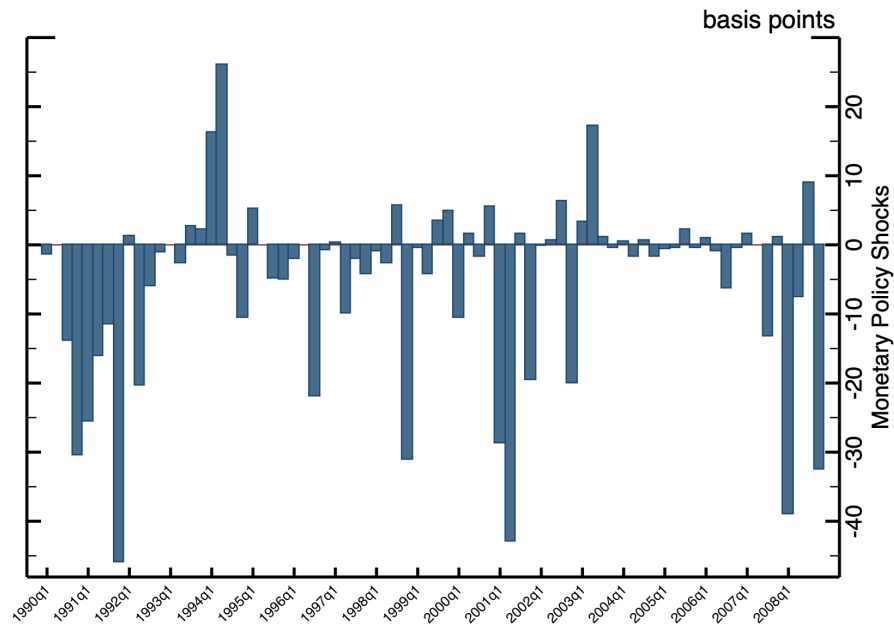
Figures

Figure 2.1: Monetary Policy Shocks

a) Monthly



b) Quarterly (Summed)

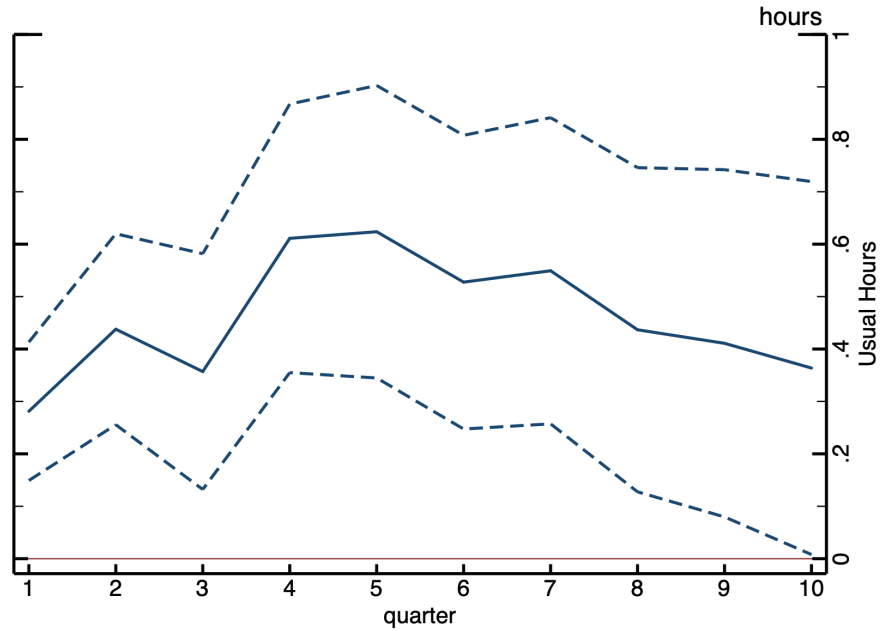


High-Frequency identified policy shocks offer substantial time series variation

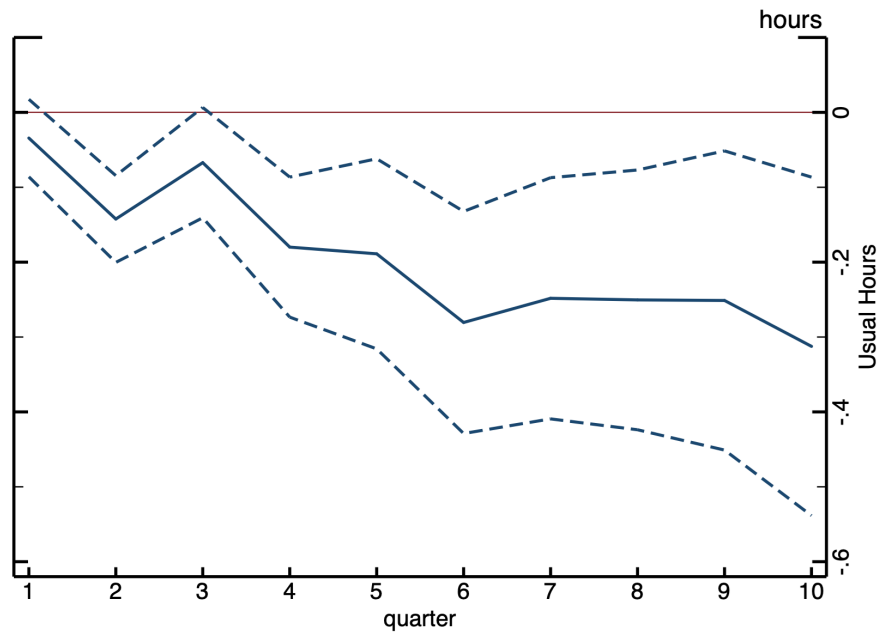
Panel a) shows monetary policy shocks identified through high-frequency changes in the Federal Funds Futures in a 30 minute window around FOMC announcements. Panel b) shows the summed quarterly shocks used in the analysis.

Figure 2.2: Impulse Responses - Usual Hours worked

a) Contractionary Shock



b) Expansionary Shock

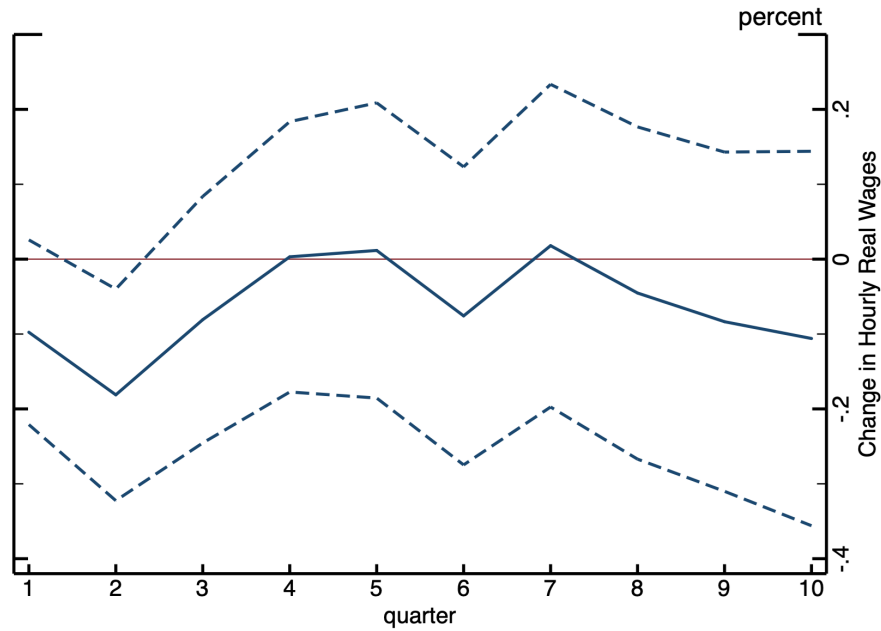


Monetary policy has economically insignificant effects on usual hours worked

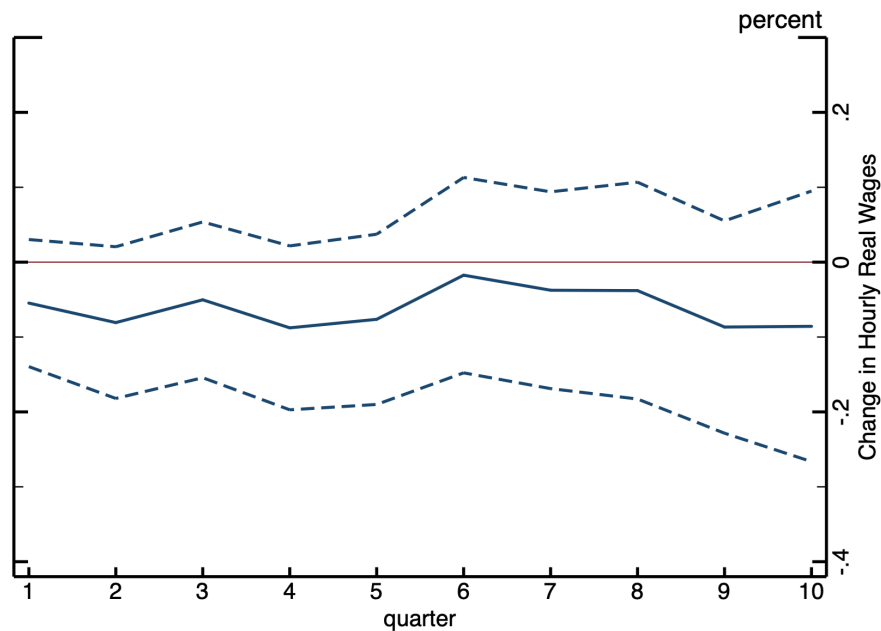
Panel a) shows impulse responses of usual hours worked to a one standard deviation contractionary monetary policy shock. Panel b) shows impulse responses to a one standard deviation expansionary shocks. Dashed lines denote 95% confidence intervals. Standard errors are clustered at the individual level.

Figure 2.3: Impulse Responses - Hourly Real Wages

a) Contractionary Shock



b) Expansionary Shock

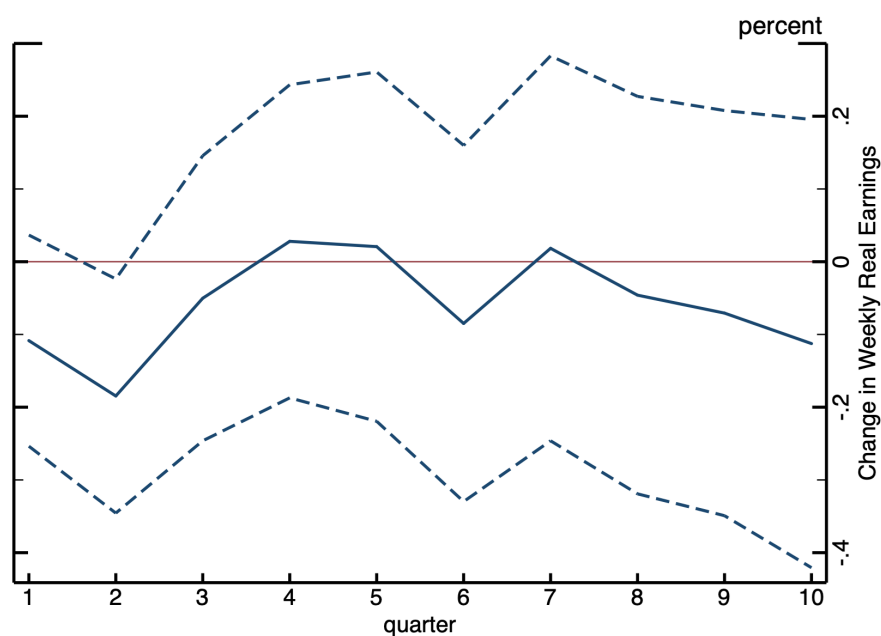


Monetary policy has no significant effects on hourly real wages

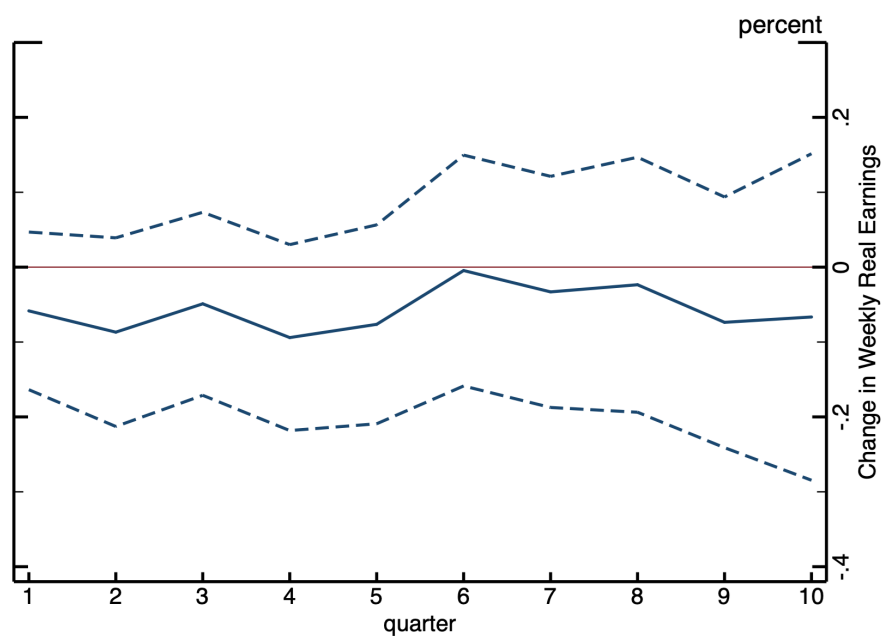
Panel a) shows impulse responses of hourly real wages to a one standard deviation contractionary monetary policy shock. Panel b) shows impulse responses to a one standard deviation expansionary shocks. Dashed lines denote 95% confidence intervals. Standard errors are clustered at the individual level.

Figure 2.4: Impulse Responses - Weekly Real Earnings

a) Contractionary Shock



b) Expansionary Shock

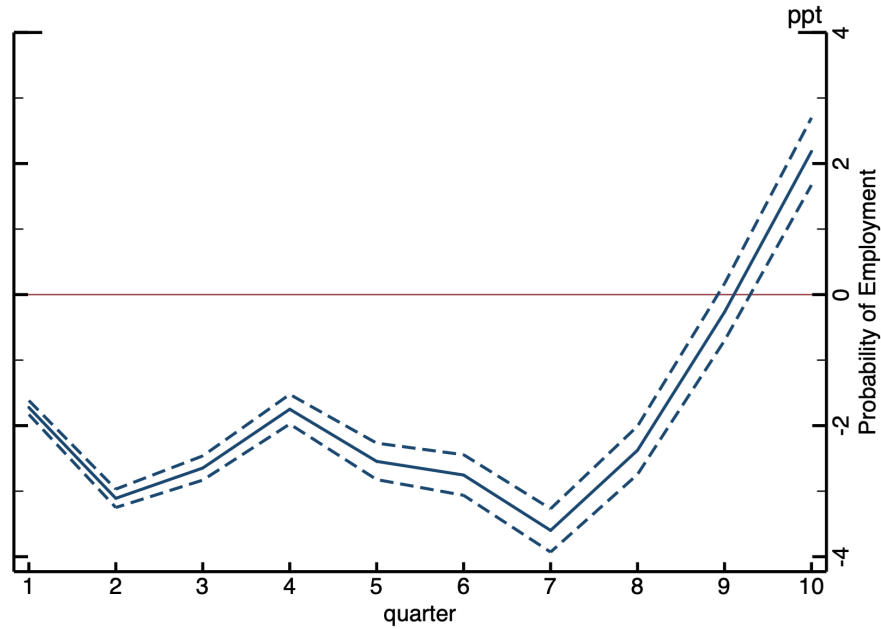


Monetary policy has no significant effect on the intensive labor margin

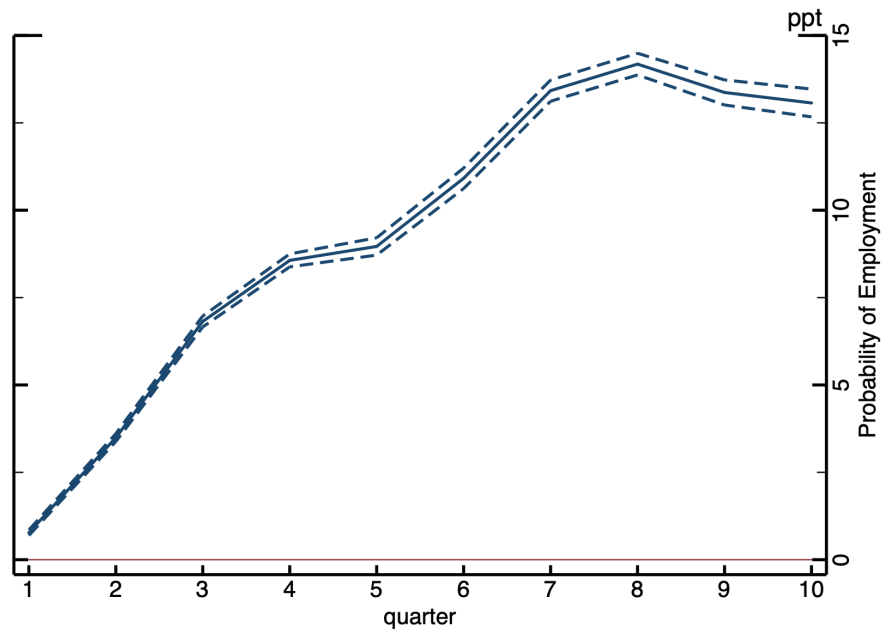
Panel a) shows impulse responses of weekly real earnings to a one standard deviation contractionary monetary policy shock. Panel b) shows impulse responses for one standard deviation expansionary shocks. Dashed lines denote 95% confidence intervals. Standard errors are clustered at the individual level.

Figure 2.5: Impulse Responses - Probability of Employment

a) Contractionary Shock



b) Expansionary Shock

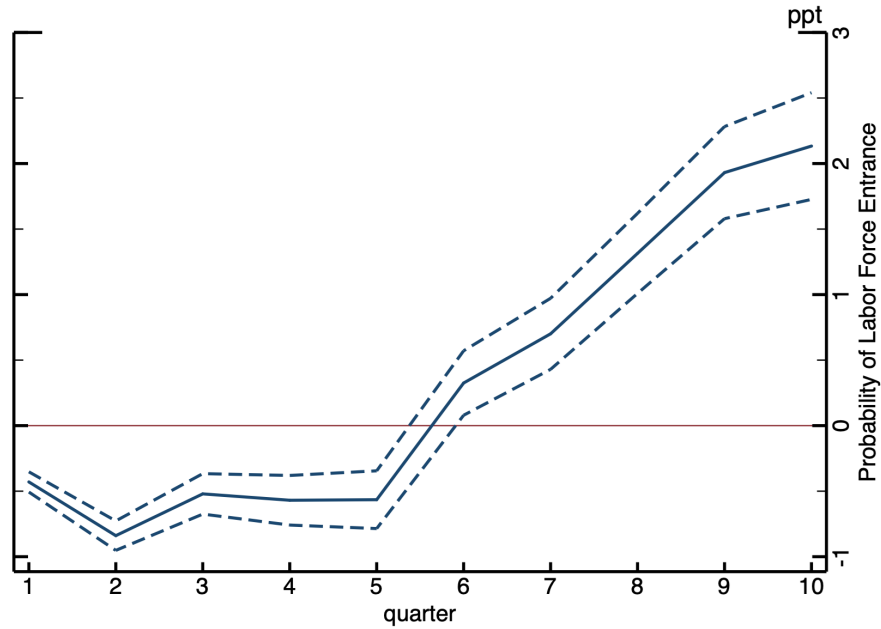


Monetary policy has significant effects on employment

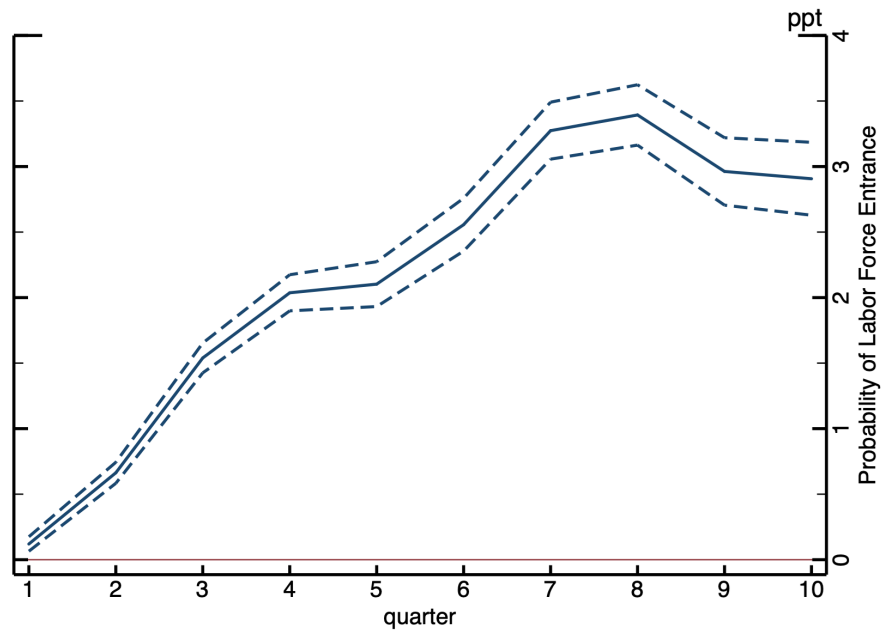
Panel a) shows impulse responses of the probability of employment to a one standard deviation contractionary monetary policy shock. Panel b) shows impulse responses for one standard deviation expansionary shocks. Dashed lines denote 95% confidence intervals. Standard errors are clustered at the individual level.

Figure 2.6: Impulse Responses - Probability of Entering Labor Force

a) Contractionary Shock



b) Expansionary Shock



Monetary policy has significant but weaker effects on labor force participation

Panel a) shows impulse responses of the probability of entering the labor force to a one standard deviation contractionary monetary policy shock. Panel b) shows impulse responses for one standard deviation expansionary shocks. Dashed lines denote 95% confidence intervals. Standard errors are clustered at the individual level.

Tables

Table 2.1: Summary Statistics - Monetary Policy Shocks

	daily		quarterly	
	tight	wide	tight	wide
mean	-0.0182	-0.0157	-0.0398	-0.0341
median	0	0	0.0062	0.0051
std	0.0853	0.0857	0.1208	0.1230
min	-0.438	-0.463	-0.459	-0.479
max	0.163	0.152	0.261	0.261
num	157	157	72	72
>0	54	52	25	25
<0	68	66	42	39

Monetary policy shocks offer rich variation for econometric analysis

Monetary policy shocks are identified through high-frequency changes of Federal Funds Futures in 30 minute (tight) or 60 minute (wide) windows around FOMC announcements. Quarterly refers to summed monetary policy shocks used in the analysis. Mean is the average, median the 50th percentile, min the smallest and max the largest observed monetary policy shock. Std is the standard deviation, num the number of observed, >0 the number of observed contractionary and <0 the number of observed expansionary policy shocks.

Table 2.2: Current Population Survey design

Survey tenure month	1	2	3	4	...	13	14	15	16
Month in Sample	1	2	3	4	...	5	6	7	8
Labor Force Status	✓	✓	✓	✓		✓	✓	✓	✓
Earnings Data				✓					✓

The 4-8-4 sampling scheme of the Current Population Survey

Individuals are interviewed in survey month 1-4 and survey month 13-16. Data on labor market status is collected in each survey month whereas earnings data is only collected in the outgoing month 4 and 8 if the individual is employed

Chapter 3

The Floating-Rate Channel of Firm Bond-Financing during the Financial Crisis 2008-2009

3.1 Introduction

How does conventional monetary policy affect firm investment decisions through interest rate changes? Theory uniformly predicts a negative correlation - business spending on fixed capital should rise when interest rates fall. However, this relationship proves to be difficult to establish empirically due to numerous endogeneity issues at both the individual and aggregate level. At the macroeconomic level interest rates and the prices of new investment goods typically fall during economic downturns exhibiting a positive correlation. At the firm level, due to the joint determination of investment and financial policies, higher investment often goes hand in hand with higher leverage which raises the likelihood of default and thereby increases the user cost of capital. This again induces a positive correlation between interest rates and investment spending if a company relies at least partially on external finance.

In this chapter I propose to use cross-sectional differences in firm bond-financing as a quasi-experimental setting to investigate the effects of conventional monetary policy. To finance investment spending through bond issuances, firms have the choice between three types of bonds: i) fixed-rate coupon bonds, whose coupon payments remain constant over the life-time of the bond, ii) floating-rate coupon bonds, whose coupon payments are calculated as a spread over some base interest rate (usually the Federal Funds Rate) and are adjusted if the base rate changes and iii) zero-coupon bonds, which don't pay any coupons over the life-time of the bond but are sold at a discount from par value which implicitly serves as an interest payment. Changes in monetary policy rates by changing base interest rates lead to direct cash-flow gains for firms issuing floating-rate bonds by reducing their effective coupon payment but leave the other two types unaffected.

Because firms' choice for the type of bond to issue might involve ex-ante anticipations of - possibly announced - future interest rate changes, I use the financial crisis of 2008 as a historical setting to investigate differential effects between floating-rate and fixed-rate issuers. During the financial crisis the Federal Reserve reduced interest rates from 4 percent at the beginning of 2008 to zero percent within the span of twelve month. Because the crisis was largely unforeseen and the interest rate reductions were a direct response to it, this setting offers the unique advantage of the changes in the federal funds rate being fully unexpected.

Arguably, the financial crisis constitutes a large-scale macroeconomic event that introduces a variety of potential endogeneity concerns. The most important one concerns interventions other than the reductions of the federal funds rate that were undertaken by the Federal Reserve in order to mitigate the panic on financial markets and ease funding conditions. While most of these interventions resulted in liquidity provisions for financial institutions one such intervention, the Commercial Paper Funding Facility, directly targeted non-financial corporations.

To establish causal results of interest changes in 2008 on real and financial outcomes I rely on difference-in-difference estimation in a treatment-effects framework. I categorize firms that issued at least one variable coupon bond prior to the onset of the crisis in the third quarter of 2007 as treated firms and compare these to non-treated firms, which issued only fixed- or zero-coupon bonds. To mitigate concerns about inherent differences between treated and non-treated firms I use a shortest-distance matching estimator as proposed by Abadie and Imbens (2006) and for example used by Almeida et al. (2012). Treated firms are matched to control firms based on firm and bond control variables in the year prior to the beginning of the crisis in August 2007. This should also mitigate concerns about differential exposure to Federal Reserve policies other than the changes in the federal funds rate. I then compare financial and real outcomes during 2008 and 2009 with a particular focus on fixed capital investment.

The main finding of this chapter is that although all firms reduced their investment after the onset of the financial crisis, floating-rate issuers had differentially higher investment rates after the decline in the federal funds rate. Due to the somewhat small sample size this result is however not statistically significant. Looking at financial outcomes there does not seem to be any significant difference between floating- and fixed-rate issuers as regards equity issuance, debt issuance or cash holdings. Several explanations are possible for this result: i) Firms might hedge their interest rate risk or at least the risk exposure resulting from bond financing, ii) call options on fixed bond holdings might make non-treatment a soft constraint, i.e. once interest rates decrease, fixed-coupon issuers call back their bonds and issue new bonds at a lower coupon rate, iii) non-standard monetary policy measures targeted at the financial sector lead to substantial easing of funding conditions for non-financial corporations that affected fixed- and floating-rate issuers similarly.

Relation to the Literature

The most closely related strand of literature employs a user-cost of capital framework as pioneered by Hall and Jorgenson (1967). The maximization of a neoclassical production function subject to the cost of capital and partial adjustment motivates an empirical specification which tries to measure the (long-run) elasticity of capital with respect to the user cost of capital. Changes in capital, i.e. investment are regressed on the output-to-capital ratio and the user cost of capital, which itself is a function of several cost factors like depreciation, taxes on capital purchases and capital income, the (post-tax) nominal interest rate, expected gains or losses associated with capital purchases and the relative price of investment goods to the relative price of output. As discussed in Gilchrist and Zakrajsek (2007) there are three approaches to empirical estimation of the effects of fluctuations of the cost of capital on investment.

Natural experiment analysis as undertaken for example by Cummins et al. (1994) and more recently by House and Shapiro (2006) usually focus on episodes where tax changes are large and account for almost all of the variation in the user cost of capital but has been unable to provide an explicit link between interest rates and investment spending due to the sole focus on tax changes.

User-Cost specification analysis employs some variant of the theoretically motivated empirical equation where interest expenses are regressed on the user cost of capital. Papers like Bernanke et al. (1988), Caballero (1994) or Tevlin and Whelan (2003) and Schaller (2006) rely on aggregate data in order to construct measures of the user cost (and usually find that components of the user cost like interest rates and tax terms play a modest role as determinants of investment spending in time series models) whereas more recent work like Chirinko et al. (2004) combines long-run analysis with firm-level panel data (usually Compustat). Overall reported long-run elasticity estimates are frequently estimated to be lower than unity and tend to be estimated with considerable imprecision.

Q-theoretic specifications like Abel et al. (1986) rely on formal description of adjustment costs along with assumptions on production technology in order to obtain an empirical relationship between investment and a tax-adjusted measure of Tobin's Q but given the well-documented empirical failure of Q-theoretic specifications offer little guidance for sensitivity estimates. More recently Philippon (2007) offers an alternative interpretation of the Q-theory utilizing information from the bond market as opposed to the equity market to construct an empirical proxy for Q. According to this paper, more than half of the volatility in aggregate investment in post-war U.S. data can be explained by this proxy.

This chapter differs from this strand of literature in relying on individual panel level data instead of aggregate data. Furthermore while the user-cost of capital incorporates several different types of capital costs I'm solely interested in the effects of interest rate changes on firm investment.

Credit Channel of Monetary Policy

Monetary policy can affect the economy and firms in particular through more than just interest rate policy. Motivated by the weak empirical evidence of the user-cost literature this strand of literature has been concerned with the so called credit channel of monetary policy.¹ It does not necessarily constitute an alternative explanation but puts emphasis on the amplification and propagation of monetary policy. In particular according to this literature the direct effects of interest policy are amplified by endogenous changes in the external finance premium, which is the difference in cost between funds raised externally and funds generated internally. Two potential linkages are the balance sheet channel, which stresses the potential impact of monetary policy changes on borrower's balance sheets and income statements, and the bank lending channel, which focuses on the effect of monetary policy actions on the supply of loans

¹See Bernanke, Gertler (1995) for an early review.

by depository institutions. While earlier papers like Kashyap and Stein (1995, 2000) rely on aggregated data, Khwaja and Mian (2008) in their seminal analysis separate the two linkages by looking at a natural experiment in an emerging market and using loan-level data in order to separate loan supply and demand, a method that other papers like Jiménez et al. (2010) who use Spanish credit register data have followed. A general finding is that credit supply matters at the individual level as banks facing an adverse funding supply shock cut their credit supply but aggregate effects are less clear as firms usually substitute at least part of their financing towards other means. As opposed to this strand of the literature I'm not interest in the effects of the credit supply channel but want to measure the effect of interest rate changes on firm investment.

Effects of the Financial Crisis

Another related strand of the literature concerns the effects of the recent financial crisis on firm financing and firm real outcomes. Chodorow-Reich (2014) looks at the syndicated loan market by merging Dealscan and the Longitudinal Business Database (LBD). He compares firms that had borrowed before the crisis from relatively healthy financial institutions with otherwise similar firms that had borrowed from lenders which were more adversely affected during the crisis and finds that the latter faced a measurable impact in terms of employment. Greenstone et al. (2014) offer a county-level within-state analysis leveraging the heterogeneity in the extent to which different national banks cut their small business lending during the financial crisis. They find that counties incorporating banks which cut their lending the most faced the strongest decline in small business loan origination and had the lowest small establishment employment growth.

Contrary to that Kahle and Stulz (2013) argue that the economic significance of the link between bank lending and capital expenditures is rather tenuous. Using

Compustat and employing a matching estimator they don't find that bank-dependent firms decrease their capital expenditures more than matching firms and highly levered firms actually decrease their capital expenditures by less. Another closely related paper by Almeida et al. (2012) looks at the debt maturity structure of Compustat firms and similarly employs a matching estimator. They find that firms which had to refinance a large portion of their debt right after the onset of the financial crisis 2007 saw a two-three percentage point decrease in capital expenditure compared to a sample of matched firms whose capital structure had a longer maturity.

This chapter differs from the aforementioned papers as it is not concerned with the effects of the crisis on corporate outcomes (although the crisis effects will be clearly visible in the estimation) but asks whether and how the monetary policy measures undertaken to mitigate the crisis (in particular lowering the federal funds rate) actually affect firm behavior. Furthermore to the best of my knowledge it is the first chapter trying to link corporate bond data with firm balance sheets directly instead of only relying on the maturity structure as for example Almeida et al. (2012).

Household Finance and Monetary Policy

Finally this chapter is similar in spirit to several papers in the household finance literature who try to address the question of the effects of interest rate policy on consumer spending and consumer behavior. Notably Keys et al. (2014) use the variation in the timing of rate resets of adjustable rate mortgages originated between 2003 and 2007 with initial fixed rate periods to address the familiar endogeneity problem of monetary policy. As mortgages are a large part of household balance sheets consumers with mortgages which adjust their rates right after the onset of the credit crisis after monetary policy rates drop to zero experience large unexpected windfall gains from paying less interest on their mortgages. Using a difference-in-difference methodology

the authors show that these windfall gains are used to increase consumption as well as reduce outstanding household debt.

This chapter proceeds as follows: Section 3.2 outlines the data and describes the variable construction. Section 3.3 develops the matching estimator employed in the treatment-effects analysis and presents some summary statistics. Section 3.4 presents the results of the analysis for real and financial outcomes whereas section 3.5 provides a discussion of the results.

3.2 Data Description

The empirical analysis in this chapter relies on two main data sources. The first is the Mergent Fixed Income Securities Database (MFISD) which provides data on financial and non-financial corporate bond issuances whereas Compustat provides firm balance sheet information. This section describes each dataset in turn and the merging procedure between the two.

Mergent FISD

Mergent FISD is a comprehensive bond-level database of publicly offered U.S. bonds. It contains issue details on over 140.000 corporate, supranational, U.S. Agency and U.S. Treasury debt securities. Data collection started in 1950 but complete coverage of all bond issuances only begins in 1998. Issue details contain information on a companies NAICS code, the offering amount, maturity and most importantly the coupon type of a bond. Additionally, MFISD also provides information on the last action on a bond is, e.g. partial bond calls, restructurings or conversions.

While the Mergent database provides comprehensive bond coverage, its data collection procedure complicates the empirical analysis. The main data limitation as available through the web-interface of Wharton Research Data Services (WRDS)

is that the status of a bond is not tracked through time. In particular, only a single observation is offered for each bond issuance containing information on the current coupon rate, offering amount, offering date and maturity alongside other bond attributes. This implies that without additional assumptions it is not possible track the actual interest expenditure on the bond and the windfall gain experienced by variable-coupon issuers. Similarly in the case of bond actions, where multiple instances may have taken place over time, only the last instance is included in the bond information.

To construct a time series for outstanding amounts and interest rate exposure of a bond I therefore assume that the last action affecting a bond issuance is the only action that took place throughout its life-time. This is important as it biases estimates against finding differential effects of interest changes on floating-rate issuers. Table 1 provides an example to understand why. Consider a company that issues a 200 million dollar variable coupon bond in 2004, partially calls 100 million dollar at the end of 2006 and decides to call the entire outstanding amount in 2009. For simplicity assume that the company pays a 5% base rate premium over the average yearly federal funds rate. Under the above assumptions the amount outstanding would be classified as 200 million dollar in 2008 and then as zero dollar. The assumed windfall gain on this coupon bond would be 6.18 million dollar when its true gain would only be half of it. Thus the assumed benefit from monetary policy easing would be overstated and the true exposure to treatment is smaller than the one implied by this timing assumption.

To construct the sample of firms that are of interest to this analysis I drop bond issuances of utility firms (Naics 22), finance and insurance companies (Naics 52) as well as issuances of Public Administrations (Naics 92). Because my focus lies on the effect of US monetary policy I only consider companies incorporated in the US. In measuring interest rate exposure I exclude Canadian and foreign-currency bonds due to the confounding exposure to exchange rate risk as well as global issuances and

yankee bonds, i.e. bonds that are denominated in U.S. dollars but publicly issued in the U.S. by foreign banks and corporations. Additionally, I drop bonds maturing before the first quarter of 2009 because they are not fully exposed to the interest rate decline in 2008. I also exclude bond issuances after the second quarter of 2007 once the first signs of a potential economic slowdown occurred in order to mitigate concerns about floating-rate issuers having anticipated the subsequent interest rate decreases. Finally, I exclude all bond issuances with missing offering amount, offering date or missing maturity. Aggregating bond issuances to the firm-quarter level yields 4.439 firm-quarter observations and a firm is observed in a quarter if it issued a bond in that particular quarter.²

Compustat North America

Firm balance sheet information comes from the Compustat North America Fundamentals Quarterly database. I exclude firms with missing or negative values for total assets (atq), capital expenditures (capxy), property, plant and equipment (ppentq), cash holdings (cheq) or sales (saleq). Similarly, I discard observations for firms with cash holdings, capital expenditures or property, plant and equipment larger than total assets.

The main outcome variable of interest is investment of firms and is constructed as capital expenditures over lagged property, plant and equipment. Financial outcome variables of interest are equity issuance, debt issuance and cash holdings. Equity issuance is defined as the sale minus the purchase of common and preferred stock ($sstky - prstkcy$) divided by lagged assets. Debt issuance is the sum of the change in total long-term debt and the change in current liabilities ($dlttq - L.dlttq + dlcq - L.dlcq$) divided by lagged assets. Cash holdings is defined as the ratio of cash and

²Although the firm level identifier in Mergent is the item “issuer id”, a firm-level observation is here defined by the issuer cusip as it is the only variable contained in Compustat as well.

short-term investments (cheq) to total assets. Long-term leverage is the ratio of total long-term debt (ddl + dltd) to total assets.

In selecting control variables I follow the corporate finance literature and include Tobin's Q, cash flow, size, cash holdings, long-term leverage, two-digit SIC codes and credit ratings.³ Q is defined as the ratio of total assets plus market capitalization minus common equity minus deferred taxes and investment tax credit ($atq + prccq \times cshoq - ceqq - txditc$). Cash Flow is the ratio of net income plus depreciation and amortization ($ibq + dpq$) to the lag of quarterly property, plant and equipment. Size is defined as the log of total assets. Credit ratings are constructed from S&P's quality rating and defined as either investment grade (Compustat variable spsrc from AAA to B+), speculative grade (spsrc from B to D) or unrated (spsrc missing).

Merging Bond and Balance Sheet data

A complication in combining the MFISD bond data with Compustat balance sheet data arises because both datasets use different permanent identifiers. In MFISD each unique bond issuance observation is assigned a unique, permanent issue ID and a unique issuer through the permanent issuer ID. This ID differs from the unique company identifier in Compustat, gvkey. The only variable commonly available in both datasets is the issuer cusip. However, while the issuer cusip is a permanent variable in MFISD and hence doesn't change, e.g. if a company was acquired by another, it is a head variable in Compustat. This means that it is backfilled throughout the entire time series to show the latest number and gvkey-cusip pairs can change with each new Compustat vintage.

To mitigate these issues I perform a two-stage merging procedure. In the first step I merge MFISD to COMPUSTAT via issuer cusip and manually check the merging quality. The first step matches around 47% or 2.068 of the 4.439 firm-quarter

³Cash holdings serve as a control or matching variable whenever it is not the outcome variable.

observations. In the second step I employ a conservative fuzzy matching algorithm and merge firm-quarter observations based on the quarter, company name, zip code, city and phone number and require perfect string matches for the quarter, zip code and phone number. This yields additional 525 merges yielding a total of 2.583 (58%) merged firm-quarter observations. Keeping each firm in the sample which has at least one bond issuance before the second quarter of 2007 that matures after the first quarter of 2009 the final dataset contains 12.337 firm-quarter observations for 1184 firms with a timespan from the third quarter of 2006 to the fourth quarter of 2009.

3.3 Empirical Strategy

The empirical strategy in this chapter relies on comparing floating-rate issuers with fixed rate issuers and exploiting the unexpected decrease in monetary policy rates during the financial crisis. This requires a discussion about potential limitations of this experimental setting and an appropriate strategy to avoid endogeneity issues.

Background

The recent financial crisis began with a crisis in the subprime mortgage market in early 2007. Figure 1 shows that the Federal Reserve initially reacted by lowering interest rates beginning in August 2007 from 5.25% to 2% in April 2008 to counteract the deteriorating economic outlook. First liquidity programs like the Term Auction Facility (TAF) in December 2007, the Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF) in March 2008 where all geared towards financial institutions with direct accounts at the Fed. While aimed at easing interbank funding conditions and maintaining liquidity in Repo markets these measures in principle functioned like the usual discount window lending except without the usual stigma attached to it. While concerns about the stability of the US financial system

were heightened, these measures were short-term in nature and recessionary pressures were generally thought to be temporary as evidenced by the plateau that the federal funds rate reached after April 2008. The decrease in the federal funds rate after the onset of the mortgage crisis thus constitutes a largely unexpected change in monetary policy rates.

Only with the collapse of Lehman Brothers in September 2008 did the mortgage crisis develop into a full-blown banking crisis threatening the financial system as a whole and therefore also credit supply for non-financial firms. The Fed undertook a series of measures to support bank stability and maintain bank lending. Unfortunately, directly controlling for bank lending conditions between floating- and fixed-rate issuers is not possible without access to loan level data. The analysis thus relies on the important identification assumption that improved funding conditions for non-financial corporations due to Federal Reserve liquidity programs did not correlate with the pre-crisis type of bond issuance.

While the Fed interventions to stabilize the financial system might have indirectly affected floating- and fixed-rate issuers differentially, direct interventions to ease corporate funding conditions are primary endogeneity concerns. In October 2008 the Fed introduced its Commercial Paper Funding Facility (CPFF) under which it purchased newly issued, highly rated corporate commercial paper. While this intervention might have directly impacted firm funding conditions, the CPFF is unlikely to have had important effects on firm investment for at least three reasons. First, the CPFF was quite small in size. With the exception of January 2009 the CPFF never reached more than 80 billion dollars in purchased, outstanding corporate commercial paper. This compares to 1 trillion dollar of bond *issuances* even during the year 2009. Second, more than half of the participating firms were foreign firms. These firms are likely to account for the bulk of the CPFF because of their limited number of alternatives for access to dollar funding in the US market but are excluded

from the subsequent analysis. Third, commercial paper has a short maturity of usually 90 days and at most up to 270 days. As such it is not used by corporations for long-term investment but mostly as a low-cost alternative to raise cash for current transactions and to smooth short-term financing needs by optimizing short-term cash flow streams.

Counterfactual Matching

The ideal empirical strategy would regress quarterly firm investment as an outcome variable on the quarterly coupon payments that the company is required to pay, and as coupon payments are not directly observed in the data they could potentially be instrumented.⁴ However, figure 2 shows that the required assumption of parallel trends for average investment between fixed- and floating-rate coupon bond issuers is not entirely robust.

To robustify such a simple difference-in-difference design I thus pursue a strategy that is less parametric and more design-based by employing a matching estimator.⁵ The idea behind such an estimator is to isolate treated observations - here the firms that issue at least one variable coupon bond prior to the second quarter of 2007 with a maturity past the first quarter of 2009 - and then to search for control observations from the population of non-treated observations, that best “match” the treated ones in multiple dimensions (covariates). The set of counterfactual outcomes then is restricted to the matched controls and the matches are made so as to ensure that treated and control observations have identical distributions along the covariates. Inferences about

⁴One such instrument could be an interaction of the amount of outstanding bonds prior to the decrease in interest rates interacted with interest rates to get a predictor of the likely interest payment. Though the strategy proposed here relies on the amount outstanding prior to the interest rate decrease as well and though we observe the Federal Funds Rate, I abstain from such a strategy here. The reason is twofold: First, I do not observe the base interest rate, i.e. the interest rate that serves as a base for calculating the coupon payment. Second as I do not observe the actual coupon payments, the validity of the instrument cannot be test in a first stage.

⁵See Angrist and Pischke (2010). The discussion in the following draws heavily on Almeida et al (2012).

the treatment of interest then are based on differences in the post-treatment outcomes of treated and control groups. The specification used is less centered around the idea of representing a model to explain the outcome variable but the focus is in ensuring that variables that might both influence the selection into treatment and observed outcome are appropriately accounted for in the estimation.

Although a variety of matching estimators are available, I follow Almeida et al (2012) and Kahle, Stulz (2012) and employ a minimum distance estimator as implemented by Abadie et al (2004). The estimator minimizes the distance between a vector of observed covariates across the treated and non-treated firms, finding control observations based on matches for which the distance between vectors is the smallest. Firms are allowed to serve as control observations more than once, which decreases the bias but increases the variance. The Abadie-Imbens estimator produces exact matches on categorical variables but naturally matches on continuous variables will not be exact. The procedure recognizes this difficulty and applies a bias-correction component to the estimates of interest. In addition, it produces heteroscedastic-robust standard errors.

The outcome variable of ultimate interest is investment as defined in the last section. Matching then is done on the average values in the year prior to the beginning of the crisis, i.e. between the third quarter of 2006 and the second quarter of 2007 and compared to post-treatment average outcomes in the year after the crisis (third quarter of 2007 to the second quarter of 2008) and the year after the Lehman failure (first to last quarter of 2009) . The categorical firm variables, that are used in the matching process are a firm's industry classification code and it's rating. Non-categorical firm variables are a firms' market-to-book-rate (Tobin's Q), cash flow, cash holdings, size and the ratio of long-term debt to total assets. Non-categorical bond variables are the amount of bonds outstanding, how much of this amount is

enhanced, has covenants, is redeemable, has a call option, is convertible and the average maturity of the amount outstanding.⁶

Data Summary

Table 1 and 2 report median values for firm and bond variables used in the matching procedure across treatment groups. I use the Pearson χ^2 -statistic to test for the significance of differences in the medians of the variables of interest across groups.

Panel A compares the 54 treated firms in the sample to the remaining 473 non-treated firms. Treated firms have higher Tobin's Q, Cash Flow and Sales, are larger and more leveraged. but have lower cash holdings and investment. While the Pearson test does not reject most medians to be similar - except and importantly for the outcome variable - differences are statistically significant for almost all bond characteristics. In particular, floating-rate issuers have a longer residual maturity of 29 quarters on their outstanding bond issuances at the second quarter of 2007 compared to 21 quarters for fixed-rate issuers.

Furthermore, treated firms finance 2.5 percent more of their balance sheets with bonds and for the median treated firm around 5.7 percent of the balance sheet or almost one third of all bonds outstanding are variable coupon bonds. A simple back of the envelope calculations shows that for the medium treated firm a reduction of interests to zero potentially yielded an unexpected windfall gain of around 7 to 8 percent of overall cash holdings.⁷

Panel B compares median values for treated and matched control firms. The Abadie-Imbens matching estimator is able to match 45 treatment firms to 37 unique control firms. Notably after the matching procedure there are no statistical differences

⁶ Average maturity is constructed as $avg.mat = \frac{\sum_i amount_i * maturity_i}{\sum_i amount_i} = \sum_i \frac{amount_i}{\sum_i amount_i} * maturity_i$, where $amount_i$ is the outstanding amount at the second quarter of 2007 of the i-th bond issuance.

⁷ The Federal Funds Rate in early 2007 was at 5.25% and yields for corporate bond medium term notes around 75 basis points. Hence for the medium firm $\frac{variable\ amount * FFR}{cash\ holdings} = \frac{5.82 * 6}{4.8} = 7.12$. A similar calculation for the 75th percentile firm yields around 8.2%.

in the median values of neither firm nor bond characteristics across treated and control firms.

Table 2 compares the entire distributions of the various matching covariates rather than just the medians. The results mirror those reported in Table 1. Panel A shows that treated firms differ significantly from non-treated firms in terms of size as well as investment. While the Kolmogorov-Smirnov test shows no significant difference in the distributions of rest of the firm covariates Table 2 shows that the opposite is true for the majority of bond covariates. Panel B of Table 2 shows again that after matching treated firms to appropriate control firms there are no statistical differences in the distributions of the various bond characteristics.⁸ These statistics support the assertion that the matching estimator moves the analysis closer to an experimental design.

3.4 Empirical Results

3.4.1 Real but insignificant effects of monetary policy

I examine the investment behavior of treated and matched control firms before, during and after the decrease of interest rates. Before doing so, I perform a group-mean comparison between the 54 treated and 473 non-treated firms, which is equivalent to a standard OLS regression of the outcome of interest (investment changes) on a dummy for treated firms. Panel A of Table 4 shows that prior to the decrease in interest rates, both treated and non-treated firms invested at different rates. The average investment-to-capital ratio between the third quarter of 2006 and the second quarter of 2007 (pre-period) is 4.97 percent for treated firms and 6.38 percent for non-treated firms which is not only economically but also statistically significant.

⁸With the notable exception of the fraction of callable bonds.

This suggests that comparisons between the groups is potentially confounded by other factors.

Panel A also shows average investment rates for the third quarter of 2007 to the second quarter of 2008 (between-period) and for the first to the last quarter of 2009 (post-period). Investment falls for non-treated firms during the between-period to 5.0 percent and tanks to 3.9 percent in the post-period, while surprisingly treated firms first see an increase in investment of 0.6 percentage points during the between-period. Eventually though investment also falls for this group in 2009 to 4.07 percent reflecting the general recession during that period. This however means that treated firms end up with higher average investment rates in 2009 and the difference-in-difference estimator suggests that treated firms invested 1.6 percentage points more than non-treated firms after interest rate decreased.

The implementation of the matching estimator in Panel B however does not confirm these findings. Firms in the treatment group are now compared with closer counterfactuals and pre-period investment levels are economically similar and statistically insignificant now.⁹ Now control firms actually increase their investment in the between-period as well (and more so than treated firms) but for both group investment drops significantly between 2008 and 2009. While it is also true for the matched sample that treated firms end up with higher investment rates in 2009 - the difference-in-difference estimator suggests that treated firms on average invest 0.74 percent more than control firms - these differences become insignificant now. While this could be seen as a confirmation of confounding factors that are present in the simple comparison of treated to non-treated firms in the non-matched sample, one could also argue that the number of observations in the matched sample is quite low

⁹The higher mean investment rate for treated firms in the matched sample compared to the treated firms in the plain balanced panel before matching raises slight concerns about selection issues of the matching estimator though.

which also drives standard errors up and requires strong treatment effects in order to render them statistically significant.

However, Panel B also reports the differential change in investment that is produced by the Abadie-Imbens matching estimator of the average effect of the treatment on the treated (ATT). The ATT difference is equal to 0.71 percentage points for the time 2007-2009 (pre-period until post-period). This is the central result of the chapter. It indicates that while economically investment for treated firms is higher than for non-treated firms, these results are statistically not significant.¹⁰

3.4.2 No financial effects of monetary policy

While we do not see any statistically significant effect of interest rate policy on investment it might be that variable coupon bond issuing firms decided not to increase their investment relative to fixed-rate coupon issuing firms but decrease their equity issuance or use the windfall gains to repay existing debts or stock up on their cash holdings. These financial alternatives to real investment will be investigated in the following.

Panel A of table 3.6 shows the average quarterly equity issuance for non-treated and treated firms.¹¹ Both types of firms already engaged in stock buy backs in 2007, i.e. have negative equity issuances, though treated firms (-1 percent) more so than non-treated (-0.78 percent). During the between-period both types of firms reduce their equity issuance even further but once interest rates hit the zero lower bound firms increased their equity issuances in 2009. Interestingly though throughout all the periods treated firms on average never issue new equity whereas non-treated firms'

¹⁰The Abadie-Imbens matching estimator which only matches on the covariates displayed in table 2 (except of course the amount of variable coupon bonds outstanding) on the other hand produces significant results on the 5% significance level indicating a difference of 0.83 percentage points with a standard error of 0.42. This suggests that the estimation results are not extremely robust and a bigger sample size could increase precision.

¹¹Due to missing information on equity issuance for some firms the sample size decreased to 458 non-treated and 51 treated firms.

equity issuances become mildly positive in 2009. Overall the differences between equity issuances are slightly negative, i.e. treated firms issue less equity than non-treated firms as would be expected. These results again are not statistically significant though.

The matching estimator in Panel B shows roughly similar patterns. Again both groups of firms start with negative equity issuances in 2007. Treated firms on average issued -0.93 percent equity and control firms -0.41 percent. Again control firms end up with slightly positive equity issuances of 0.04 percent in 2009 whereas treated firms never issue positive equity (-0.2 percent). However comparing the difference in the change of equity issuance between both types reveals that treated firms actually have higher issuances of 0.72 percent compared to control firms over the whole period. This is because treated firms in the between-period reduce equity issuances to a significant amount of -1.48 percent but lower this pace of buybacks in 2009, which could be an indication that most windfall gains actually occurred in 2008 and were used to buy back stocks.

For average quarterly debt issuances a less consistent picture emerges. Panel A of table 3.7 shows that non-treated firms start with a higher level of debt issuances in the pre-period of 1.57 percent compared to 0.8 percent for treated firms. However in the between period debt issuances are very similar around 0.75 percent and in the post-period it turns negative for both types of firms. This means that over the whole period floating-rate coupon issuing firms in the non-matched sample cut back stronger on their debt issuance and hence treated firms, because starting from a lower level of debt issuances in 2007 issued comparably more debt than non-treated firms. This is at odds with the proposed explanation for the impact of interest rate policy on firm behavior as we would expect treated firms to partially use their windfall gains to cut down on new debt issuances.¹²

¹²However, we could imagine fixed-rate coupon issuing firms to call their bonds due to relatively high interest costs and not issue any new bonds. This should be reflected in cash holdings, i.e. fixed

Panel B paints a similar picture for the whole period. Although treated firms in the matched sample actually start with a higher level of debt issuances of 0.85 percent in 2007 compared to 0.27 percent for control firms, they do not cut down on their debt issuances by as much as control firms do and end up with debt buybacks of around 0.5 percent in 2009 compared to 1.16 percent for control firms. While the reduction in debt issuance is statistically for both firms the difference-in-the difference is not. I.e. although treated firms issue comparable more debt (or buy back less) then control firms similar to panel A, these differences are not statistically significant.

For cash holdings an equally inconsistent picture emerges. Given that there are no statistically significant effects on investment, equity and debt issuance, i.e. treated firms statistically don't increase their investment, equity or debt, the proposed channel should yield a visible differential increase in cash holdings for treated firms. Panel A of table 3.8 however shows, that this is not the case. Treated firms have on average significantly lower cash holdings in 2007 and while they do catch up slightly in the between-period, the actual difference-in-difference over the whole period is just 0.05 percent, i.e. in 2009 after interest rates dropped to zero treated firms have not seen any differential increase in their cash holdings compared to non-treated firms.

The estimates in the matched sample even paint the opposite picture. Treated firms in the matched sample start with higher cash holdings of around 8 percent compared to control firms with cash holdings of 5.9 percent. While both types of firms increase their cash holdings in the between-period, control firms do so by 1.6 percent more than treated firms, i.e. control firms actually see a *gain* in cash holdings compared to treated firms, although the latter ones should have experienced the windfall gains from interest rate policy. However, these results - similar to the ones for investment, equity and debt issuance - are not statistically significant.

coupon rate firms should see a decrease in cash holdings. Table 3.8 however shows that this is not the case.

3.4.3 Discussion

The last subsection established that the economic significance of the proposed channel goes in the right direction for investment and equity issuances, i.e. treated firms invest more and issue less equity during and after interest rates decrease. However, a less consistent picture emerges for debt issuances and cash holdings and none of the difference-in-difference results for the matched sample are statistically significant.

Three potential caveats need to be kept in mind when interpreting the results. First, the conservative merging procedure of Mergent FISD with Compustat and the matching of treated with control firms yields a sample size, that is small and puts high demand on the data to get statistically precise estimates. For example, standard errors for the difference-in-difference estimate on investment in table 3.5 are around 0.66 (0.53 for the ATT) requiring treated firms to invest at least 1.29 percent more over the whole period compared to control firms in order to find a significant effect. This effect would account for around 25 percent of the overall investment of treated firms in the pre-period, i.e. for the matching estimator to yield a significant effect the data would have to exhibit large *differential* changes between treated and control firms.

Second, companies might engage in interest rate hedging. This could render fixed-rate issuers to actually be floating-rate firms that are exposed to changing policy rates. Although they would issue a bond with periodically fixed coupon payments, they could have entered into an interest rate swaps exchanging fixed interest rate payments for floating interest rate payments thus turning the fixed-coupon bond effectively into a floating rate bond. While non-financial corporations are required to report derivative activities on their 10-K corporate filings, the details of reporting vary widely across corporations and often do not include specifics on interest rate swap agreements.

Third, measures by the Federal Reserve to improve liquidity and funding conditions for financial corporations might have indirectly and disproportionately benefited fixed-rate issuers. However, due to a lack of loan-level data it is impossible to control for differentially changing funding conditions.

3.5 Conclusion

This chapter proposes measuring the effects of conventional monetary policy on firm investment through firm bond financing. Using a matching estimator I compare fixed-rate coupon bond issuing firms to floating-rate coupon bond issuing firms. The latter type of firms experiences cash windfall gains from reductions in monetary policy rates that directly translate into lower coupon rates. The empirical results show differential outcomes in real investment rates after the onset of the financial crisis, statistically insignificant ones due to the restricted sample size.

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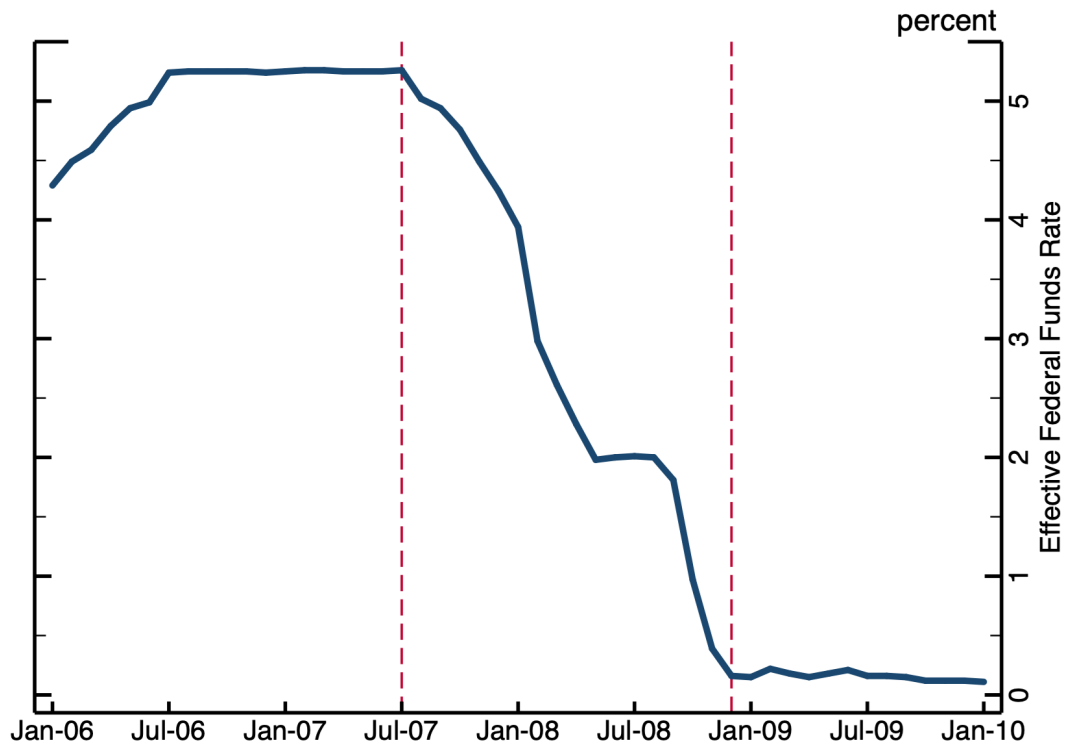
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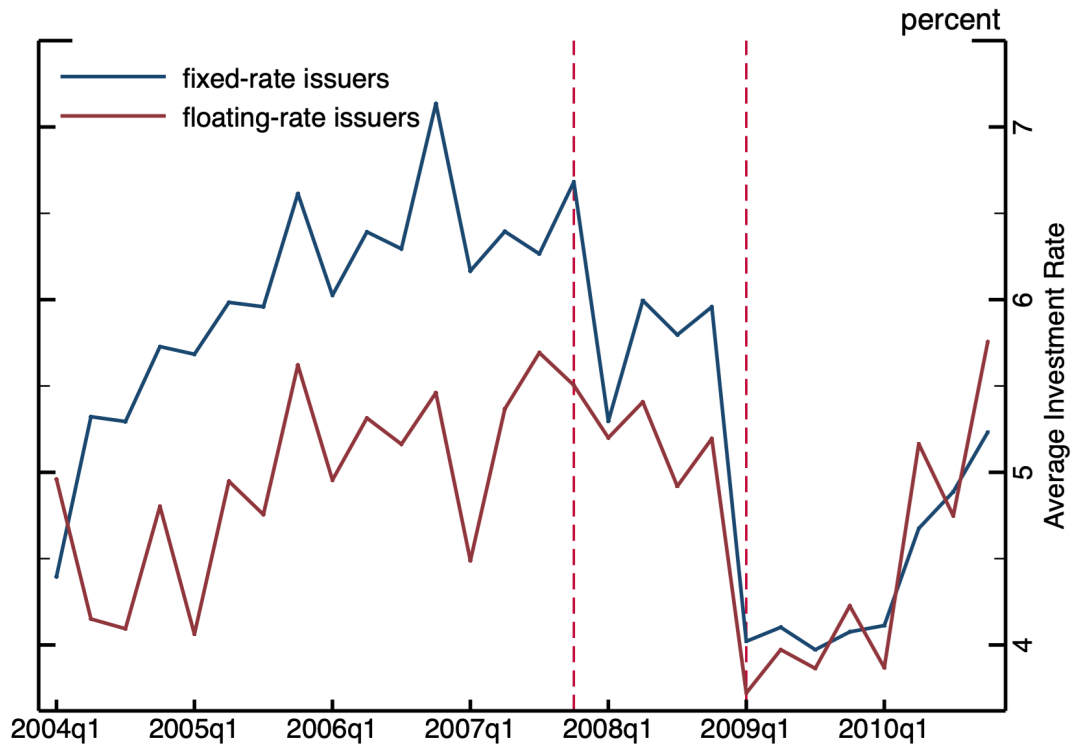
Figures

Figure 3.1: Effective Federal Funds Rate 2006-2009



This figure shows the effective federal funds rate from January 2006 to January 2010. The red vertical lines delineate the beginning of the interest decrease in July 2007 and the end in December 2008.

Figure 3.2: Unconditional Parallel Trends - Treated vs. Non-treated firms



This figure shows the raw (unconditional) average quarterly investment rate for non-treated firms (fixed-rate coupon bond issuers) and 54 treated firms (floating-rate coupon bond issuers).

Tables

Table 3.1: Timing Assumption of Coupon Payments

	2004	2005	2006	2007	2008	2009
Amount Outstanding (million \$)	200	200	200	100	100	100
Average Federal Funds Rate (percent)	1.35	3.21	4.96	5.02	1.93	0.16
Average Coupon Rate (percent)	6.35	8.21	9.96	10.02	6.93	5.16
Actual Coupon Payment (million \$)	12.7	16.42	19.92	10.02	6.93	5.16
Assumed Coupon Payment (million \$)	12.7	16.42	19.92	20.04	13.86	10.32

This table shows the impact of the timing assumption in the construction of a time series for the bond life-cycle as described in section 3.2.

Table 3.2: Pre-Treatment Characteristics of Treated, Non-Treated and Control Firms

	Q	Cash Flow	Size	Cash	Leverage	Sales	Maturity	Amount	Variable Amount	Investment
<i>Panel A: Medians for Non-Treated and Treated Firms in 2007q2</i>										
Non-Treated	1.500	0.080	7.887	0.052	0.305	0.223	21	0.164	0.000	0.051
Treated	1.593	0.099	8.134	0.048	0.340	0.259	29.2	0.189	0.582	0.042
Difference	0.093	0.019	0.247	-0.004	0.035	0.026	8.2	0.025	0.582	-0.009
Median Test	0.117	0.252	0.148	0.785	0.557	0.557	0.035	0.043	0.000	0.088
p-value										
<i>Panel B: Medians for Control and Treated Firms in 2007q2</i>										
Control	1.548	0.094	7.841	0.039	0.357	0.247	25.1	0.170	0.000	0.044
Treated	1.611	0.105	8.055	0.043	0.332	0.248	28	0.180	0.570	0.044
Difference	0.063	0.011	0.214	0.004	-0.025	0.001	2.9	0.010	0.570	0.000
Median Test	0.824	0.506	0.506	0.824	0.824	0.824	0.824	0.506	0.000	0.824
p-value										

The table compares the properties of treated, non-treated and control firms (median comparison). In Panel A the 527 sample firms are split into treated and non-treated groups. Treated firms are defined as those which have issued at least one variable coupon bond before the second quarter of 2007 which matures after interest rates decreased to zero in the first quarter of 2009. Non-treated firms are defined as firms which have issued only fixed-coupon or fixed-and zero-coupon bonds. There 473 non-treated firms and 54 treated firms.

In Panel B control and treated firms are the subset of firms that were matched using a shortest-distance matching estimator, based on a set of firm-characteristics (Tobin's Q, cash flow, size cash holdings, leverage, 2-digit SIC industry, ratings), and bond-characteristics (amount outstanding divided by total assets, asset-weighted maturity, and the fraction of the outstanding bonds being enhanced, redeemable, callable, putable, convertible and facing covenant-restrictions). There are 37 unique control firms matched to 45 treated firms.

The medians of Q, cash flow, size, cash holdings, leverage as well as average bond-maturity, the bond-amount outstanding and the outstanding amount of variable coupon bonds divided by assets are displayed. The average quarterly investment-to-capital ratio over the four quarters 2006q3-2007q2 is also displayed. See the text for further variable description and the appendix table for the distribution of further bond-characteristics.

The test for a difference in the medians of firm and bond characteristics across the two groups is conducted by calculating the Pearson's χ^2 statistic, with the p-values of this test reported at the bottom row of each panel.

Table 3.3: Pre-Treatment distributional tests of differential firm characteristics

		25th %	Median	75th %	Kolmogorov-Smirnov Test p-value
<i>Panel A: Characteristics of Non-Treated vs. Treated Firms in 2007q2</i>					
Q	Non-Treated	1.200	1.500	2.056	0.500
	Treated	1.211	1.593	2.140	
Cash Flow	Non-Treated	0.038	0.080	0.173	0.616
	Treated	0.048	0.099	0.174	
Size	Non-Treated	7.010	7.887	8.845	0.084
	Treated	7.035	8.134	9.828	
Cash	Non-Treated	0.022	0.049	0.130	0.834
	Treated	0.020	0.044	0.125	
Leverage	Non-Treated	0.195	0.307	0.438	0.521
	Treated	0.206	0.327	0.50	
Sales	Non-Treated	0.131	0.219	0.323	0.330
	Treated	0.159	0.245	0.373	
Maturity	Non-Treated	14	21	41.7	0.096
	Treated	15.7	29.2	58	
Amount	Non-Treated	0.089	0.164	0.253	0.102
	Treated	0.109	0.189	0.306	
Variable	Non-Treated	0	0	0	0.000
		0.027	0.058	0.170	
Investment	Non-Treated	0.034	0.051	0.077	0.084
	Treated	0.028	0.042	0.059	

Table 3.3 (cont.): Pre-Treatment distributional tests of differential firm characteristics

<i>Panel B: Characteristics of Control vs. Treated Firms in 2007q2</i>					
Q	Control	1.235	1.548	2.103	0.903
	Treated	1.211	1.611	2.140	
Cash Flow	Control	0.054	0.094	0.139	0.776
	Treated	0.053	0.105	0.174	
Size	Control	6.905	7.841	9.308	0.648
	Treated	7.035	8.055	9.828	
Cash	Control	0.179	0.039	0.072	0.643
	Treated	0.020	0.043	0.125	
Leverage	Control	0.257	0.357	0.504	0.913
	Treated	0.215	0.332	0.524	
Sales	Control	0.190	0.247	0.373	0.275
	Treated	0.157	0.248	0.372	
Maturity	Control	18.8	25.1	61	0.960
	Treated	16.2	28	57	
Amount	Control	0.111	0.170	0.250	0.540
	Treated	0.099	0.180	0.306	
Variable	Control	0	0	0	0.000
		0.027	0.057	0.154	
Investment	Control	0.036	0.044	0.058	0.761
	Treated	0.031	0.044	0.067	

This table compares distributional properties of the various matching covariates of treated, non-treated and control firms. In Panel A the 527 sample firms are split into treated and non-treated groups. Treated firms are defined as those which have issued at least one variable coupon bond before the second quarter of 2007 which matures after interest rates decreased to zero in the first quarter of 2009. Non-treated firms are defined as firms which have issued only fixed-coupon or fixed- and zero-coupon bonds. There 473 non-treated firms and 54 treated firms.

In Panel B control and treated firms are the subset of firms that were matched using a shortest-distance matching estimator, based on a set of firm-characteristics (Tobin's Q, cash flow, size cash holdings, leverage, 2-digit SIC industry, ratings), and bond-characteristics (amount outstanding divided by total assets, asset-weighted maturity, and the fraction of the outstanding bonds being enhanced, redeemable, callable, puttable, convertible and facing covenant-restrictions). There are 37 unique control firms matched to 45 treated firms.

The 25th percentile, median, and the 75th percentile of Q, cash flow, size, cash holdings, leverage, investment as well as average bond-maturity, the bond-amount outstanding and the outstanding amount of variable coupon bonds divided by assets are displayed. The test for differences in the distribution of a firm/bond characteristic across two groups is conducted by calculating the corrected Kolmogorov-Smirnov's D-statistic, with the p-values of this test reported in the rightmost column.

Table 3.4: Pre-Treatment distributional tests of differential bond characteristics					
					Kolmogorov-Smirnov
					Test p-value
<i>Panel A: Characteristics of Non-Treated vs. Treated Firms in 2007q2</i>					
Enhanced	Non-Treated	0	0	1	0.026
	Treated	0	0	0.34	
Covenant	Non-Treated	1	1	1	0.619
	Treated	1	1	1	
Redeemable	Non-Treated	1	1	1	0.041
	Treated	0.85	1	1	
Callable	Non-Treated	1	1	1	0.017
	Treated	0.85	1	1	
Putable	Non-Treated	0	0	0	0.012
	Treated	0	0	0.66	
Convertible	Non-Treated	0	0	0.56	0.363
	Treated	0	0	0.66	
Amount	Non-Treated	0.16	0.27	0.42	0.884
	Treated	0.14	0.29	0.42	
<i>Panel B: Characteristics of Control vs. Treated Firms in 2007q2</i>					
Enhanced	Control	0	0	0	0.678
	Treated	0	0	0	
Covenant	Control	1	1	1	0.997
	Treated	1	1	1	
Redeemable	Control	1	1	1	0.207
	Treated	0.85	1	1	
Callable	Control	1	1	1	0.078
	Treated	0.83	1	1	
Putable	Control	0	0	0.89	0.971
	Treated	0	0	0.66	
Convertible	Control	0	0	0.89	0.956
	Treated	0	0	0.86	
Amount	Control	0.16	0.25	0.36	0.594
	Treated	0.14	0.29	0.44	

This table compares distributional properties of the various matching bond covariates of treated, non-treated and control firms. In Panel A the 527 sample firms are split into treated and non-treated groups. Treated firms are defined as those which have issued at least one variable coupon bond before the second quarter of 2007 which matures after interest rates decreased to zero in the first quarter of 2009. Non-treated firms are defined as firms which have issued only fixed-coupon or fixed- and zero-coupon bonds. There 473 non-treated firms and 54 treated firms.

In Panel B control and treated firms are the subset of firms that were matched using a shortest-distance matching estimator, based on a set of firm-characteristics (Tobin's Q, cash flow, size cash holdings, leverage, 2-digit SIC industry, ratings), and bond-characteristics (amount outstanding divided by total assets, asset-weighted maturity, and the fraction of the outstanding bonds being enhanced, redeemable, callable, putable, convertible and facing covenant-restrictions). There are 37 unique control firms matched to 45 treated firms.

The 25th percentile, median, and the 75th percentile are displayed for the bond-fraction that is enhanced, redeemable, callable, putable, convertible and faces covenant restrictions. The fraction of the bond amount outstanding as part of the total liabilities is also displayed. The test for differences in the distribution of a firm/bond characteristic across two groups is conducted by calculating the corrected Kolmogorov-Smirnov's D-statistic, with the p-values of this test reported in the rightmost column.

Table 3.5: Investment before, during and after the Federal Funds Rate decrease

Average Quarterly Investment (in percentage points)						
<i>Panel A: Non-Treated vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Non-Treated	6.38*** (0.21)	5.90*** (0.17)	3.93*** (0.13)	-0.47* (0.27)	-1.97*** (0.21)	-2.45*** (0.24)
Treated	4.97*** (0.48)	5.56*** (0.61)	4.07*** (0.36)	0.61 (0.77)	-1.51** (0.70)	-0.90 (0.59)
Difference	-1.41*** (0.51)	-0.32 (0.63)	0.14 (0.36)	1.08*** (0.33)	0.46 (0.47)	1.55*** (0.40)
<i>Panel B: Control vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Control	5.19*** (0.52)	5.93*** (0.83)	3.36*** (0.30)	0.74 (0.98)	-2.57*** (0.88)	-1.83*** (0.60)
Treated	5.25*** (0.55)	5.86*** (0.71)	4.61*** (0.41)	0.60 (0.90)	-1.69*** (0.82)	-1.09 (0.68)
Difference	0.06 (0.76)	-0.08 (1.1)	0.80 (0.51)	-0.14 (0.71)	0.88 (0.99)	0.74 (0.66)
ATT				1.10* (0.65)		0.71 (0.53)

This table presents estimates of the change in the average quarterly investment rates during the four quarters 2006q3-2007q2, 2007q3-2008q2 and 2009q1-2009q4 as well as the difference in the difference between the two groups of firms over the respective periods. ATT is the Abadie-Imbens bias corrected matching estimator estimating the average treatment effect on the treated. The average of quarterly investment is defined as capital expenditures over lagged property, plant and equipment. Heteroscedasticity-consistent standard errors are in parentheses.

In Panel A the 527 sample firms are split into treated and non-treated groups. Treated firms are defined as those which have issued at least one variable coupon bond before the second quarter of 2007 which matures after interest rates decreased to zero in the first quarter of 2009. Non-treated firms are defined as firms which have issued only fixed-coupon or fixed- and zero-coupon bonds. There 473 non-treated firms and 54 treated firms.

In Panel B the average of quarterly investment is calculated for the subset of firms that were matched using a shortest-distance matching estimator, based on a set of firm-characteristics (Tobin's Q, cash flow, size cash holdings, leverage, 2-digit SIC industry, ratings), and bond-characteristics (amount outstanding divided by total assets, asset-weighted maturity, and the fraction of the outstanding bonds being enhanced, redeemable, callable, putable, convertible and facing covenant-restrictions). There are 37 unique control firms matched to 45 treated firms. ***, **, * indicate significance at the 1, 5 and 10% significance level respectively.

Table 3.6: Equity issuance before, during and after the Federal Funds Rate decrease

Average Quarterly Equity Issuance (in percentage points)						
<i>Panel A: Non-Treated vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Non-Treated	-0.78*** (0.23)	-0.90*** (0.18)	0.21 (0.15)	-0.11 (0.29)	1.11*** (0.23)	0.99*** (0.28)
Treated	-1.00* (0.60)	-1.35*** (0.38)	-0.17 (0.20)	-0.35 (0.70)	1.18*** (0.43)	0.83 (0.63)
Difference	-0.22 (0.63)	-0.46 (0.42)	-0.38 (0.25)	-0.24 (0.52)	-0.08 (0.38)	-0.16 (0.58)
<i>Panel B: Control vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Control	-0.41 (0.28)	-0.65* (0.34)	0.04 (0.12)	-0.24 (0.44)	0.69* (0.36)	0.45 (0.30)
Treated	-0.93 (0.68)	-1.48*** (0.44)	-0.20 (0.24)	-0.56 (0.81)	1.28*** (0.49)	0.72 (0.72)
Difference	-0.52 (0.74)	-0.83 (0.56)	-0.25 (0.27)	-0.31 (0.57)	0.59 (0.51)	0.27 (0.66)
ATT						-0.20 (0.27)

This table presents estimates of the change in the average quarterly equity issuance rates during the four quarters 2006q3-2007q2, 2007q3-2008q2 and 2009q1-2009q4 as well as the difference in the difference between the two groups of firms over the respective periods. ATT is the Abadie-Imbens bias corrected matching estimator estimating the average treatment effect on the treated. The average of quarterly equity issuance is defined as the sale minus the purchase of common and preferred stock over lagged assets. Heteroscedasticity-consistent standard errors are in parentheses.

In Panel A the 509 sample firms with non-missing information on equity issuance are split into treated and non-treated groups. Treated firms are defined as those which have issued at least one variable coupon bond before the second quarter of 2007 which matures after interest rates decreased to zero in the first quarter of 2009. Non-treated firms are defined as firms which have issued only fixed-coupon or fixed- and zero-coupon bonds. There 458 non-treated firms and 51 treated firms.

In Panel B the average of quarterly equity issuance is calculated for the subset of firms that were matched using a shortest-distance matching estimator, based on a set of firm-characteristics (Tobin's Q, cash flow, size cash holdings, leverage, 2-digit SIC industry, ratings), and bond-characteristics (amount outstanding divided by total assets, asset-weighted maturity, and the fraction of the outstanding bonds being enhanced, redeemable, callable, putable, convertible and facing covenant-restrictions). There are 37 unique control firms matched to 44 treated firms. ***, **, * indicate significance at the 1, 5 and 10% significance level respectively.

Table 3.7: Debt issuance before, during and after the Federal Funds Rate decrease

Average Quarterly Debt Issuance (in percentage points)						
<i>Panel A: Non-Treated vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Non-Treated	1.57*** (0.27)	0.72*** (0.15)	-0.62*** (0.24)	-0.84*** (0.17)	-1.34*** (0.25)	-2.19*** (0.33)
Treated	0.80* (0.44)	0.76** (0.29)	-0.63** (0.26)	-0.05 (0.53)	-1.38*** (0.40)	-1.43*** (0.52)
Difference	-0.76 (0.51)	0.03 (0.33)	-0.01 (0.33)	0.80 (0.61)	-0.44 (0.42)	0.75 (0.55)
<i>Panel B: Control vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Control	0.27 (0.38)	0.00 (0.31)	-1.16*** (0.41)	-0.27 (0.48)	-1.16** (0.51)	-1.43** (0.55)
Treated	0.85 (0.52)	0.78 (0.35)	-0.52* (0.29)	-0.07 (0.62)	-1.30*** (0.45)	-1.37*** (0.59)
Difference	0.57 (0.64)	0.78* (0.46)	0.64 (0.50)	0.21 (0.75)	-0.14 (0.83)	0.68 (0.82)
ATT						0.53 (0.48)

This table presents estimates of the change in the average quarterly debt issuance rates during the four quarters 2006q3-2007q2, 2007q3-2008q2 and 2009q1-2009q4 as well as the difference in the difference between the two groups of firms over the respective periods. ATT is the Abadie-Imbens bias corrected matching estimator estimating the average treatment effect on the treated. The average of quarterly debt issuance is defined as the sum of the change in total long-term debt and the change in current liabilities over lagged assets. Heteroscedasticity-consistent standard errors are in parentheses.

In Panel A the 527 sample firms with non-missing information on equity issuance are split into treated and non-treated groups. Treated firms are defined as those which have issued at least one variable coupon bond before the second quarter of 2007 which matures after interest rates decreased to zero in the first quarter of 2009. Non-treated firms are defined as firms which have issued only fixed-coupon or fixed- and zero-coupon bonds. There 473 non-treated firms and 54 treated firms.

In Panel B the average of quarterly debt issuance is calculated for the subset of firms that were matched using a shortest-distance matching estimator, based on a set of firm-characteristics (Tobin's Q, cash flow, size cash holdings, leverage, 2-digit SIC industry, ratings), and bond-characteristics (amount outstanding divided by total assets, asset-weighted maturity, and the fraction of the outstanding bonds being enhanced, redeemable, callable, puttable, convertible and facing covenant-restrictions). There are 37 unique control firms matched to 45 treated firms. ***, **, * indicate significance at the 1, 5 and 10% significance level respectively.

Table 3.8: Cash holdings before, during and after the Federal Funds Rate decrease

Average Quarterly Cash Holdings (in percentage points)						
<i>Panel A: Non-Treated vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Non-Treated	10.26*** (0.60)	10.02*** (0.59)	11.84*** (0.57)	-0.24 (0.84)	1.82** (0.82)	1.58* (0.82)
Treated	7.90*** (1.14)	7.95*** (1.26)	9.53*** (1.14)	0.04 (1.70)	1.59 (1.7)	1.63 (1.61)
Difference	-2.36* (1.28)	-2.07 (1.39)	-2.31* (1.27)	0.28 (0.48)	-0.24 (0.75)	0.05 (0.72)
<i>Panel B: Control vs. Treated Firms</i>						
	2007	2008	2009	2007-2008	2008-2009	2007-2009
Control	5.87*** (1.04)	6.21*** (1.02)	9.39*** (1.40)	0.34 (1.46)	3.18* (1.73)	3.52** (1.75)
Treated	8.05*** (1.33)	8.40*** (1.49)	9.99*** (1.33)	0.36 (1.99)	1.59 (1.99)	1.94 (1.87)
Difference	2.18 (1.69)	2.20 (1.80)	0.60 (1.93)	0.02 (0.70)	-1.59 (1.23)	-1.57 (1.28)
ATT						1.27 (1.45)

This table presents estimates of the change in the average quarterly cash holdings rates during the four quarters 2006q3-2007q2, 2007q3-2008q2 and 2009q1-2009q4 as well as the difference in the difference between the two groups of firms over the respective periods. ATT is the Abadie-Imbens bias corrected matching estimator estimating the average treatment effect on the treated. The average of quarterly cash holdings is defined as cash and short-term investment over assets. Heteroscedasticity-consistent standard errors are in parentheses.

In Panel A the 527 sample firms with non-missing information on equity issuance are split into treated and non-treated groups. Treated firms are defined as those which have issued at least one variable coupon bond before the second quarter of 2007 which matures after interest rates decreased to zero in the first quarter of 2009. Non-treated firms are defined as firms which have issued only fixed-coupon or fixed- and zero-coupon bonds. There 473 non-treated firms and 54 treated firms.

In Panel B the average of quarterly cash holdings is calculated for the subset of firms that were matched using a shortest-distance matching estimator, based on a set of firm-characteristics (Tobin's Q, cash flow, size cash holdings, leverage, 2-digit SIC industry, ratings), and bond-characteristics (amount outstanding divided by total assets, asset-weighted maturity, and the fraction of the outstanding bonds being enhanced, redeemable, callable, putable, convertible and facing covenant-restrictions). There are 37 unique control firms matched to 45 treated firms. ***, **, * indicate significance at the 1, 5 and 10% significance level respectively.