

The Elasticity of Substitution Between Time and Market Goods: Evidence from the Great Recession*

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Preliminary

Abstract

This paper examines the variation in households' returns to shopping and their implied cost of time over the business cycle. Using scanner data on grocery purchases, we document how households lower the prices that they pay during downturns by increasing their coupon usage, sale purchasing, buying larger sizes and generic products. We show that this behavior is consistent with a significant decline in households' cost of time in recessions, which is comparable to the decline in cost of time over an individual's life-cycle. Using our estimated cost of time and data from time-use diaries, we estimate a high elasticity of substitution between time and goods in home production. This implies that households are able to smooth a sizable fraction of consumption, relative to market expenditures, by varying their intra-temporal allocation of time during recessions.

Keywords: Returns to shopping; opportunity cost of time; home production.

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1 Introduction

During recessions, individuals are faced with lower income but have more free time. One way for consumers to reduce expenditure and take advantage of the extra time is to spend more time on non-market work, such as home production and shopping. For example, when shopping for food, consumers can economize by buying during sales, using coupons, substituting to cheaper brands, buying in bulk, and shopping at discount (Big Box) stores. All of these activities can reduce food expenditures, but require more shopping time. In this paper, we address the following questions. Do individuals change their shopping behavior during recessions and allocate lost work hours to shopping? Assuming a change in shopping behavior, does the return to these behaviors also differ during recessions, and what does this imply for the substitution between time and goods in home production? To what extent are households able to smooth consumption relative to market expenditures by varying their time use during recessions? Answering these questions is important for interpreting the co-movement of aggregate variables over the business cycle, and for computing the welfare costs of recessions.

An important component of many macroeconomic models is how individuals substitute between time and market goods. For instance, Benhabib, Rogerson and Wright (1991), and Greenwood and Hercowitz (1991) propose home production models that incorporate substitution between market and non-market work. In these models, the co-movement between expenditure and labor supply over the business cycle depends on the willingness of households to substitute between market work, non-market work, and expenditure. However, most estimates of the elasticity of substitution used in these models are based on data from non-recession periods. It is possible that, like returns to market work, the returns to non-market work also change during recessions.

Aguiar, Hurst, and Karabarbounis (2012), a notable exception to the above mentioned studies, use the American Time Use Survey to show that households reallocated lost labor market hours towards non-market work, including shopping, during the Great Recession. The first contribution of this paper is to examine how this reallocation of time actually translates to lower prices. To do so, we use a sample of households from the Nielsen Homescan dataset, to document how households changed their shopping intensity. The consumers in our data record their food purchases, the prices that they pay, and when and where the product was purchased. Each consumer is in the data for several years. In total, we have 112,837 households documenting their food purchases from 2004-2010.

We find that households have increased their shopping intensity over different shopping activities. Specifically, coupon usage, purchases of sale items, generic products, and large sized items rose as a share of total household expenditure during 2008-2010, compared to pre-recession trends. Moreover, the increase is more pronounced in regions that experienced a larger rise in unem-

ployment, suggesting that the rise in shopping intensity is cyclical. We find that the increase in shopping intensity is pervasive across various household demographics, including age, income, and employment status.

Next we ask whether the increase in shopping intensity is driven by an increase in the returns to shopping. We compute for each household the ratio of the price they paid for the basket of goods purchased, and the cost of the same basket if “average” market prices were paid instead. We then regress this ratio on shopping intensity in our five different activities, controlling for omitted variables in a couple of ways. This allows us to measure the returns to shopping. We find that these shopping activities lower the price paid by households. For example, consumers who use more coupons or buy larger sizes pay a lower (per ounce) price. However, the return to shopping has declined over the recent recession, even as shopping intensity increased. Our preferred estimates suggest that in 2008-2010 relative to 2004-2007, the returns were around 2-4 percentage points lower for purchases of sale items, buying generic products, using coupons, shopping at Big Box stores, and buying larger sized items.

The increase in shopping intensity, coupled with the decrease in returns, suggest a decline in households’ opportunity cost of time. This motivates the last step of our analysis, where we use data on prices and quantities to estimate key parameters of a home production function. Using predictions from a home production model, we recover households’ opportunity cost of time, and the elasticity of substitution between time and market goods in home production. Specifically, we exploit the fact that at the optimum, households equate the marginal return from shopping to the opportunity cost of time. This allows us to use the estimated returns to shopping to infer the opportunity cost of time, and the elasticity of substitution between time and market goods in home production.

We find that households’ opportunity cost of time declined by 25-30 percent over 2008-2010. These estimates are comparable to the estimated decline in cost of time of around 27 percent over the life-cycle (from age 25-29 to age 65-74) in Aguiar and Hurst (2007). The decline in cost of time is consistent with the increase in time spent on non-market work during recessions, which has been documented using time use data in Aguiar, Hurst, and Karabarbounis (2012). Using the estimated opportunity cost of time and price data, we recover a point estimate of 1.7 for the elasticity of substitution between time and market goods in home production, with a standard error of 0.48. This implies a high elasticity of substitution between the home sector and the market sector, which is supportive of parameters used in existing home production models.¹

Our estimated home production function allows us to address two questions related to the

¹For models of home production, see for example, Benhabib, Rogerson, and Wright (1991), Greenwood and Hercowitz (1991), Chang and Schorfheide (2003), and Aguiar and Hurst (2007).

recent recession. First, we ask whether shocks to the non-market sector were important drivers of the decline in aggregate expenditure and increase in time spent on non-market work over 2008-2010. We find that the elasticity between expenditure on market goods and time spent on home production is not statistically different between the pre-recession and recession periods, which implies that the recession was not driven by shocks to the non-market sector. Second, we use our estimated home production function to examine the ability of households to smooth consumption over time by varying their time allocation. We find that consumption declined by 60 percent less than the fall in market expenditure due to increased home production and time spent shopping during the recession. This shows the importance of intra-temporal reallocation of time for smoothing consumption in response to unanticipated income shocks.

Our work contributes to various strands of macroeconomic literature. First, our work relates to recent studies that use the American Time Use Survey to understand how the allocation of time evolves over the business cycle. Aguiar, Hurst, and Karabarbounis (2012), for instance, have shown that roughly 30 percent of the lost labor hours are reallocated towards non-market work. Our finding that households' opportunity cost of time and returns to shopping declined during the recent recession provides a motivation for this reallocation of time. Theory implies that it is less costly to engage in home production when the cost of time is lower. Thus, increased shopping intensity and home production is accompanied by a decrease in labor hours and purchases of market goods.

Second, our findings support business cycle models which assume strong complementarities between market consumption and market work in the utility function (for example, Monacelli and Perotti (2008), Hall (2009), Christiano, Eichenbaum, and Rebelo (2011), and Nakamura and Steinsson (2011)). Under the complementarity assumption, these models generate similar predictions for joint movements in aggregate variables as home production models that assume high elasticity of substitution between market expenditure and time.

Third, our results relate to recent studies that seek to explain the gap between the marginal product of labor and the marginal rate of substitution between consumption and leisure (known as the "labor wedge"), which widens during recessions.² One hypothesis for the cyclical wedge is that it reflects the unaccounted for substitution of time between the market sector and the home sector in models without home production. This omission affects the measured rate of substitution between consumption and leisure, and therefore the measured labor wedge. Karabarbounis (2013) shows volatility of the labor wedge over the business cycle can be explained by a home production model that assumes a value of 4 for the elasticity of substitution between the market sector and the home sector. Our point estimate of 1.7 for the elasticity implies that the inclusion of a home

²Studies that have discussed the labor wedge include Karabarbounis (2013), Hall (1997), Shimer (2009), Cole and Ohanian (2004), Chari, Kehoe, and McGrattan (2007), Chang and Kim (2007), and others.

production sector in these models may explain a sizable proportion of the labor wedge.

Lastly, our paper relates to studies on the response of household consumption to income shocks. Aside from formal savings and public insurance, households can also smooth unanticipated shocks to income via informal means, such as family insurance and variation in the labor supply of the second worker in the family (see for example, Kaplan (2008), Blundell et al (2012), and Heathcote et al (2009)). In this paper, we discuss a different margin of consumption smoothing: that is, the intra-temporal allocation of lost labor hours towards non-market work. Our findings are consistent with studies such as Hall (1997) that emphasize the role of intra-temporal shifts in time use during recessions in explaining the joint movements in market expenditure, market work, and time spent on non-market activities.

The rest of the paper is organized as follows. In Section 2, we describe our data and in Section 3, we display some trends in shopping characteristics over the cycle. In Section 4, we present our estimates of the returns to shopping during the recent recession. In Section 5, we present a formal home production model and use it to derive the estimation strategy for two key model parameters: 1) the price of time, and 2) the elasticity of substitution between market goods and home production. We conclude in Section 6.

2 Data

The main data on prices and quantities come from the Nielsen Homescan dataset.³ The dataset includes information on all food purchased and brought into the home by a large number of households during 2004-2010. The data are recorded by households using hand-held scanners in the home. The households record the store where the product was purchased, the date, quantity purchased and the total amount of discounts received from promotions, sales or coupons, at the Universal Product Code (UPC) level. Prices come from one of two sources. If the store where the product was purchased is one that reports prices to Nielsen as part of their store-level survey, then Nielsen obtains the price from the store data. If the store is not in the store sample then households are required to report the prices. Nielsen spends significant time ensuring the data is of high quality. Einav, Leibtag and Nevo (2010) check the quality of the data and conclude that the error in prices is of similar magnitude to that found in commonly used economic data sets.

Households in the sample are recruited by Nielsen over mail and internet. Nielsen offers incentives to households to join and remain active in reporting transactions. These incentives include

³The data were purchased by the USDA and used as part of a cooperative agreement between the USDA/ERS and Northwestern University. Similar data are available for academic research from the Kilts-Nielsen Data Center see <http://research.chicagobooth.edu/marketing/databases/> for details.

monthly prize drawings, gift points and sweepstakes. To ensure the high quality of data, Nielsen filters out households who do not regularly report their transactions, and regularly adds new households to the panel to replace households that leave the sample.

The survey contains household demographic information, which are updated annually. These include information on the head of household’s age, sex, race, education, occupation, region of residency, employment status, family composition and household income. Our analysis below is based on 4,236,594 household transactions involving all food products with a barcode. In total, we use data from 112,837 households, who on average report data over 32 consecutive months.

3 Change in Shopping Patterns over the Cycle

We start by documenting shopping patterns. First, we document the fraction of expenditure due to the various shopping activities. More importantly, we show how the shopping patterns changed, on average, during the Great Recession. Finally, we examine these patterns for different demographic groups.

We focus on five aspects of shopping behavior: coupon use, purchases of sale items, of generic products, of large size items (which are typically cheaper per ounce)⁴, and purchases in discount (Big Box) stores. For each of these measures, we compute the fraction of household expenditure in each month that comes from each activity. For example, when looking at coupons, we ask in each month what fraction of purchases were made with a coupon.⁵ We focus mainly on the changes in these measures over time.

We report three types of results in the figures below. In all cases, we regress the fraction of overall expenditure for each shopping activity by each household in each month, on household fixed effects (to control for differences across households), calendar month fixed effects (to control for seasonality), and a time trend. We examine three different trends. First, we describe the data non-parametrically, i.e., we allow for month-year fixed effects. The coefficients on the month-year effects gives a non-parametric estimate of the average fraction of expenditure per the month accounted for by the particular shopping activity. To highlight the trend over the sample period, we also calculate cubic and linear spline trends. The cubic trend is estimated from a regression with a cubic trend, instead of month-year fixed effects. The linear spline series is estimated with two break points: first in January 2007, which was the start of the period when food prices began to

⁴To define large sized items, we follow Griffith et al. (2009) and rank by size all UCPs in our data within a narrowly defined category. A large product is defined as being in the upper two quantiles of this distribution, i.e., in the top 40 percent of products, ranked by product size.

⁵We also examined the fraction of purchases, rather than expenditures, and found similar trends in shopping patterns to those discussed in the text.

increasing significantly; and second, in December 2007, at the official start of the Great Recession as dated by the NBER.

Changes for the Average Consumer

Figures 1-5 display the estimates of the fraction of household expenditures which involve coupon usage, purchases of sale items, purchases of generic items, purchases of large-sized items, and purchases from big box stores, respectively. We observe a change in all five of the household shopping activities over the recession period, compared to pre-recession trends. For four out of the five shopping activities, expenditure made via the shopping activity increased relative to pre-recession trends. The exception is expenditure in Big Box stores, where the pre-recession trend increase slowed during the recession period (which we discuss further below).

Prior to 2007, coupon usage, purchases of items on sale, purchases of generic products, and purchases of large items were either stable or declining as a share of total expenditure. This contrasts with a distinct increase in each of these four shopping activities during the recession. Over 2008-2010, these shopping activities each increased by 1.5-2.0 percentage points of total household expenditure. Given the large number of observations, the trend is very precisely estimated and all the changes are highly statistically significant. Interestingly, we see few or no changes during 2007 when food prices increased significantly due to increased demand from developing countries, mainly China, and drought conditions that limited supply.

The one shopping attribute that is different is the fraction of expenditure in Big Box stores. Prior to 2007 it displays a clear upward trend. One explanation for this trend increase is the expansion of big box retailers, such as Walmart, over this period. During the recession, this fraction is still increasing, but at a slower rate. As we show in Appendix A Figure 11, the same pattern is observed if instead of the fraction of expenditure in Big Box stores, we look at other measures of store search intensity, such as the share of expenditure in the household's main store (ranked by spending in that store), their top two stores, their top three stores, and a Herfindahl index of household expenditure by store.

In principle, it is possible that the observed shifts in shopping activities during the recession simply reflects a trend change in shopping technology or preferences, which are unrelated to the business cycle. However, this change would have to coincide almost exactly with the dates of the recession. Nevertheless, to address this issue, we also examine cross-county variations in shopping intensity over the shopping activities by estimating the following equation

$$y_{ict}^k = b_0 + b_1 UR_{ict} + \gamma' X_{ict} + \lambda_R + \lambda_c + \lambda_i + \epsilon_{ict} \quad (1)$$

where y_{ict}^k is the average fraction of expenditure from shopping activity k over the month t for

Figure 1: Purchases Involving Coupon Usage
Share of total household expenditure

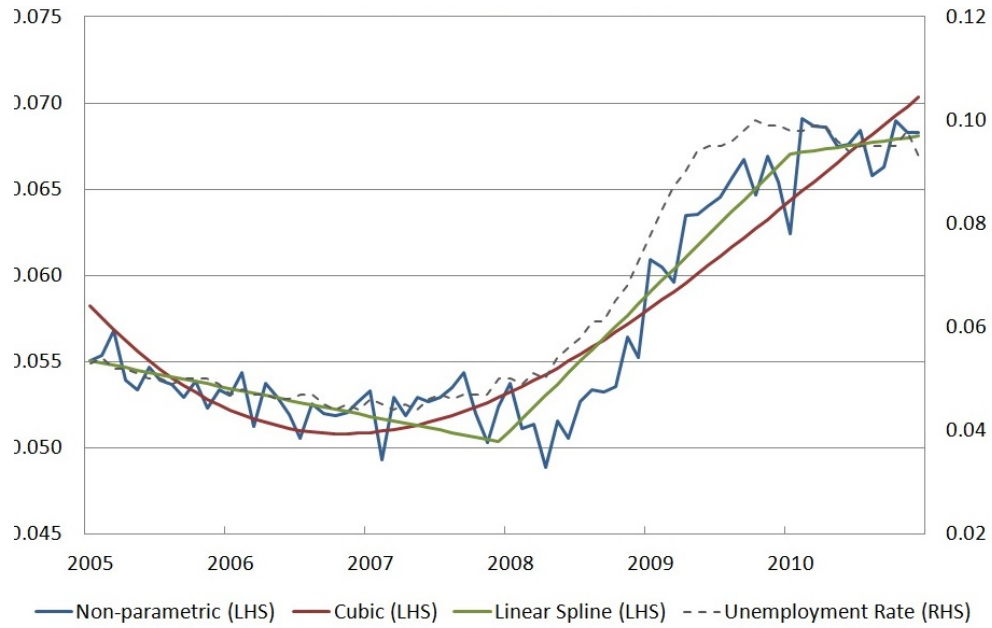


Figure 2: Purchases of Sale Items
Share of total household expenditure

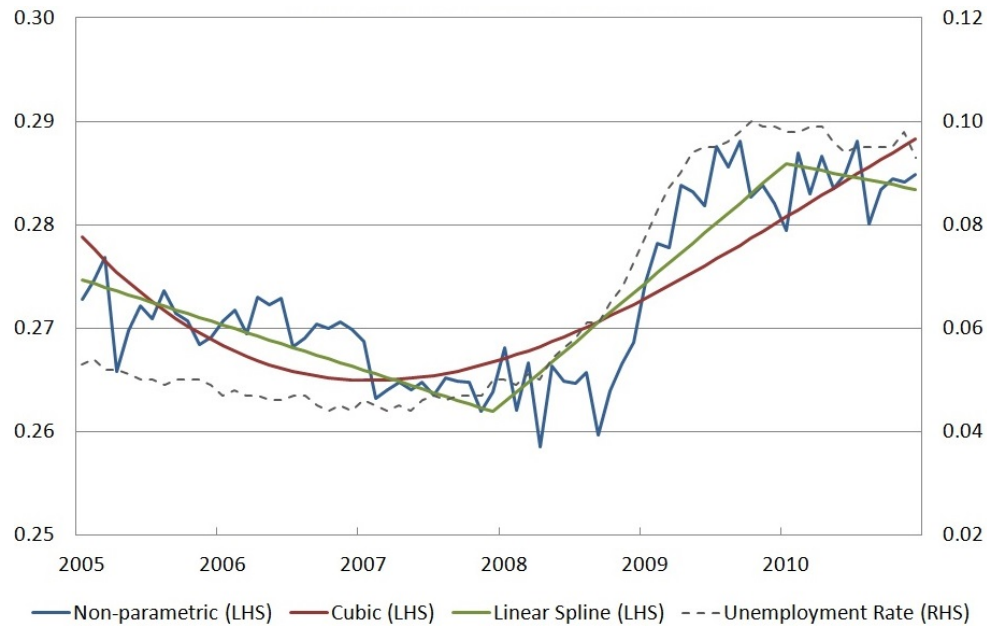


Figure 3: Purchases of Generic Items
Share of total household expenditure

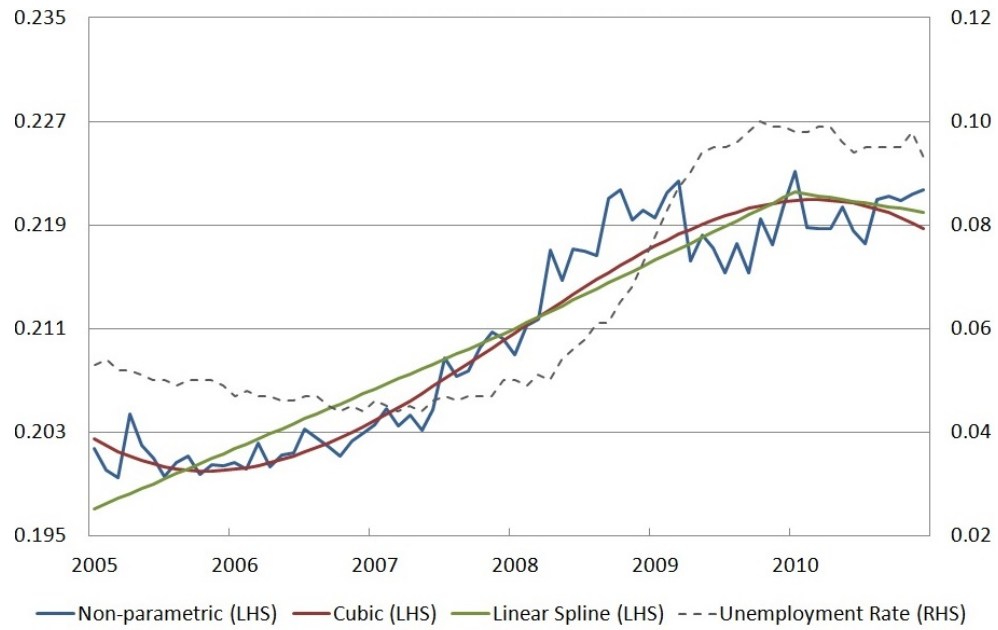


Figure 4: Purchases of Large Sized Items
Share of total household expenditure

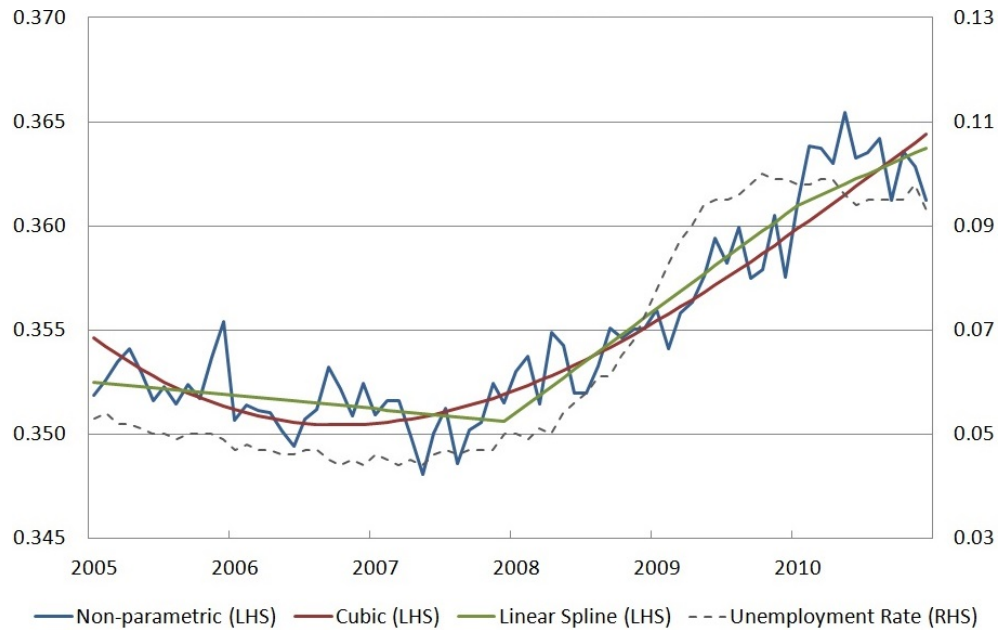
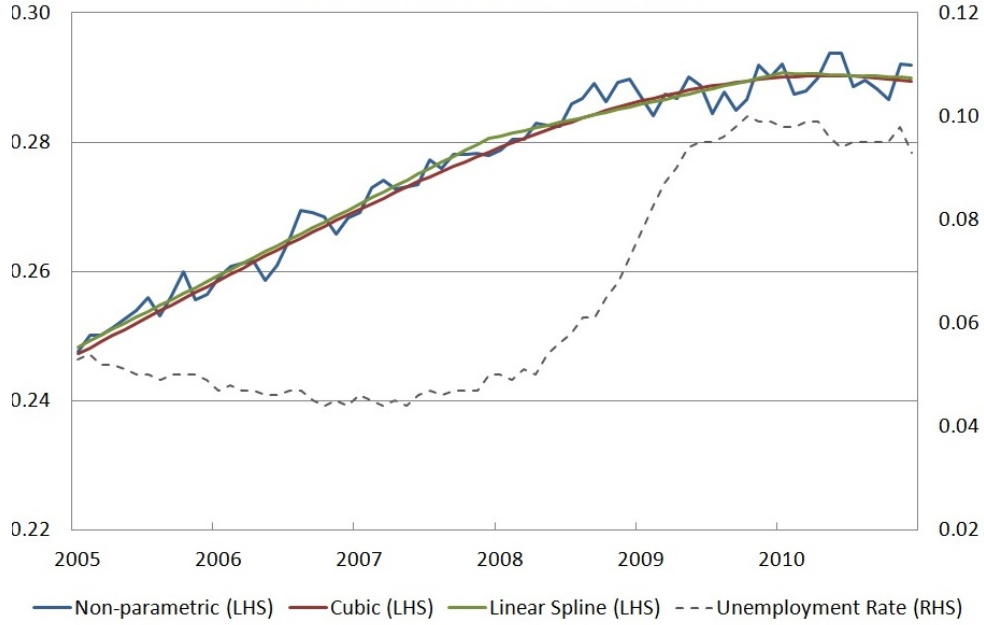


Figure 5: Purchases in Big Box Stores
Share of total household expenditure



household i living in county c , UR_{ict} denotes the unemployment rate in county c , λ_c , λ_R , and λ_i denote the county, recession, and household fixed effects, respectively, X_{ict} is a vector of household demographics (which include the race of the male head of household, employment status, age, and income group), and ϵ_{ict} is the random error term.

Table 1 displays the coefficient for unemployment, which are statistically significant for each of the shopping activities. The coefficient is positive for coupon usage, purchases of sale item, purchases of generic products, and purchases of large-sized items, and negative for expenditure in Big Box stores. This implies that counties that experienced a greater rise in unemployment also had more pronounced increases in shopping activities, implying that the change over 2008-2010 in shopping intensity was related to business cycle factors. Our results are consistent with Aguiar, Hurst, and Karabarbounis (2012), who use data from the American Time Use Survey to show that households increased their time spent on non-market work, including shopping, during the recent recession.

Change in Shopping Patterns by Demographics

We now repeat the analysis by demographic group. To aid the presentation, we display only the results from the linear spline regression. In Figure 6, we display the linear spline trends by age group. We see that households over 65 years of age use more coupons and purchase more items on sale and buy more generic products. This is consistent with Aguiar and Hurst (2007),

Table 1: Cyclical Changes in Shopping Activities

Percent of expenditure with the features:	Generic (1)	Sales (2)	Large Size (3)	Coupon Use (4)	Big Box Stores (5)
Unemployment Rate	0.064 (0.003)	0.345 (0.004)	0.107 (0.004)	0.214 (0.002)	0.231 (0.006)
Constant	19.124 (0.222)	26.000 (0.291)	32.690 (0.267)	3.573 (0.148)	22.939 (0.405)

Columns 1-5 present estimates from regressions of Equation 1. Each column gives the coefficient of the unemployment rate from regressing the fraction of total expenditure in each month with the shopping activity (in each column). The standard errors are in parentheses. In total, there are 4,042,910 household-month observations.

who show that households increase their shopping time upon retirement. However, over 2008-2010, the difference in shopping intensity between the age groups narrowed, particularly with regards to coupon usage and purchases of sale items, and all age groups exhibited an increase in shopping intensity. Similarly, Figure 7 shows an increase in shopping intensity across all income groups.

We also examined the change in shopping activities across different households, split by their employment status (“non-employed” and “employed”) and the number of household heads. We define the non-employed group as the households whose head(s) of household is currently not employed in the labor force. The data does not distinguish between unemployment and non-participation in the labor force. However, we restrict the group to include only working age households, so that our results are distinct from the effects of retirement on shopping patterns (described in Aguiar and Hurst (2007)).

The linear spline trends by employment status for single-head households are shown in Figure 8 and for multiple-head households in Figure 9. Both of these figures show that non-employed households use more coupons, buy more generic items, and purchase less sale items than employed households. Both employed and non-employed groups exhibit an increase in shopping intensity during 2008-2010. This implies that the average increase in shopping intensity over this period was not driven only by non-employed households. It may also reflect greater income uncertainty during recessions, which can cause households to engage in more price-saving activities.

A similar increase in shopping intensity across the shopping activities can also be seen if we restrict the employment groups to households who are in the sample for more than one year. This

Figure 6: Shopping behavior by age group (years)
Share of total household expenditure

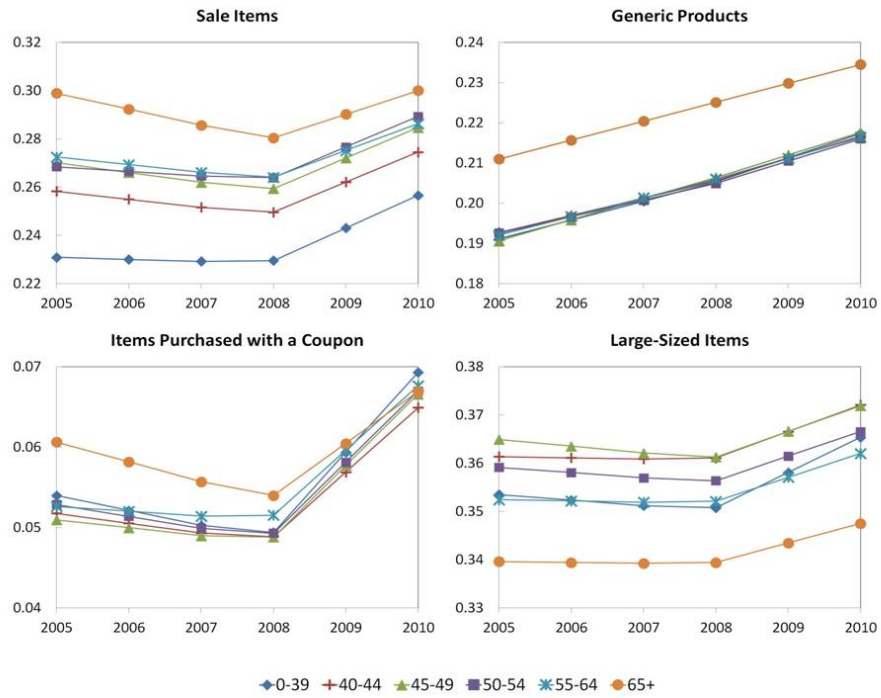


Figure 7: Shopping behavior by income groups (\$'000)
Share of total household expenditure

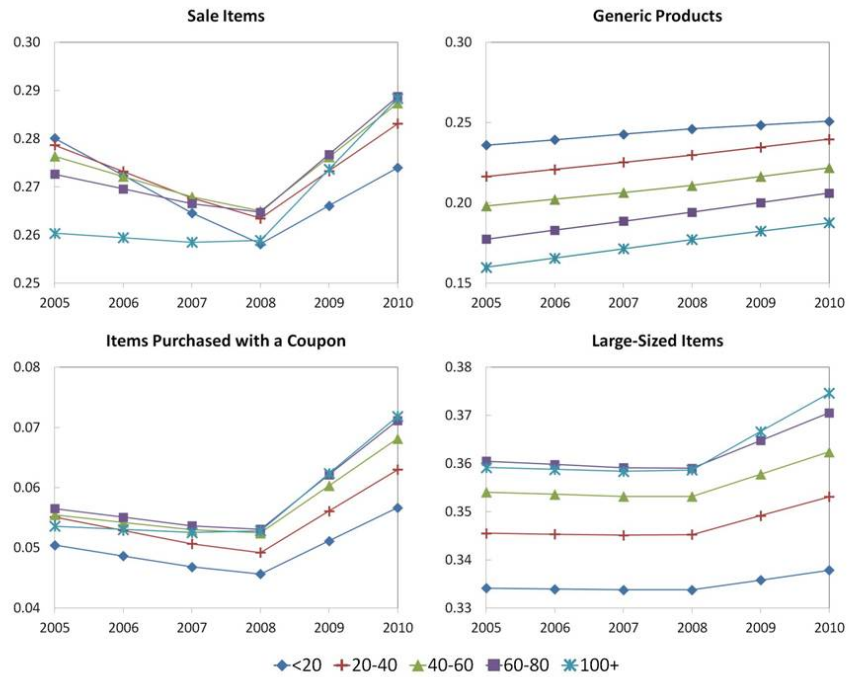


Figure 8: Shopping behavior by employment status
Of single-headed households

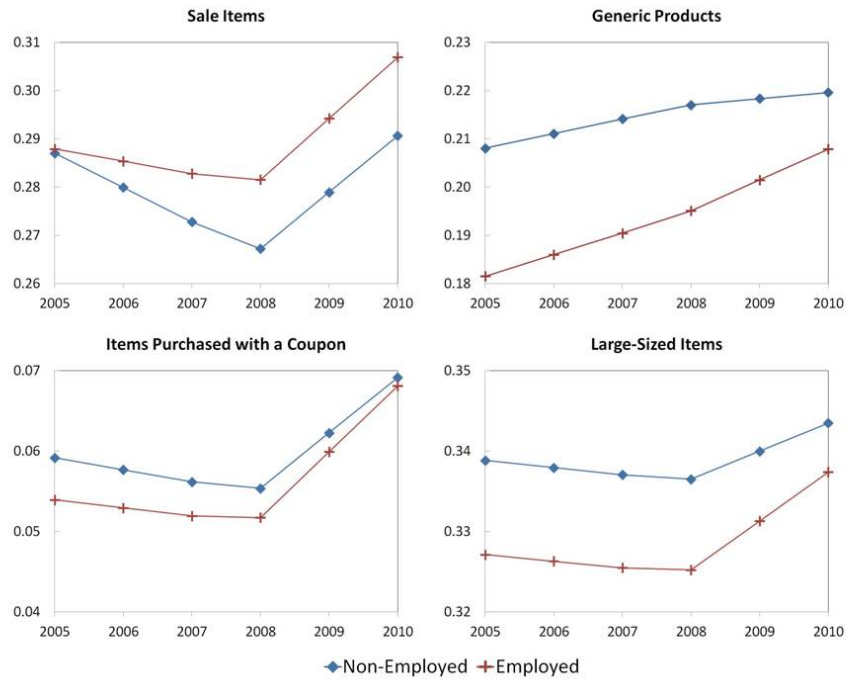
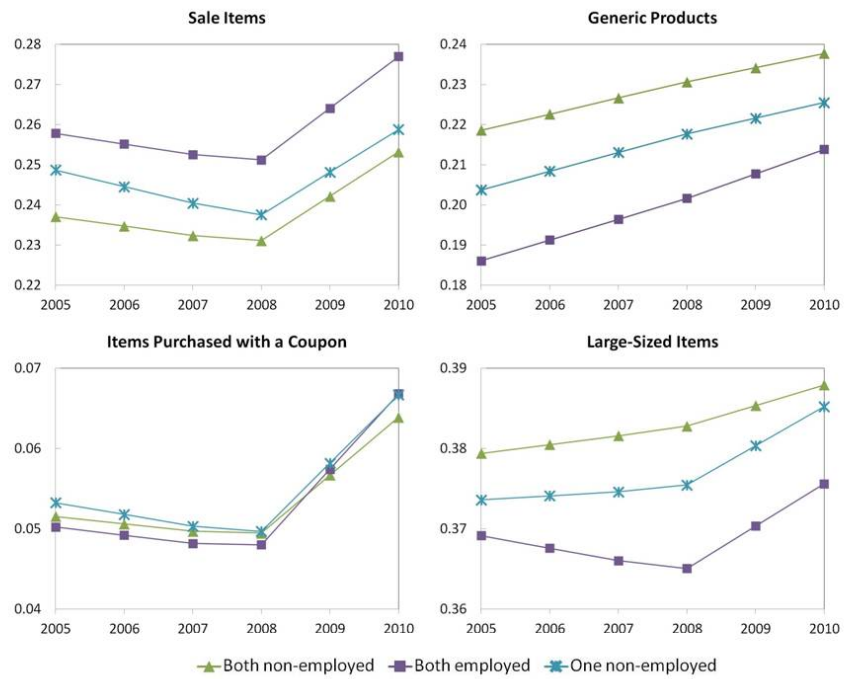


Figure 9: Shopping behavior by employment status
Of multiple-head households



allows us to compute groups based on transitions in employment status. We group household into the following four groups: 1) households with one or more members who went from being employed to non-employed, 2) households with one or more members who went from being non-employed to employed, 3) households with members who remained employed in both years, and 4) households with members who remained non-employed in both years. Figure 10 in the Appendix shows that all groups experienced an increase in shopping intensity during 2008-2010, relative to pre-recession trends. This again suggests that the increase in shopping intensity over this period may be a reflection of both lower market hours and increased income uncertainty.

4 Change in the Returns to Shopping

In the previous section, we documented that households increased their search intensity during the Great Recession. In this section, we start exploring the forces that are driving this behavior. In particular, we examine whether the returns to the shopping activity have changed.

Price Index

Households differ in the amount and type of goods in their basket. In order to measure the returns to shopping, we need to compute a measure of the relative price that each household pays. We therefore construct two household-specific price indices, similar to the methodology developed in Aguiar and Hurst (2007). The indices inform whether the household is paying higher or lower prices than average for its basket of goods.

Denote the price paid for good j by household h on shopping trip t by $p_{j,t}^h$, and the corresponding quantity by $q_{j,t}^h$. Therefore, the total nominal expenditure by the household in month m is given by

$$X_m^h = \sum_{j \in \mathbf{J}, t \in m} p_{j,t}^h q_{j,t}^h$$

We compare this to the nominal expenditure that the household would have incurred if they had instead paid the average price in the market. This expenditure is given by

$$\bar{X}_m^h = \sum_{j \in \mathbf{J}, t \in m} \bar{p}_{j,m} q_{j,t}^h$$

where $\bar{p}_{j,m}$ denotes the average price for item j in month m . We compute two different price indices, which vary in the way that $\bar{p}_{j,m}$ is computed. These two approaches are described below.

We then define the price index for the household in month m as the ratio of their actual expenditure to the cost of the bundle at the average price

$$\tilde{p}_m^h \equiv \frac{X_m^h}{\bar{X}_m^h} = \frac{\sum_{j \in \mathbf{J}, t \in m} p_{j,t}^h q_{j,t}^h}{\sum_{j \in \mathbf{J}, t \in m} \bar{p}_{j,m} q_{j,t}^h}$$

The index is then normalized by dividing by the average price index across households within the month

$$p_m^h \equiv \frac{\tilde{p}_m^h}{\frac{1}{H} \sum_k \tilde{p}_m^k} \quad (2)$$

This ensures that the distribution of price indices across households is centered around one each month. An index that is above one indicates that the household h paid a higher average price for its basket of goods in month m , while an index below one indicates that a lower average price was paid.

Therefore, total nominal expenditure in month m for household h is given by

$$X_m^h = p_m^h \cdot \bar{X}_m^h$$

Deflating the nominal expenditure by the average market inflation will give the real expenditure

$$X_m^{h,\text{real}} = p_m^h \cdot Q_m^h$$

where $Q_m^h = \bar{X}_m^h / \Pi_{0t}$ is the composite quantity of market goods purchased, which is deflated by the inflation index (relative to date 0).

We consider two approaches to calculating the average price paid in the market for item j . First, we compute the average price paid by households for a particular item j (at a UPC level)

$$\bar{p}_{j,m} \equiv \sum_{h \in \mathbf{H}, t \in m} \left(\frac{q_{j,t}^h}{\sum_{h \in \mathbf{H}, t \in m} q_{j,t}^h} \right) p_{j,t}^h \quad (3)$$

This approach takes the average of prices across households, holding the item fixed. It does not take into account substitutions between items, which is one way that households may lower their expenditure. One example is the decision to switch from premium to generic goods, a trend in the recent recession that we documented in the previous section. To the extent that not all stores offer particular products or sizes, the index will also not capture any store switching associated with changes in the brand and size composition of the household's basket.

Therefore, we also consider a second approach to estimating the average price paid, where we allow for substitution between items within the same product of size s (this set of items is denoted by J_s). Specifically, we calculate the average price paid for item j of size s , by taking the average across all items of the same size belonging to the product category. For example, the average price associated with a 2 liter bottle of Coke is given by the quantity-weighted average price over all of

the different types of 2 liter sodas bought in that month across all households. This average price is then normalized by dividing by the size of the item to allow for comparison across different product sizes.⁶

$$\bar{p}_{j,m} \equiv \sum_{k \in \mathbf{J}_s, h \in \mathbf{H}, t \in m} \left(\frac{q_{k,t}^h}{\sum_{k \in \mathbf{J}_s, h \in \mathbf{H}, t \in m} q_{k,t}^h} \right) p_{k,t}^h / s \quad (4)$$

Returns to Shopping

Households can lower their average price index by increasing their shopping intensity over various shopping activities. Denote f_i as the fraction of items in the household's basket of goods with shopping activity i , which includes items purchased using coupons, purchases of sale items, of generic products, of large-sized items, and purchases from Big Box stores. Specifically, the fraction f_i is calculated as the number of items purchased with shopping activity i , divided by the total number of items purchased during the month. We estimate the return to shopping over these activities by considering the following benchmark specification

$$\begin{aligned} \ln p_m^h = & \alpha_0 + \sum_i \alpha_i f_{i,m}^h + \sum_i \beta_i \mathbf{1}(\text{yr} > 2007) \cdot f_{i,m}^h \\ & + \gamma \mathbf{1}(\text{yr} > 2007) + \delta X_m^h + \nu X_m^h \cdot \mathbf{1}(\text{yr} > 2007) + \epsilon_m^h \end{aligned} \quad (5)$$

where p_m^h is the price index of the basket of goods purchased by household h in month m ; X_m^h denotes the vector of household demographics (including age, income, marital status, employment status, state of residency, and race of the male head of household). We estimate equation (5) for the two price indices defined in the previous subsection. The coefficients of interest are α_i and β_i , which give the sensitivity of price to the intensity of each shopping activity.

Table 2, column (1) shows the OLS estimates of the returns to shopping for the price index which holds fixed the household's basket. The estimates suggest that during 2008-2010 the returns to shopping declined for coupon usage, purchases of sale items, of generic products, and purchases from Big Box stores. Specifically, the return to sales decreased by around 0.5-2.0 percentage points compared to the pre-recession period. Allowing for substitution and adjusting for size in the computed price index, we observe a similar decline in returns for purchases of large sized items in column (4). The decline in shopping returns, which occurs during a period when households shopped more intensely (documented in Section 3), implies a concave price function, with decreasing returns to shopping intensity.

⁶We note that this approach assumes all items with the product are substitutable, and therefore does not consider quality differences.

Table 2: Returns to Shopping

	ln Price (1)	ln Price Index 1 (2)	ln Price Index 2 (3)
Sale	-0.061 (0.0002)	-0.032 (0.0013)	-0.067 (0.0035)
Coupon	-0.668 (0.0051)	-0.295 (0.0033)	-0.258 (0.0062)
Big box	-0.153 (0.001)	-0.049 (0.0009)	-0.104 (0.0021)
Generic	-0.815 (0.0051)	0.002 (0.0015)	-0.253 (0.0035)
Large sizes	-0.805 (0.0011)	0.011 (0.0017)	-0.458 (0.0034)
Sale · 1(yr>2007)	0.018 (0.0002)	0.022 (0.0022)	0.026 (0.0026)
Coupon · 1(yr>2007)	0.048 (0.0067)	-0.0001 (0.0049)	0.013 (0.0058)
Big box · 1(yr>2007)	0.033 (0.0015)	0.009 (0.0013)	0.018 (0.0021)
Generic · 1(yr>2007)	0.057 (0.0072)	0.002 (0.0023)	0.025 (0.0038)
Large sizes · 1(yr>2007)	0.067 (0.001)	0.003 (0.0026)	0.021 (0.0042)
Frequency	Daily	Monthly	Monthly
No. observations	276,748,718	4,042,910	4,042,910

Column 1 presents estimates from separate regressions on each shopping activity at a transaction level. Columns 2 and 3 presents estimates from a monthly-level regression of a log price index on all shopping activities. Price Index 1 does not allow for substitution between UPCs, while Price Index 2 does. Standard errors are in parentheses.

Table 3: Change in Returns to Shopping

Ratio of (2008-10) to (2004-07) returns	(1)	(2)	(3)
Sale items	0.707	0.315	0.604
Coupon usage	0.928	1.000	0.951
Big box stores	0.784	0.815	0.825
Generic items	0.930	1.796	0.900
Large-sized items	0.917	1.279	0.954

Using estimated returns from Table 2: Column (1) Column (2) Column (3)

Column 1 is calculated from returns estimated using transaction level data. Columns 2 and 3 are calculated from returns estimated using the Price Index 1 (which does not allow for substitution between UPCs) and Price Index 2 (which does allow for substitution between UPCs), respectively.

One potential concern about the OLS estimates is there may be unobserved individual-specific factors that are correlated with f and affect the average price paid. This will result in f being correlated with the error term, which may bias the estimates. To address this concern, we also include fixed effects to control for time-invariant unobserved individual activities in our estimates. Our estimates in columns (2) and (5) of Table 2 confirm that the returns to shopping declined during the recession period. The decline in returns is slightly larger when we allow for substitution across products in the price index. Specifically, we observe a decline of around 1.0-1.7 percentage points for each of the shopping activities, compared to the pre-recession period. These declines in returns are statistically significant.

In addition, we also consider instrumenting for the possibility that prices may endogenously affect the household's decision to engage in various shopping activities f . For example, larger discounts may induce the household to buy more sale items, and therefore drive up the fraction of sale items in the household's basket. We instrument for shopping intensity using the average fraction of expenditure accounted for by each shopping activity

$$\bar{f}_i^k = \frac{1}{H_k} \sum_{h \in k} f_i^h$$

where the average is taken over all households belonging to reference group k , and H_k denotes the number of households in reference group k . The household reference groups are defined based on a combination of employment status, age, income, and state of residency.⁷

The intuition is that the average shopping activity for the group may capture common factors that affect the individual's shopping basket activities, other than variations in the price paid by the individual. For example, low-income households living in a particular region may be exposed to an exogenous sales campaign of a particular chain, which affects the tendency of the individuals in that group to buy items that are on sale. The average f of the group is a valid instrument of the individual f_i under two assumptions. First, the individual's shopping basket activity is correlated with the group's average activity. Second, $\bar{f}$ is uncorrelated with unobserved individual-specific factors which affect the price paid by that individual. This is a reasonable assumption, as the number of households within each group are sufficiently large. Therefore, by taking the average f across the individuals within each demographic group, the individual-specific factors will average out to be close to zero.

The results from using the group average as an instrument is shown in columns (3) and (6) of

⁷The five employment groups are defined as: single head of household employed, single head of household non-employed, multiple heads of household employed, multiple heads of household non-employed, and multiple heads of household with one employed and one non-employed. The six age groups are defined as: under 39, 40-44, 45-49, 50-52, 55-64, and over 65 years of age. The income groups are defined as: less than \$20K, \$20-40K, \$40-60K, \$60-100K, and more than \$100K.

Table 2. We observe that the five shopping activities lower the average price paid by the household. The returns over 2008-2010 are around 5 percentage points below the pre-recession period for sale and generic items, coupon usage, and shopping at big box stores, while returns to purchase of large sized items are around 1 percentage points lower. These findings again imply a concave price function, with decreasing returns to shopping intensity.

5 A Model of Home Production

In this section, we explore the implications for households' opportunity cost of time from the shopping returns during the recent recession. This will allow us to recover the elasticity of substitution between time and market goods, a key parameter in the home production literature. To recover households' opportunity cost of time, we describe a simple model of household cost minimization. The model we describe is in the spirit of Becker (1965), and subsequent time use and home production papers, including Rupert, Rogerson, and Wright (2000), Greenwood and Hercowitz (1991), Aguiar and Hurst (2007) and others. The basic intuition behind these models of home production is that individuals substitute between home and market goods based on their relative price. Therefore, changes to the price of time and elasticity of substitution can be recovered from changes to the returns to shopping.

In the previous section, we showed that households can reduce the price they pay by varying the shopping activities of their basket. However, engaging in these shopping activities also has a cost of time for the household. For example, shoppers may spend time searching through newspapers to find coupons for a particular store. They may also spend time driving to multiple stores to find the lowest price for a particular set of goods. This relationship between shopping time and price can be summarized in a price function $p(s, \mathbf{N})$, where $\partial p / \partial s < 0$ and $\partial^2 p / \partial s^2 > 0$. The time spent shopping is denoted by s . Other activities of the shopping basket, not related to shopping time, that may influence price paid are denoted by $\mathbf{N}$. Total expenditure on the quantity Q of market goods purchased is given by

$$p(s, \mathbf{N})Q$$

In the spirit of Becker (1965), we assume that the quantity of purchased market goods is converted into consumption goods C using home production $K(h, Q)$. Households combine time h on home production with the quantity of market good Q to produce C , which enter the household's utility function. The home production function is assumed to be concave in h and Q . Therefore, in addition to the shopping technology, households can also substitute time for expenditures via their home production function.

The trade-off between time, market goods, and consumption goods can be summarized in the cost minimization problem (dropping the household subscript):

$$\min_{s_t, h_t, Q_t} p(s_t, \mathbf{N}_t)Q_t + \mu_t(s_t + h_t) \quad (6)$$

subject to

$$K(h_t, Q_t) = C_t$$

where μ_t is the opportunity cost of time in period t , which is assumed to be the same for shopping and home production. Note that the other choices made by the household are reflected in μ_t and C_t , including decisions about labor supply and inter-temporal allocation of consumption. We consider interior solutions to the problem, by making the usual monotonicity and concavity assumptions for the utility, price, and home production functions.

The first-order condition for shopping time is given by

$$\mu_t = -\frac{\partial p_t}{\partial s_t}Q_t \quad (7)$$

This condition implies that as the opportunity cost of time μ_t falls, shopping intensity s_t increases and the price paid declines (since $\partial p_t / \partial s_t < 0$). This implies that the opportunity cost of time can therefore be recovered from the marginal return to shopping.

The first-order condition for home production is

$$\mu_t = \frac{\partial K_t}{\partial h_t}\lambda_t \quad (8)$$

where λ_t is the multiplier on the constraint. The first-order condition for Q_t is

$$\lambda_t \frac{\partial K_t}{\partial Q_t} = \frac{\partial p_t}{\partial Q_t}Q_t + p_t \quad (9)$$

where Q_t is an element of $\mathbf{N}_t$. Combining with the intra-temporal condition (8) gives the marginal rate of transformation between time and market goods in home production:

$$\frac{\partial K_t / \partial h_t}{\partial K_t / \partial Q_t} = -\frac{\frac{\partial p_t}{\partial s_t}Q_t}{\frac{\partial p_t}{\partial Q_t}Q_t + p_t} \quad (10)$$

Therefore, the first-order conditions from the household's maximization problem allows us to recover their opportunity cost of time, and the elasticity of substitution between time and market goods in home production.

5.1 Implications for The Opportunity Cost of Time

Equation (8) implies that the opportunity cost of time can be estimated from the returns to shopping, which can be rewritten as

$$-\frac{\partial p_t}{\partial s_t} Q_t = -\frac{\partial \ln p_t}{\partial s_t} \cdot p_t Q_t = -\frac{\partial \ln p_t}{\partial f_{it}} \cdot \frac{\partial f_{it}}{\partial s_t} \cdot X_t \quad (11)$$

where s denotes the shopping time, f_{it} denotes the share of items purchased with shopping activity i , and $X_t = p_t Q_t$ denotes total expenditure. The empirical counterparts of p_t and Q_t are the composite relative price index and composite quantity of market goods defined in Section 4.

We have estimates of two of the terms in equation (11): $\partial \ln p_t / \partial f_{it}$, the sensitivity of price to each shopping activity (which was estimated in Section 4), and X_t , the expenditure per month. To recover the cost of time, we also need to know $\partial f_{it} / \partial s_t$. We can recover $\partial f_{it} / \partial s_t$ by making an assumption about the shopping technology. Specifically, we assume decreasing returns to time spent shopping - that is, $\partial^2 f_{it} / \partial s_t^2 < 0$. This assumption is intuitive, and implies that, for example, the marginal return from coupon usage decreases in time spent shopping, as there may be a limit to the number of coupons that can be used per transaction. One specification of $\partial f_{it} / \partial s_t$ under this assumption is γ_i / f_{it} , which we can observe in the data (up to some positive scalar γ_i). Under this assumption, the opportunity cost of time is given by:

$$\mu_t = -\frac{\partial \ln p_t}{\partial f_{it}} \cdot \frac{\gamma_i}{f_{it}} \cdot X_t \quad (12)$$

which is equal for all shopping activities (coupon usage, purchase of sale items, purchase of large items, purchase of generic products, and purchases from Big Box stores), because at the optimum households equate the marginal return from each shopping activity. This can be recovered from the shopping return estimates in Section 4 (Table 2), combined with quantity data on f_{it} from Homescan. Note that the scalar term γ_i drops out when we consider the change in cost of time.

The change in the opportunity cost of time is given by

$$\Delta \mu_{t+1} \equiv \frac{\mu_{t+1}}{\mu_t} = \frac{\partial \ln p_{t+1} / \partial f_{i,t+1}}{\partial \ln p_t / \partial f_{it}} \cdot \frac{f_{it}}{f_{i,t+1}} \cdot \frac{X_{t+1}}{X_t} \quad (13)$$

We consider the change in the opportunity cost of time over two periods: t denotes the pre-recession period of 2004-2007, and $t + 1$ denotes the recession period 2008-2010. As discussed above, the returns from each shopping activity imply the same change in opportunity cost of time because at the optimum, households equate the marginal return from each activity. However, suppose we (the

econometrician) measure the cost of time with some error ϵ_{it} for each shopping activity i . This implies that we observe

$$\Delta\mu_{t+1} = \Delta\hat{\mu}_{t+1} + \epsilon_{i,t+1} \quad (14)$$

where $\Delta\hat{\mu}_{t+1}$ is the actual change in opportunity cost of time. Combining equations (13) and (14), taking logs and rearranging, we have

$$\ln\left(\frac{\partial \ln p_{i,t+1}/\partial f_{i,t+1}}{\partial \ln p_{it}/\partial f_{it}} \cdot \frac{f_{it}}{f_{i,t+1}}\right) = \beta_0 + \eta_{i,t+1} \quad (15)$$

where $\beta_0 = (-\ln \Delta x_{t+1} + \ln \Delta\hat{\mu}_{t+1})$ is the constant, that can be estimated from a regression of equation (15). We can therefore recover the underlying change in cost of time $\Delta\hat{\mu}_{t+1}$ from an estimate of β_0 . The error term is denoted by $\eta_{i,t+1}$, and the empirical counter-part of the dependent variable of equation (15) is constructed from our estimates of $\partial \ln p_t / \partial f_{it}$ from Section 4 (Table 2, column 6), combined with data on f_{it} for each shopping activity i .

Table 4 displays the estimated change in the opportunity cost of time during the recession. The estimates in columns 1 and 2 use our preferred estimates of shopping returns from Section 4 (Table 2, columns 1 and 3). We observe a decline in the households' opportunity cost of time of 25-30 percent during the recession. The decline in cost of time is driven by three factors (as seen in Equation 13): variation in shopping returns, in shopping activities, and in expenditure. Approximately half of the decline in cost of time is due to lower shopping returns, while changes in expenditure and shopping activities account for the rest. This implies that the opportunity cost of time would have declined by 14 percent, even if shopping returns did not change (column 3). This reflects the increase in shopping activities.

To put these changes into context, Aguiar and Hurst (2007) estimate a decline of 27 percent in the cost of time over the life-cycle (from age group 25-29 to age group 65-74). This implies that the business cycle is as important as the life-cycle in influencing an individual's cost of time. The decline in the opportunity cost of time is consistent with the implications of the model described in Section 5. The home production model implies that a decline in the cost of time is associated with a willingness to substitute from market work towards non-market work, which includes shopping and home production. Our finding that the opportunity cost of time declines significantly during recessions is consistent with the reallocation of time during the recent recession, documented in Aguiar, Hurst, and Karabarbounis (2012). Our findings are also supportive of business cycle models with home production, such as in Benhabib, Rogerson and Wright (1991) and Greenwood and Hercowitz (1991), which explain the joint movement in market work and household expenditure over the business cycle based on the substitution between time and expenditure.

Table 4: Implied Change in the Opportunity Cost of Time

(2008-2010) vs. (2004-2007)	(1)	(2)	(3)
Estimated change in cost of time:	-0.268 (0.040)	-0.297 (0.058)	-0.137 (0.013)
Using the estimated returns from:	Table 2, Column 1	Table 2, Column 3	Assuming no change in returns
Regression type	Transaction-level	Monthly	n.a.

This table reports the recovered opportunity cost of time, using data on household expenditure, and returns to shopping, estimated in Section 4. Column 1 and 2 uses estimated returns from transaction-level and monthly data respectively. Column 3 reports the estimated change in cost of time assuming no change in returns. Standard errors are in parentheses.

5.2 The Elasticity of Substitution Between Time and Market Goods

In this section, we use our estimated cost of time to derive the parameters of the home production function, including the elasticity of substitution between time and market goods. Models with home production typically rely on a high elasticity parameter in order to explain a number of business cycle facts, such as the observed level of variation in aggregate output and market hours of labor over the business cycle.⁸ Karabarbounis (2013) shows that a model of home production that assumes an elasticity parameter close to 4 can explain the observed variation over the business cycle in the wedge between marginal product of labor and the marginal rate of substitution between consumption and leisure.

Previous estimates of the elasticity of substitution between time and market goods using micro data typically rely on cross-sectional household variation for identification. We contribute to the literature in two ways. First, we estimate the elasticity by exploiting the variation over the recession period, in addition to variation across household demographic groups. The panel dimension of the data helps us in two ways. First, we can control for unobserved, time-invariant household heterogeneity with household-group fixed effects, which could bias the estimates of the home production parameters. Second, we can allow for variation in returns to non-market work (and therefore op-

⁸Models that explain the joint variation in aggregate variables based on the inclusion of a home production sector include Aguiar and Hurst (2007), Benhabib, Rogerson and Wright (1991), Baxter and Jermann (1999), Chang and Schorfheide (2003), Greenwood and Hercowitz (1991), and Rupert, Rogerson, and Wright (1995).

portunity cost of time) across households and time. Furthermore, using time variation allows us to test whether home production shocks were important drivers of the joint variation in time spent on non-market work and expenditure on market goods observed during the recent recession.

We restrict our home production function to have a constant elasticity of substitution between time and market goods:

$$c_t = K(h_t, Q_t) \equiv (\phi h_t^\rho + Q_t^\rho)^{1/\rho} \quad (16)$$

for some positive constant ϕ . This specification of a constant elasticity of substitution between time and market goods is commonly used in existing studies, and therefore adopting this form allows us to compare our results to estimates in other papers. Time spent on home production is denoted by h_t and the quantity of market goods used in home production is denoted by Q_t . The elasticity of substitution between h_t and Q_t is given by $\sigma \equiv 1/(1 - \rho)$, where ρ is a positive constant parameter, which we estimate below. Under this form, the MRT is given by

$$\text{MRT} = \frac{\partial K_t / \partial h_t}{\partial K_t / \partial Q_t} = \phi \left(\frac{h_t}{Q_t} \right)^{\rho-1} \quad (17)$$

Substituting in equation (10) and taking logs, we have

$$\ln\left(\frac{h_t}{Q_t}\right) = \sigma \ln(\phi) - \sigma \ln\left(\frac{-\frac{\partial \ln p_t}{\partial s_t} Q_t}{\frac{\partial \ln p_t}{\partial \ln Q_t} + 1}\right) \quad (18)$$

The Homescan data does not have information on time spent on home production h_t and shopping s_t . Therefore to estimate equation (18), we combine data on time use data from the American Time Use Survey (ATUS) with the Homescan price and quantity data based on the household's age, gender, and marital status. We define home production as the time spent on housework, including cleaning, cooking, gardening and other home related activities, and shopping as time spent procuring goods.⁹ We split the sample into two non-overlapping periods (2004-2007 and 2008-2010), i.e. $t=1,2$, to examine the change over the recession period. The time use, quantity, and price data are averaged across households and time within each household demographic group-time period. The empirical series for the second term in equation (18) is derived by combining Homescan observations on Q , with our estimates of the returns to shopping (Table 2, column 6), and an estimate of the price elasticity $\partial \ln p / \partial \ln Q$.¹⁰

⁹This is consistent with the broad definition of home production used in Aguiar and Hurst (2007), and core home production and home ownership activities defined in Aguiar, Hurst, and Karabarbounis (2012).

¹⁰The price elasticity $\partial \ln p_{jt} / \partial \ln Q_{jt}$ is estimated from the following regression

$$\ln p_{jm} = \alpha_0 + \alpha_{Q1} \ln Q_{jm} + \alpha_{Q2} \ln Q_{jt} \cdot 1(\text{year} > 2007) + \alpha_3 1(\text{year} > 2007) + \sum_i \delta_i f_{ijm} + \lambda_j + \nu_{jm}$$

for household j in month m . The price elasticity $\partial \ln p_{jt} / \partial \ln Q_{jt}$ is estimated to equal α_{Q1} for $t=1$ (years 2004-2007),

We estimate Equation (18) based on the following regression:

$$\ln\left(\frac{h_{jt}}{Q_{jt}}\right) = \beta_0 + \beta_1 \ln\left(\frac{-\frac{\partial \ln p_{jt}}{\partial s_{jt}}}{\frac{\partial \ln p_{jt}}{\partial \ln Q_{jt}} + 1} \cdot Q_{jt}\right) + \beta_2 \ln\left(\frac{-\frac{\partial \ln p_{jt}}{\partial s_{jt}}}{\frac{\partial \ln p_{jt}}{\partial \ln Q_{jt}} + 1} \cdot Q_{jt}\right) \cdot \lambda_R + \lambda_j + \lambda_R + \epsilon_{jt} \quad (19)$$

for household-group j (defined based on age, gender, and marital status) in period t . We control for household-group fixed effects using λ_j , and time fixed effects using λ_R (which is an indicator variable equal to one for $t = 2$). The estimate for the elasticity of substitution between home production time and market goods is given by the coefficient $-\beta_1 = \sigma$, and the home production parameter ϕ is recovered from $\beta_0 = \sigma \ln(\phi)$. We test for changes in σ over the business cycle based on β_2 . A significant β_2 would imply the existence of shocks to home production during the recession.

The results are reported in Table 4. Column 1 gives the between-effects estimate, where the identification of the coefficient comes from variation across household demographic groups. The elasticity of substitution between market goods and time spent on home production is estimated to be 1.2, with a standard error of 0.39. One concern with this estimate is that there may be unobserved heterogeneity within each household demographic group, which may bias the estimate of the elasticity. Therefore, we re-estimate equation (19), controlling for household-group fixed effects, and allowing for variation across both household-group and time. This gives a higher elasticity of 1.7, with a standard error of 0.48 (Table 4, column 2).

Our estimates are consistent with other micro and macro estimates of the elasticity.¹¹ The estimates are supportive of business cycle models with a strong degree of complementarity between leisure and consumption, and home production models that assume a high elasticity of substitution between the market sector and non-market sector. In these models, home production amplifies the volatility of market work and consumption relative to output, and lowers the correlation between productivity and market work (see for example Benhabib, Rogerson and Wright (1991) and Greenwood and Hercowitz (1991)). Karabarbounis (2013) shows that a model of home production which assumes an elasticity of 4 can explain variations in the gap between marginal product of labor and the marginal rate of substitution between consumption and leisure (known as the “labor wedge”). Our point estimate of an elasticity of 1.69 (with a standard error of 0.47) is statistically within the range of 4. Thus, our results imply that the inclusion of a home production sector is important for modeling joint variations in aggregate variables over the business cycle.

and $\alpha_{Q1} + \alpha_{Q2}$ for $t = 2$ (years 2008-2010).

¹¹For example, Rupert, Rogerson, and Wright (1997) use aggregate U.S. data to estimate an estimate that is slightly less than 2, while Chang and Schorfheide (2003) estimate a value of 2.3. Using micro data, estimates of 1.8-2.0 are estimated in studies including Rupert, Rogerson and Wright (1995) and Aguiar and Hurst (2007).

Table 5: Elasticity of Substitution in Home Production

Coefficient	Interpretation	(1)	(2)
$-\beta_1$	σ (elasticity of substitution between time and goods in home production)	1.205 (0.389)	1.708 (0.481)
$-\beta_2$	$\sigma \cdot 1(\text{recession})$		0.024 (0.080)
Estimation		Between-effects	Fixed-effects
Additional controls		Marital status	None
Number of groups		27	54

This table reports the estimates of the elasticity of substitution between time and goods in home production. Columns 1 and 2 refer to coefficients estimated from equation (19), a regression of $\ln(h/Q)$ on price elasticities. American Time Use Survey and Homescan data are merged using 27 demographic period cells, based on age, sex, and marital status, for each year. Regressions are performed on cell averages across the demographic group within each period (2004-2007, and 2008-2010). Standard errors are in parentheses. See text for additional details.

The second issue that we examine is whether home production shocks are important drivers of the joint fluctuations between expenditure on market goods and time spent on non-market work during 2008-2010. We find a statistically and economically insignificant coefficient (β_2) on the interaction term from equation (19) in our fixed-effects estimates (Table 4, column 2). This result implies that home production shocks were not the driving force behind the decline in market expenditure and increase in time spent on non-market work between 2008 and 2010. This is consistent with Aguiar, Hurst, and Karabarbounis (2012), who derive a similar conclusion using data on state-level unemployment rates and time use.

5.3 Implications for consumption smoothing

Our estimated home production function also allows us to describe how households smooth consumption in the face of income shocks. Recent studies, such as Blundell et al (2012), show that households can partially smooth consumption when a member of the family becomes unemployed by increasing the hours worked by the secondary head of household. Here, we consider a different

margin of time allocation within a household: that is, the intra-temporal allocation between market hours and non-market work. This is relevant for understanding the ability of households to smooth unanticipated income shocks over the business cycle.

Recessions are characterized by a rise in unemployment and a fall in expenditure on market goods. Part of the lost labor hours are reallocated towards non-market work, such as shopping and home production (as documented in Aguiar, Hurst, and Karabarbounis (2012)). In Section 3, we showed that households did indeed increase their shopping activities (coupon use, purchases of items on sale, purchases of larger sizes, purchases of generic products, and shopping at Big Box stores). In Section 4, we showed that the increase in shopping activities lowered the price paid by households. We now show how much of these changes in household behavior translate to variation in consumption relative to market expenditure using our estimated home production function.

To see how consumption changed over 2008-2010, we take the derivative of the home production function (Equation 16), and use a hat symbol to denote percentage change (relative to previous two-year period 2006-2007). This gives

$$\hat{C} = \theta \hat{h} + (1 - \theta) \hat{Q}$$

where

$$\theta \equiv \frac{\phi h^\rho}{\phi h^\rho + Q^\rho}$$

Noting that $\hat{X} = \hat{p} + \hat{Q}$, we can decompose the change in consumption relative to market expenditure as:

$$\hat{C} - \hat{X} = \theta (\hat{h} - \hat{Q}) - \hat{p} \quad (20)$$

where $\hat{X}$ denotes the change in expenditure on market goods. The expenditure is deflated by an aggregate inflation index so that $\hat{X}$ excludes overall shifts in food prices, but includes changes in prices that were due to shifts in households shopping behavior (documented in Section 3) denoted by $\hat{p}$.

The decomposition in equation (20) shows that households can smooth consumption relative to expenditure on market goods by intra-temporally reallocating time. The first term, $(\hat{h} - \hat{Q})$, reflects the substitution between time spent on home production and market goods. The second term, $\hat{p}$, gives the price savings derived from the change in shopping behavior during the recession. The price savings is given by $\hat{p} = \sum_i \hat{f}_i \cdot (\partial \ln p / \partial f_i)$, where $\hat{f}_i$ denotes the increase in fraction of items with each shopping activity i (coupon usage, purchases of sale, purchases of large items, purchases of generic products, and buying from Big Box stores), and $\partial \ln p / \partial f_i$ denotes the sensitivity of price to the shopping activity, estimated in Section 4 (Table 2, column 6).

Table 5 shows the decomposition of the change in consumption relative to market expenditure, based on an estimated θ of 0.1.¹² Over the recession period, expenditure fell by 8.8 percent ($\hat{X}$), comprised of a 7.7 percent decline in quantity and a 1.1 percent decrease in prices paid due to increased shopping intensity. In contrast, consumption is measured to have declined by only 3.6 percent, which is about 60 percent less than the decline in market expenditure. As a result, the gap between consumption and market expenditure widened by 5.2 percent ($\hat{C} - \hat{X}$). Approximately 80 percent of the increase in the gap was due to a substitution from market goods towards time spent on home production (which rose by 3.8 percent), while increased shopping intensity accounted for the remaining 20 percent.¹³

These results from our estimated home production function highlight the importance of intra-temporal variations in time use for the purposes of smoothing consumption. During recessions, households are faced with lower income, but also more free time due to lower market hours and higher unemployment. By reallocating some of the lost market hours towards non-market work, they are able to partially smooth the decline in consumption (relative to market expenditure). The results imply that intra-temporal reallocation of time reduced the decline in consumption by almost 60 percent during the recession. These facts are consistent with the observed joint decline in household expenditure and labor hours during recessions.

It is worth noting that our results pertain to food expenditures, which is amenable to home production. Nonetheless, the ability to shop for bargains and utilize other means of home production can also apply to broader classes of goods. Thus, although we do not have data on consumption of other goods, we expect that the ability to substitute between time and market expenditure can also play an important role in smoothing household consumption when households are faced with unanticipated income shocks.

6 Robustness

In this section, we show that our results in Sections 5 and 6 are various definitions and assumptions, documented in Table 7. Under all cases examined in Table 7, the opportunity cost of time declined over the recession period, and there is a high estimated elasticity of substitution between time and market goods within home production.

First, we consider the exclusion of the year 2007. This was a year that was subject to food

¹²The θ of 0.1 is derived using the average h and Q over period $t = 1$ (years 2006 and 2007). This is combined with our estimates of the home production parameters.

¹³The share of the wedge ($\hat{C} - \hat{X}$) accounted for by the substitution between market goods and time spent on home production is calculated by $\theta(\hat{h} - \hat{Q})/(\hat{C} - \hat{X})$. The share accounted for by lower prices due to increased shopping time is given by $\hat{p}/(\hat{C} - \hat{X})$.

Table 6: Percentage change over 2008-2010, relative to 2006-2007

	(1)	(2)	(3)	(4)	(5)
Variable	$\hat{X}$	$\hat{p}$	$\hat{Q}$	$\hat{h}$	$\hat{C}$
% change	-8.83 (0.10)	-1.13 (0.01)	-7.70 (0.10)	3.77 (2.23)	-3.65 (0.79)

This table reports the percentage changes from 2008-2010 relative to 2006-2007 in market expenditure, price paid (due to increased shopping intensity), quantity of market goods purchased, home production time, and consumption. Standard errors are in paratheses.

price increases, which were arguably unrelated to the business cycle. We re-estimate the returns to shopping (see Appendix for results), which we use to compute the cost of time and elasticity of substitution between time and market goods within home production.

Secondly, we control for changes in quality associated with the shifts from non-generic to generic product. We do this by constructing an alternative price index, which constructed using the same methodology described in Section 4. The difference is that we compute two average prices paid in each month: one for generic products, and one for non-generic products.

Thirdly, we consider alternative assumptions for the response of the fraction of each shopping activity to an extra unit of time spent shopping ($\partial f / \partial s$). Specifically, we consider varying Box-Cox functional forms:

$$f_{it} = (s_t^\lambda - 1) / \lambda$$

for shopping activity i . We consider a range of values for λ (0, -1, and 1). The results are given in Columns 3-5.

7 Conclusion

This paper examines how households substituted between time and money during the recent recession, and the implications for consumption smoothing. We find that households increased their time spent on home production and shopping to reduce their market expenditure, in a manner that is consistent with their lower cost of time during the recession. Our findings are consistent with theoretical home production models, which predict positive co-movement between labor hours and expenditure.

Table 7: Robustness Results under Varying Assumptions

Robustness Check:	Excluding	Alternative	Box-cox form for $f(s)$		
	Year 2007	Price Index	$\lambda = -1$	$\lambda = 0$	$\lambda = 1$
	(1)	(2)	(3)	(4)	(5)
Change in cost of time:	0.281 (0.043)	0.237 (0.07)	0.216 (0.075)	0.201 (0.077)	0.191 (0.079)
Elasticity of substitution:					
σ	0.965 (0.356)	1.64 (0.498)	1.553 (0.38)	1.655 (0.399)	1.709 (0.413)
$\sigma \cdot 1(\text{recession})$	-0.05 (0.076)	-0.027 (0.081)	0.002 (0.06)	0.004 (0.063)	0.004 (0.065)
Consumption decomposition: (% change 2006/07 vs 2008/10)					
$\hat{X}$ (expenditure)	-5.88 (0.14)	-8.61 (0.14)	-8.83 (0.10)	-8.83 (0.10)	-8.83 (0.10)
$\hat{p}$ (price)	-1.28 (0.02)	-0.69 (0.01)	- 1.13 (0.01)	-1.13 (0.01)	- 1.13 (0.01)
$\hat{Q}$ (quantity)	-4.60 (0.14)	-7.92 (0.10)	-7.70 (0.10)	-7.70 (0.10)	-7.70 (0.10)
$\hat{h}$ (home production time)	3.97 (2.89)	3.77 (2.23)	3.77 (2.23)	3.77 (2.23)	3.77 (2.23)
$\hat{C}$ (consumption)	-1.53 (0.46)	- 3.80 (1.02)	-2.96 (0.92)	-3.78 (0.77)	-4.35 (0.65)
$\hat{C} - \hat{X}$	4.35 (0.45)	4.82 (1.02)	5.87 (0.92)	5.05 (0.76)	4.48 (0.65)

This table gives the results under various robustness checks. Column 1 excludes year 2007. Results in column 2 use an alternative price index, which controls for the decline in quality due to the switch from non-generic to generic products. Results in columns 3-5 assume varying Box-Cox functional forms for $f = (s^\lambda - 1)/\lambda$. Standard errors are in parentheses.

Using scanner data from Nielsen, we show that during the recent recession, households increased their shopping intensity over purchase activities, including coupon usage, purchasing on sale, buying larger sizes, and buying generic products. However, we find that the returns to shopping were lower during the recession. The lower returns are consistent with a concave price function, with decreasing returns to search, and imply a sizable decline in opportunity cost of time of 25-30 percent over 2008-2010, compared to the pre-recession period. The change in opportunity cost of time is consistent with an elasticity of substitution between market goods and time in home production of 1.7, which is indicative of a high degree of complementarity between leisure and consumption. These results imply that households are able to smooth a sizable portion of their consumption during recessions by varying their intra-temporal allocation of time.

8 References

- Aguiar, Mark, and Erik Hurst.** 2007. "Life-cycle Prices and Production." *American Economic Review*, 97(5): 1533-1559.
- Aguiar, Mark, Hurst, Erik, and Loukas Karabarbounis.** 2012. "Time Use During Recessions." NBER Working Paper No. 17259.
- Baxter, Marianne, and Urban J. Jermann.** 1999. "Household Production and the Excess Sensitivity of Consumption to Current Income." *American Economic Review* 89(4): 902-920.
- Becker, Gary.** 1965. "A Theory of the Allocation of Time." *Economic Journal* 75(299): 493-508.
- Benhabib, Jess, Richard Rogerson, and Randall Wright.** 1991. "Homework in Macroeconomics: Household Production and Aggregate Fluctuations." *Journal of Political Economy* 99(6): 1166-1187.
- Blundell, Richard, Luigi Pistaferri, and Itay Saporta-Eksten.** 2012. "Consumption Inequality and Family Labor Supply." NBER Working Paper No. 18445.
- Chang, Yongsung, and Sun-Bin Kim.** 2007. "Heterogeneity and Aggregation: Implications for Labor Market Fluctuations." *American Economic Review*, 97(5): 1939-1956.
- Chang, Yongsung, and Frank Schorfheide.** 2003. "Labor Supply Shifts and Economic Fluctuations." *Journal of Monetary Economics* 50(8): 1751-1768.
- Chari, Varadarajan V., Patrick J. Kehoe, and Ellen R. McGrattan.** 2007. "Business Cycle Accounting." *Econometrica*, 75(3): 781-836.
- Christiano, Lawrence, Martin Eichenbaum, and Sergio Rebelo.** 2011. "When Is the Government Spending Multiplier Large?" *Journal of Political Economy*, 119(1): 78-121.
- Cole, Harold L., and Lee E. Ohanian.** 2004. "New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis." *Journal of Political Economy*, 112(4): 779-816.
- Greenwood, Jeremy, and Zvi Hercowitz.** 1991. "The allocation of Capital and Time over the Business Cycle." *Journal of Political Economy*. 99(6): 1188-1214.
- Hall, Robert E.** 2009. "Reconciling Cyclical Movements in the Marginal Value of Time and the Marginal Product of Labor." *Journal of Political Economy*, 117(2): 281-323.
- Hall, Robert E.** 1997. "Macroeconomic Fluctuations and the Allocation of Time." *Journal of Labor Economics*, 15(1): 223-250.
- Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L. Violante.** 2009. "Quantitative Macroeconomics with Heterogeneous Households." *Annual Review of Economics*, 1: 319-354.

Kaplan, Greg. 2012. “Moving Back Home: Insurance Against Labor Market Risk.” *Journal of Political Economy*, 120(3): 446-512.

Kaplan, Greg, and Guido Menzio. 2012. “Shopping Externalities and Self-Fulfilling Unemployment Fluctuations.” NBER Working Paper No. 18777.

Karabarbounis, Loukas. 2013. “Home Production, Labor Wedges, and International Real Business Cycles.” NBER Working Paper No. 18366.

Monacelli, Tommaso, and Roberto Perotti. 2008. “Fiscal Policy, Wealth Effects, and Markups.” NBER Working Paper No. 14584.

Nakamura, Emi, and Jon Steinsson. 2011. “Fiscal Stimulus in a Monetary Union: Evidence from U.S. Regions.” NBER Working Paper No. 17391.

Shimer, Robert. 2009. “Convergence in Macroeconomics: The Labor Wedge.” *American Economic Journal: Macroeconomics*, 1(1): 267-297.

A Additional Figures of Shopping Activity

Figure 10: Shopping behavior by employment transitions
Share of total household expenditure

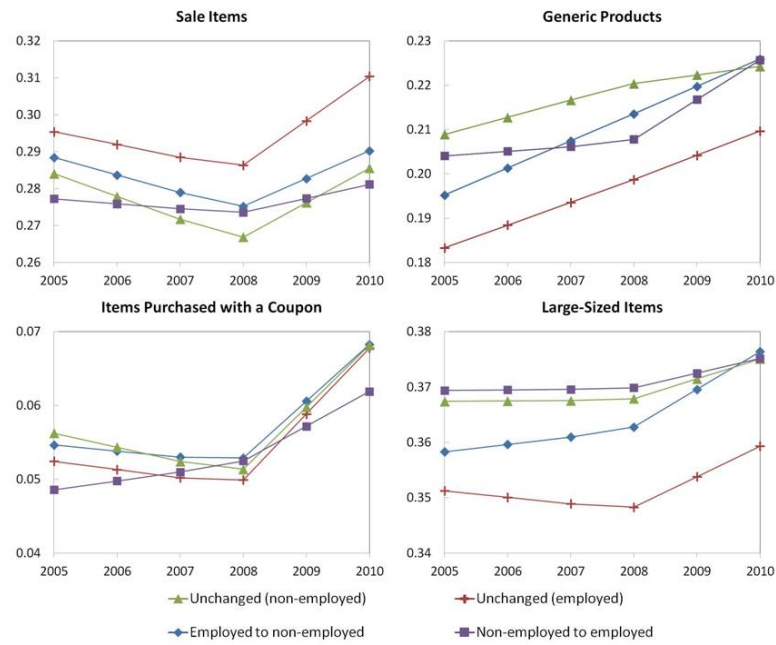
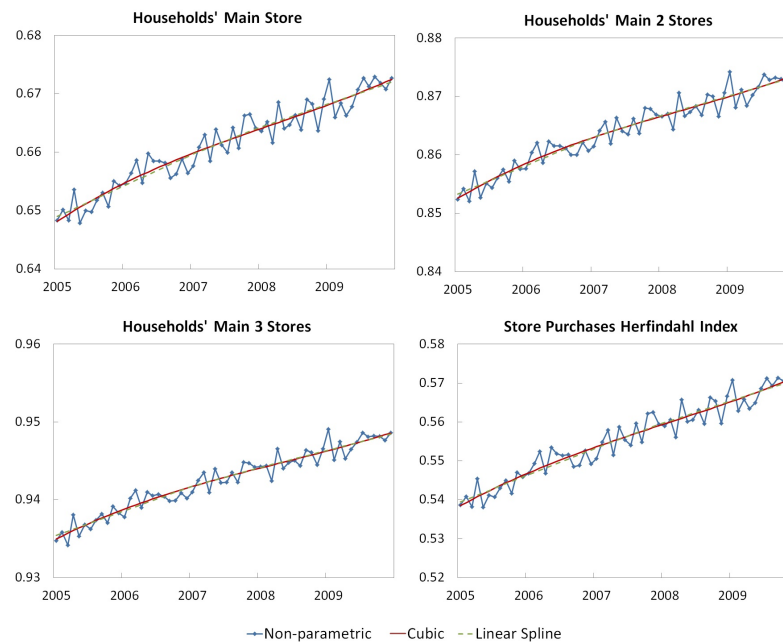


Figure 11: Concentration of expenditure by store
Share of total household expenditure



A.1 Returns to Shopping

Table 8 gives the estimated returns to shopping under two different robustness checks. In Column 1, we estimate the returns excluding the year 2007, a year that was subject to food price increases which were arguably unrelated to the business cycle. The estimates are based on using Price Index 2, which allows for substitution between UPCs. In Column 2, we estimate the returns using an alternative price index which controls for the decline in quality due to a shift from non-generic to generic products.

Table 8: Returns to Shopping

	Exclude 2007 (1)	Price Index 3 (2)
Sale	-0.037 (0.0036)	-0.065 (0.0034)
Coupon	-0.294 (0.0069)	-0.259 (0.0061)
Big box	-0.113 (0.0024)	-0.094 (0.002)
Generic	-0.259 (0.004)	0.047 (0.0035)
Large sizes	-0.456 (0.004)	-0.449 (0.0034)
Sale · 1(yr>2007)	0.012 (0.0034)	0.024 (0.0026)
Coupon · 1(yr>2007)	0.029 (0.0072)	0.011 (0.0057)
Big box · 1(yr>2007)	0.027 (0.0026)	0.014 (0.0021)
Generic · 1(yr>2007)	0.028 (0.0044)	0.005 (0.0037)
Large sizes · 1(yr>2007)	0.023 (0.0048)	0.021 (0.0042)

Columns 1-2 present estimates from the regressions of log-price on the shopping activities at a monthly frequency. Column 1 excludes 2007, and column 2 controls for quality changes due to switches between generic and non-generic products