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

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Abstract

We document how households lowered their grocery bill during the Great Recession by purchasing more on sale, larger sizes and generic products, increasing coupon usage, and shopping at discount stores. We estimate that the returns to these shopping activities declined during the recession and therefore this behavior implies a significant decrease in households’ opportunity cost of time. Using the estimated cost of time and time use data, we estimate a high elasticity of substitution between market expenditure and time spent on non-market work. We find that households smooth a sizable fraction of consumption by varying their time allocation during recessions.

JEL Classifications: D12; E31; J22

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

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1 Introduction

During recessions, some consumers are faced with lower income but have more free time. One way to deal with the lower income and take advantage of the extra time is to spend more time on non-market work, such as home production and shopping. For example, consumers can lower their expenditure by buying during sales, using coupons, substituting to cheaper brands, buying in bulk, and shopping at discount stores. All of these activities can reduce food expenditures, but require more shopping time and effort. In this paper, we show that indeed consumers change their shopping behavior during recessions. We then estimate the change in the returns to these behaviors and compute the implied substitution between time and goods expenditure in home production. Finally, we ask to what extent are households able to smooth consumption relative to market expenditures by varying their time use during recessions? Our estimates are 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 employment 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 (2013), 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. Our first contribution in this paper is to examine how this reallocation of time actually translates to lower prices. 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 paid, and when and where the product was purchased. Each consumer is in the data set for several years. In total, we have 112,837 households documenting their food purchases from 2004 to 2010.

We find that households increased their shopping intensity over different shopping activ
ities during the Great Recession. Specifically, purchases of sale items, coupon usage, buying
generic products and large sized items, and shopping at discount (Big Box) stores 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 un-
employment, 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 rise in shopping intensity is driven by an increase in the returns
to shopping. For each household, we compute 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
to measure the returns to shopping, controlling for omitted variables in a couple of ways.
We find that these shopping activities lower the price paid by households - for example,
consumers who use more coupons pay a lower price. However, we find that the return to
shopping declined during 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, using a coupon, buying generic
products, purchasing large sized items, and shopping at Big Box stores.

The increase in shopping intensity, coupled with the decrease in returns to shopping,
implies a decline in households’ opportunity cost of time. This suggests that the change
in shopping behavior during the recession reflected shifts in household demand rather than
supply-side firm adjustments. This motivates the last step of our analysis, where we use data
on prices and quantities to estimate parameters of a home production function. Using a home
production model, we recover households’ cost of time, and the elasticity of substitution
between time and market goods. Specifically, we exploit the fact that at the optimum,
households equate the marginal return from shopping to their opportunity cost of time.

We estimate 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
(1997). 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 (2013). 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.\footnote{See for example, Benhabib, Rogerson and Wright (1991), Greenwood and Hercowitz (1991), Chang and Schorfheide (2003), and Aguiar and Hurst (1997).}

Our estimated home production function allows us to address two questions related to the 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. Answering this question matters for understanding the propagation mechanisms behind the recent recession. 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 (2013), 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, decreases in labor hours and purchases of market goods are accompanied by increases in shopping intensity and time spent on home production.

Second, our findings support business cycle models which assume strong complementarities between market consumption and market work in the utility function (for example, Christiano, Eichenbaum and Rebelo, 2011; Hall, 2009; Monacelli and Perotti, 2008; Nakamura and Steinsson, 2014). 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. 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 (2014) 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 production sector in these models may explain a sizable proportion of the labor wedge.

Our paper also 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, Blundell, Pistaferri and Saporta-Eksten, 2012; Heathcote, Storesletten and Violante, 2009; Kaplan, 2012). 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 to explain the joint movements in market expenditure, market work, and time spent on non-market activities.

Our study of shopping activities also relates to the literature focused on measurement of inflation. Typically, inflation is measured using fixed weights for a given basket of goods. This leads to the well known “substitution bias”: as relative prices change so do consumer choices and therefore the fixed weights inflation index will not fully capture the price changes faced by consumers. For instance, Shapiro and Wilcox (1996) and the Boskin Commission report (1996) show that store-substitution can cause biases in the measurement of consumer inflation, while Griffith et al. (2009) documents the reduction in effective prices paid from a range of shopping activities which may not be fully reflected in a fixed-weight inflation index. More recently, studies such as Chevalier and Kashyap (2011) and Coibion, Gorodnichenko and Hong (2012) show that the gap between effective prices paid and posted prices can vary over time as households change their shopping effort. Our findings that these ac-

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2Studies that have discussed the labor wedge include Karabarbounis (2014), Hall (1997), Shimer (2009), Cole and Ohanian (2004), Chari, Kehoe and McGrattan (2007), Chang and Kim (2007), and others.
tivities increased during the recent recession is consistent with the implication that inflation measurement bias is counter-cyclical - that is, the mismeasurement widens during recessions. Quantifying the degree of inflation mismeasurement matters for understanding the variation in consumption over the business cycle and cross-sectionally across households.

The rest of the paper is organized as follows. In Section 2, we describe our data and in Section 3, we display 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. In Section 6, we provide evidence of robustness of our findings under a range of alternative assumptions. We conclude in Section 7.

2 Data and Variable Definitions

The data used in this paper come from the Nielsen Homescan database. The dataset includes information on all food purchased and brought into the home by a large number of households over 2004-2010 from 54 geographically dispersed markets (each roughly corresponding to a Metropolitan Statistical Area). Households in the sample are recruited by Nielsen via mail and online. Nielsen offers incentives to households to join and remain active in reporting transactions. These incentives include monthly prize drawings, gift points and sweepstakes. To ensure the 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 who leave the sample. In doing so, Nielsen tries to make the sample demographics representative of national demographics. Several studies have examined the quality of the data. For example, Einav, Leibtag and Nevo (2010) compare the self-reported data in Homescan with data from cash registers and conclude that the reporting error is of similar magnitude to that found in commonly used economic data sets.

Participating households record the data using hand-held scanners at home. The households record the store where the product was purchased, the date and quantity purchased at the Universal Product Code (UPC) level. For each UPC, the data contains information

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3 The 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.
on the product characteristics, including brand, size and packaging. 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. In addition, households record whether the purchased item involved one of four types of deals: (i) store feature, (ii) store coupon, (iii) manufacturer coupon, (iv) any other deal. In the cases where a coupon was used, the household records its value.

Our version of the Nielsen Homescan data has approximately 325 million household purchase transactions over 2004 to 2010, where a transaction is defined at a UPC level. In total, we use data from 112,907 households who report purchases for at least 10 months. These households on average report data over 32 consecutive months. The dataset contains demographic information about the household panelist, which are updated annually. These include information on the head(s) of household’s age, sex, race, education, occupation, region of residency, employment status, family composition and household income.

We use the Nielsen Homescan data to document changes in household shopping activities and variation in the returns to these activities during the Great Recession. To do so, we focus on five aspects of shopping behavior: purchases of sale items, coupon use, buying generic products, purchases of large size items (which are typically cheaper per ounce), and shopping at discount (Big Box) stores. These five activities are defined as follows.

**Sale**  An item is defined as being on sale if the household recorded that the item purchased involved a deal.

**Coupon Use**  An item is defined as involving coupon usage if the household recorded that item purchased involved using either a store coupon or a manufacturer coupon.

**Generic Product**  An item is identified as a ‘generic product’ based on the brand code associated with the UPC.

**Large Size Items**  To define large sized items, we follow Griffith et al. (2009) and rank by size all UPCs in our data within a narrowly defined category. An item is defined as ‘large’ if the size of the item is in the upper two quantiles of this distribution, i.e., in the top 40 percent of UPCs in the category, ranked by product size.
Big Box store purchase  The data identifies the retailer channel that the item was purchased from. Big Box stores are identified as mass merchandise stores, super-centers, and club stores.

For each of these measures, we define shopping intensity as the fraction of household expenditure in each month that comes from each activity.\(^4\) For example, when looking at coupons, we ask in each month what fraction of purchases were made with a coupon. To seasonally adjust the monthly fractions of each shopping activity, we first calculate the deviation from trend, where the trend is computed as the 12-month trailing rolling average over 2004-2010. Then for each calendar month, we compute the average deviation over 2005-2010 (for example, for the calendar month of January, the average deviation is computed over all January months in each year from 2005 to 2010). We exclude 2004 from the calculation of the average and in the graphs in Section 3 since we cannot compute the trend for this year, given the trend is a trailing 12-month average. The average deviation is then subtracted from the data to adjust for calendar-month seasonality.\(^5\)

3  Change in Shopping Patterns Over the Cycle

We start by examining shopping patterns. We focus on the five aspects of shopping behavior defined in the previous section: purchases of sale items, coupon use, buying generic products, purchasing large size items, and shopping at Big Box stores. We document the fraction of expenditure involving various shopping activities and show how the patterns changed during the Great Recession. We also examine these patterns for different demographic groups.

To aid in presentation, we display our results graphically.\(^6\) We report three types of results in the figures below. In all cases, we regress the seasonally-adjusted fraction of overall expenditure for each shopping activity by each household in each month on a household fixed effect (to control for differences across households) and a time trend. We examine three different time trends. First, we describe the data non-parametrically, i.e., we allow for

\(^4\)For robustness, we also examined the fraction of purchases and find qualitatively similar results.

\(^5\)We also considered other methods to seasonally adjust the data, for example considering the data relative to the calendar months in 2004 using calendar-month fixed effects. The method of seasonality adjustment does not qualitatively alter the results presented in the paper.

\(^6\)The regressions underlying these results are presented in the online appendix. To avoid clutter in the graphs, we do not present confidence intervals around the estimates. Given the large number of observations the confidence intervals are small and are available upon request.
month-year fixed effects. The coefficients on the month-year effects give 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 using two break points: the first in December 2007, at the official start of the Great Recession as dated by the NBER; and the second in June 2009, at the end of the NBER recession date.

Changes for the Average Consumer

Figures 2-5 display estimates of the fraction of household expenditures which involve purchases of sale items, coupon usage, buying generic items, buying large-sized items, and shopping at Big Box stores, respectively. The figures are based on regressions using all the households in our sample, and represent the behavior of the average household in the sample.

The behaviors for sales, coupons, generic and large-sized items, displayed in Figures 2-4, follow similar patterns. Prior to the recession, purchases of items on sale, coupon usage, 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 shopping activities during the recession. Over the recession, these shopping activities each increased by 1.5-2.0 percentage points of total household expenditure. The breaks in the trend are statistically significant and are reported in the first panel of Table 1. These trends closely follow the movement in the aggregate unemployment rate (dashed line in Figures 2-4).

On the other hand, expenditure at Big Box stores, displayed in Figure 5, exhibits a somewhat different pattern. In the pre-recession period, the share of expenditure made at Big Box stores was rising, in large part due to the expansion and growth of Wal-Mart. During 2008-2010, the fraction of expenditure in Big Box stores continued to rise, although at a slower rate than the pre-recession period. As we show in Appendix A Figure 10, the same pattern is observed if 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. Consistent with Kaplan and Menzio (2014), our measures of store search intensity show that households consolidated their search within a smaller number of stores during the recession, which included the Big Box stores.

The increase in shopping intensity during the recession observed in the graphs may reflect business cycle variation, but may also reflect low-frequency structural changes. The
Figure 1: Purchases of Sale Items (Fraction of household expenditure)

Figure 2: Purchases Involving Coupon Usage (Fraction of household expenditure)
Figure 3: Purchases of Generic Items (Fraction of household expenditure)

Figure 4: Purchases of Large Sized Items (Fraction of household expenditure)
prevalence of structural trends is particularly relevant for the shopping patterns at Big Box stores, where the trend may reflect the pre-recession expansion of Wal-Mart and its subsequent slow-down in new store openings. The short time frame of our data prevents us from using standard statistical methods to detrend the time series data to examine the business cycle variation. Therefore to isolate the low frequency trends from potential business cyclical variation, we further examine county-level variation in shopping patterns. Using variation across counties allows us to control for common low-frequency trends. We then relate the county-level shopping patterns with local employment conditions to examine business cycle patterns, as it is a measure that is closely correlated with aggregate output during the Great Recession.\footnote{The approach of using geographic variation to identify changes in household behavior related to the business cycle has also been used in recent studies including Aguiar, Hurst and Karabarbounis (2013) and Mian and Sufi (2010).} Specifically, we estimate for each shopping activity the following equation:

\[ y_{it}^k = \alpha_0^k + \alpha_1^k UR_{c(i)t} + \alpha_2^k t + \alpha_3^k \cdot \lambda_{2007} + \alpha_4^k \cdot \lambda_{2009} + \lambda_{2007} + \lambda_{2009} + \lambda_{c(i)} + \lambda_i + \epsilon_{it} \] (1)

where \( y_{it}^k \) is the seasonally-adjusted average fraction of expenditure for household \( i \) in month \( t \) from shopping activity \( k \), and \( UR_{c(i)t}^k \) denotes the unemployment rate in county \( c(i) \) where household \( i \) resides. As in Figures 2-5, the regression specification includes linear splines with two breaks (at December 2007 and June 2009) to control for possible linear low-frequency
trends that may be occurring over the recession period. This is given by the interaction of the trend $t$ with indicator functions $\lambda_{2007}$ and $\lambda_{2009}$, which equal 1 if $t$ is after December 2007 and after June 2009, respectively. We also control for county and household fixed effects, denoted by $\lambda_c(i)$ and $\lambda_i$ respectively; and $\epsilon_{it}$ is the random error term.

The coefficients for the time trend terms are statistically significant and reported in the first panel of Table 1. The second panel of Table 1 displays the coefficients for the linear splines and for unemployment. The patterns in the trend coefficients are very similar to the results in the first panel, which did not control for the county-level unemployment rate. The coefficients on unemployment are positive and statistically significant for each of the shopping activities. Thus, counties that experienced a greater rise in unemployment also on average had more pronounced increases in shopping activities. This suggests that the shift in shopping patterns over 2008-2010, observed in Figures 2-4, were likely related to business cycle factors.

We note that the coefficient on the unemployment rate for the regression of shopping at Big Box stores (column V) is positive and statistically significant, consistent with the other shopping activities (columns I-IV). This implies that there does indeed exist a correlation between declines in economic activity and shopping at Big Box stores, even though this is difficult to see graphically in Figure 5 since the graph also captures low-frequency structural trends. Thus, in the following analysis where we examine potential variation in the shopping patterns by household demographics in a graphical format, we focus our discussion on the shopping activities excluding shopping at Big Box stores, since the graphs for Big Box stores are less useful in depicting business cycle variations.

**Change in Shopping Patterns by Demographics**

Having documented the trends for the average consumer, we now repeat the analysis by demographic group. This allows us to see if the general pattern is driven by particular groups of households. Here, we focus our discussion on the four activities that graphically exhibited a clear increase during the recession: purchasing on sale, coupon usage, buying generic products, and purchasing large sized items. As before, we focus on graphical presentation and display only the results from the linear spline regression to avoid clutter on the graphs.

In Figure 6, we display the linear spline trends by age group. We see that households over 65 years of age purchase more items on sale, use more coupons, and buy more generic products.
Table 1: Cyclical Changes in Shopping Activities

<table>
<thead>
<tr>
<th>Linear Spline Regressions</th>
<th>Sales (I)</th>
<th>Coupon Use (II)</th>
<th>Generic Item (III)</th>
<th>Large Size (IV)</th>
<th>Big Box Stores (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>time trend</td>
<td>-2.87</td>
<td>-0.71</td>
<td>2.56</td>
<td>-0.69</td>
<td>8.88</td>
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<td></td>
<td>(0.11)</td>
<td>(0.06)</td>
<td>(0.08)</td>
<td>(0.1)</td>
<td>(0.15)</td>
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<tr>
<td>time trend · 1(post Dec 2007)</td>
<td>14.8</td>
<td>8.99</td>
<td>2.34</td>
<td>3.67</td>
<td>-3.43</td>
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<tr>
<td></td>
<td>(0.27)</td>
<td>(0.14)</td>
<td>(0.21)</td>
<td>(0.25)</td>
<td>(0.38)</td>
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<tr>
<td>time trend · 1(post June 2009)</td>
<td>-12.79</td>
<td>-6.37</td>
<td>-2.24</td>
<td>0.26</td>
<td>-2.98</td>
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<tr>
<td></td>
<td>(0.37)</td>
<td>(0.19)</td>
<td>(0.28)</td>
<td>(0.34)</td>
<td>(0.52)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross-county Regressions</th>
<th>Sales (I)</th>
<th>Coupon Use (II)</th>
<th>Generic Item (III)</th>
<th>Large Size (IV)</th>
<th>Big Box Stores (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>time trend</td>
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<td>-0.71</td>
<td>2.65</td>
<td>-0.63</td>
<td>8.95</td>
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<td></td>
<td>(0.11)</td>
<td>(0.06)</td>
<td>(0.08)</td>
<td>(0.10)</td>
<td>(0.15)</td>
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<tr>
<td>time trend · 1(post Dec 2007)</td>
<td>11.29</td>
<td>8.88</td>
<td>1.24</td>
<td>2.97</td>
<td>-4.70</td>
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<tr>
<td></td>
<td>(0.34)</td>
<td>(0.18)</td>
<td>(0.27)</td>
<td>(0.32)</td>
<td>(0.49)</td>
</tr>
<tr>
<td>time trend · 1(post June 2009)</td>
<td>-9.20</td>
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<td>-1.13</td>
<td>0.96</td>
<td>-1.66</td>
</tr>
<tr>
<td></td>
<td>(0.43)</td>
<td>(0.22)</td>
<td>(0.33)</td>
<td>(0.40)</td>
<td>(0.60)</td>
</tr>
<tr>
<td>County unemployment rate</td>
<td>11.37</td>
<td>0.39</td>
<td>3.51</td>
<td>2.23</td>
<td>4.10</td>
</tr>
<tr>
<td></td>
<td>(0.68)</td>
<td>(0.36)</td>
<td>(0.53)</td>
<td>(0.63)</td>
<td>(0.96)</td>
</tr>
</tbody>
</table>

Note: For ease of readability, all coefficients and standard errors (in parentheses) on the time trend terms have been multiplied by 10,000. Columns (I)-(V) of the first segment of the table shows estimates from regressing the fraction of each activity on a linear spline with breaks at Dec-2007 and June-2009, controlling for household fixed effects. Each column corresponds to a different regression, varying by shopping activity. These estimates underlie the linear spline line for Figures 1-5. The second segment of the table shows estimates from the regressions of equation (1). These regressions include household and county fixed effects, which are not reported in the table. In total, there are 3,580,610 household-month observations.
products. This is consistent with Aguiar and Hurst (1997), who show that households increase the amount of time spent shopping upon retirement. Older households also tend to spend less on large size items, which may partly reflect the fact that these households typically have fewer members. During 2008 to 2010, all age groups exhibited an increase in shopping intensity for all the activities, which is quite similar to the patterns we saw in the previous section. The difference in shopping intensity between the age groups narrowed, particularly with regards to coupon usage and purchases of items on sale.

In Figure 7, we display the breakdown by income group. As with age, there are some differences in the levels across groups. For example, spending on generic products as a share of total expenditure tends to decline with income. As before, all groups exhibit a similar increase in shopping activities during the recession. A notable exception is the share of items purchased on sale. Before the recession, the highest income group had the lowest share. However, during the recession, this group increased the share of items bought on sale, and by 2010 it had the highest share among all the groups.

We also examined the change in shopping activities across different households, split by their employment status (“non-employed” or “employed”). 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 head of households, so that our results are distinct from the effects of retirement on shopping patterns. The linear spline trends by employment status for multiple-head households are shown in Figure 8.\footnote{We also examined single-person households and find similar increases in shopping activities during the recession period for both the non-employed and employed groups.} We see that non-employed households use more coupons, buy more generic items, and purchase fewer sale items (as a share of total household expenditure) than employed households. Both employed and non-employed groups exhibit an increase in shopping intensity during 2008-2010. We note that unemployment status is a very noisy signal since it is only updated once a year. Nonetheless, taking the definition of unemployed as given, the results imply that the average increase in shopping intensity over this period was not driven only by more non-employed households, but may also reflect other factors in the recession (for example, greater income uncertainty) which can cause both employed and non-employed households to engage in more price-saving activities.

A similar increase in shopping intensity can also be seen if we restrict the data to house-
Figure 6: Shopping behavior by age group (years): Share of total household expenditure

Figure 7: Shopping behavior by income ($’000): Share of total household expenditure
holds who are in the sample for more than one year. This allows us to compute groups based on transitions in employment status: 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. Again we exclude those aged over 65 years to abstract from retirement effects. Appendix figure 9 shows that all groups increased their shopping intensity during 2008-2010. This again suggests that the increase in shopping intensity over this period is pervasive across both employed and non-employed groups.

From the discussion above, we can therefore make two main observations: First, we observe interesting cross-sectional differences across various household groups, consistent with findings in past studies documenting differences across age groups (such as in Aguiar and Hurst (1997) and across employment status (such as in Kaplan and Menzio, 2013). Secondly, looking at the time-series variation in behavior, we observe a clear increase in shopping activities during the recession for all household groups. Since the trend changes are pervasive across all main demographic groups, and our analysis focuses on understanding the effects of the Great Recession on consumption, we therefore focus our discussion in the following
sections on the implications of these behavior changes for the average household. Specifically, we explore the implications for households’ opportunity cost of time and elasticity of substitution between market expenditure and time spent on home production.

4 Change in the Returns to Shopping

In the previous section, we documented that the fraction of expenditure from different shopping activities increased during the Great Recession. In this section, we start exploring the forces driving this behavior. In particular, we examine whether the observed change is driven by a change in the returns to shopping activity or a change in the opportunity cost of engaging in the activity. To do so, we follow an approach similar to Aguiar and Hurst (1997) and compute for each household in each month a price index that captures how much that household actually paid for the basket of goods it purchased relative to what the average consumer paid for the same basket. We then regress this relative price index on the fraction of purchases from each shopping activity. In other words, we ask how much did a household save by increasing, for example, the fraction of purchases on sale.

An alternative approach, used by Griffith et al. (2009), to measuring the changes in the return to shopping would be to regress the transaction-level price, rather than the monthly price index, on the shopping activity. We did not use this approach for a number of reasons. First, we have a quarter of a billion transaction-level observations. We are therefore somewhat limited in the variety of specifications we can test, especially since we need to weight the data to be consistent with the theory. Second, as we will see in the next section, our theory is that of an aggregated commodity. We therefore need the effects of shopping activity on the price of this aggregate commodity, which is reflected in the price index specification. In contrast, the transaction-level regression would need to be weighted in order to provide the appropriate results. For example, we may want to give a higher weight to items that account for a larger fraction of a household’s expenditure basket. This weight is thus potentially household specific. Coupled with the large size of the data, and the need for different fixed effects for different activities, this quickly becomes intractable. Moreover in Section 6, we estimate a home production function by combining the returns estimates with data from the American Time Use Survey. The time-use data is not granular enough to estimate a home production function at a UPC-transaction level, which further motivates examining a composite good approach based on a monthly price index.
Price Index

We now define the price indices that we use to compute the returns to shopping. Denote the price paid for good \( j \) (at a UPC level) on shopping trip \( t \) by household \( h \) by \( p_{j,t}^h \), and the corresponding quantity by \( q_{j,t}^h \). We compute a price index by comparing the actual expenditure to the expenditure that the household would have incurred if they had instead paid the average price in the market, denoted by \( \bar{p}_{j,m} \) for item \( j \) in month \( m \). We compute two different price indices which vary in the way that \( \bar{p}_{j,m} \) is computed.

Specifically, we define a 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

\[
\tilde{p}_m^h \equiv \frac{\sum_{J \in D} \sum_{j \in J, t \in m} p_{j,t}^h q_{j,t}^h}{\sum_{J \in D} \sum_{j \in J, t \in m} \bar{p}_{j,m} q_{j,t}^h}
\]

where \( J \) denotes the set of all UPCs belonging to product \( J \), and \( D \) denotes the set of all products. The index is then normalized by dividing by the average price index across households within the month

\[
p_m^h = \tilde{p}_m^h \frac{\tilde{p}_m}{\tilde{H}_m} \sum_k \tilde{p}_m^k
\]

where \( \tilde{H}_m \) denotes the total number of households in the sample in month \( m \). This ensures that the distribution of price indices across households is centered around 1 each month. An index that is above 1 indicates that household \( h \) paid a higher average price for its basket of goods in month \( m \), while an index below 1 indicates that a lower average price was paid.

We consider two approaches to calculating the average price paid in the market for item \( j \). First, we compute, as in Aguiar and Hurst (2007), the average price paid by households for a particular item \( j \) (at a UPC level)

\[
\bar{p}_{j,m} = \sum_{h \in H, t \in m} \left( \frac{q_{j,t}^h}{\sum_{h \in H_m, t \in m} q_{j,t}^h} \right) p_{j,t}^h
\]

where \( H_m \) denotes the set of all households in the sample in month \( m \). This approach has the advantage of controlling for the quality of the product purchased since it only considers the price paid by other households for the same UPC. However, it does not account for the savings that households can achieve by buying different sizes and different brands. It also does not fully account for potential savings from shopping at Big Box stores since these
stores often carry different UPCs. Thus, this index will underestimate the total savings from these shopping activities.

Therefore, we also consider a second approach to estimating the average price paid, which accounts for substitution among brands as well as different sizes. Specifically, we calculate the average per ounce price paid for item $j$ of size $s_j$ by taking the average across all items of the same size belonging to the product category $J$.

$$\bar{p}_{j,m}/s_j \equiv \frac{\sum_{k \in J, h \in H, t \in m} \left( \frac{q^h_{k,t}}{\sum_{k \in J, h \in H, t \in m} q^h_{k,t}} \right) p^h_{k,t}/s_k}{\sum_{k \in J, h \in H, t \in m} q^h_{k,t}/s_k}$$  \hspace{1cm} (4)

This average price is normalized by dividing by the size of the item to allow for comparison across different sizes. We note that this approach assumes all items within the product are substitutable and therefore does not consider quality differences. So in a sense, it is the other extreme from the first index: here we assume all items in a group are perfect substitutes while before we assume they are not substitutes at all. In Section 6, we consider an alternative index that controls for quality differences between generic and non-generic products, and show that our results are robust to substitution between goods of different quality.

**Returns to Shopping**

To estimate the returns to shopping we regress the price indices we previously described on the fraction of items bought involving each shopping activity. This is similar to the approach taken in Aguiar and Hurst (1997) to estimate how much a household can decrease its expenditure by increasing their shopping intensity.

We estimate the following regression using household monthly observations

$$\ln p^h_m = \alpha_0 + \delta Z^h_m + \nu Z^m \cdot 1(\text{yr} > 2007) + \lambda_h + \sum_i \alpha_i f^h_{i,m} + \sum_i \beta_i 1(\text{yr} > 2007) \cdot f^h_{i,m} + \gamma 1(\text{yr} > 2007) + \epsilon^h_m$$  \hspace{1cm} (5)

where $p^h_m$ is the price index (defined in the previous section) of the basket of goods purchased by household $h$ in month $m$; $Z^h_m$ denotes the vector of household time-varying demographics, including age, employment status, marital status and county of residence of the head of household, and household income; and $\lambda_h$ controls for household time-invariant fixed effects. The variable $f^h_{i,m}$ denotes the fraction of items in the basket of goods purchased by household $h$ involving shopping activity $i$ (which includes buying on sale, coupon usage, buying large sizes, buying generic products and shopping at Big Box stores) in month $m$. Our focus
is on the interaction of these variable with the recession dummy variable $1(\text{yr} > 2007)$.$^{10}$ The coefficients of interest are $\alpha_i$ and $\beta_i$, which give the sensitivity of price to each shopping activity before and during the recession. A negative $\alpha_i$ implies the shopping activity decreases the price (hence has a positive return), while a positive $\beta_i$ implies a decline in returns during the recession.

Since the regression includes household and recession period fixed effects, the error term in the regression primarily includes random shocks to the relative price paid by the household. However, the error term could also include additional unobservable activities that the household takes to reduces the prices paid. These additional unobservable activities could, in principle, be correlated with the shopping activities we observe. We therefore estimate equation (5) using instrumental variables. We instrument for shopping intensity using the average fraction of expenditure accounted for by each shopping activity $i$

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

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’s reference groups is defined based on a combination of employment status, age, income, and state of residency.$^{11}$

The intuition for using the average shopping activity for the group as an instrument is that it captures common supply-side factors that affect the individual’s tendency to undertake a shopping activity. For example, low-income households living in a particular region may be exposed to an exogenous sales campaign of a particular chain, which affects their tendency 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 due to common supply-side factors. Second, the unobserved individual-specific time-varying shocks that affect the price paid by an individual are not correlated across individuals.

Table 2 shows the regression results for equation (5) using the two prices indices as the

$^{10}$To simplify presentation we do not separate out the post-recession observations (i.e. the observations in year 2010). In Section 6, we show that our findings are robust to excluding the post-recession observations.

$^{11}$The 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.
dependent variable. Our preferred specification uses the second price index, which allows for substitution across products and accounts for different sizes, and is presented in Column (II). Our results are qualitatively similar if we use the first index, presented in Column (I). In both columns, we generally find that shopping activities lower the price paid by the household. In the pre-recession period, we estimate that the marginal price paid was reduced by 3-7 percent by buying on sale, 26-30 percent by using a coupon, and 5-10 percent from shopping at a Big Box store. The results for generic products and larger sizes are a bit different between the two columns: the results in Column (I) suggest these activities either do not have a meaningful economic effect on the price paid, while the results in Column (II) suggest that prices decreased by 25 percent from buying a generic product, and 46 percent from buying large-sized items. These differences are not surprising since, as we previously discussed, the first price index essentially shuts down the savings channel created by buying larger sizes or generic products because it compares the price paid for the same UPC. The direction and magnitude of the effects is consistent with those found in the literature.  

The second result that we find is that the returns to each of the shopping activities declined over the recession period. Specifically, we estimate that returns were approximately 2 percentage points lower (as seen in the estimated coefficients of the interaction of shopping activity with a dummy for the recession period in Table 2).

The estimated decline in returns, coupled with the increase in shopping activities that we documented, implies that the shifts in household shopping activities are associated with changes in their opportunity cost of time, rather than a response to changes made by firms. This therefore motivates the next section, where we use a household home production model to recover the change in the households’ opportunity cost of time over the recession.

5 A Model of Home Production

In this section, we develop the implications of the previous results for households’ opportunity cost of time during the recent recession. We then recover the elasticity of substitution between time and market goods, a key parameter in the home production literature. To do so, we describe a simple model of household cost minimization. The model is in the spirit of Becker (1965), and subsequent time use and home production papers, including Aguiar

---

12See for example, Aguiar and Hurst (1997), Hausman and Leibtag (2009), Griffith et al. (2009), and Kaplan and Menzio (2013, 2014).
Table 2: Estimated Returns to Shopping

<table>
<thead>
<tr>
<th>Shopping Activity</th>
<th>ln Price Index 1 (I)</th>
<th>ln Price Index 2 (II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale</td>
<td>-0.039 (0.001)</td>
<td>-0.067 (0.004)</td>
</tr>
<tr>
<td>Coupon</td>
<td>-0.302 (0.002)</td>
<td>-0.258 (0.006)</td>
</tr>
<tr>
<td>Generic</td>
<td>0.008 (0.001)</td>
<td>-0.253 (0.004)</td>
</tr>
<tr>
<td>Large sizes</td>
<td>0.010 (0.001)</td>
<td>-0.458 (0.003)</td>
</tr>
<tr>
<td>Big box</td>
<td>-0.053 (0.001)</td>
<td>-0.104 (0.002)</td>
</tr>
<tr>
<td>Sale * 1( yr &gt; 2007)</td>
<td>0.016 (0.001)</td>
<td>0.026 (0.003)</td>
</tr>
<tr>
<td>Coupon * 1( yr &gt; 2007)</td>
<td>0.007 (0.002)</td>
<td>0.013 (0.006)</td>
</tr>
<tr>
<td>Generic * 1( yr &gt; 2007)</td>
<td>0.005 (0.001)</td>
<td>0.025 (0.004)</td>
</tr>
<tr>
<td>Large sizes * 1( yr &gt; 2007)</td>
<td>-0.0005 (0.002)</td>
<td>0.021 (0.004)</td>
</tr>
<tr>
<td>Big box * 1( yr &gt; 2007)</td>
<td>0.007 (0.001)</td>
<td>0.018 (0.002)</td>
</tr>
</tbody>
</table>

Note: This table reports estimates of the coefficient regression estimates of equation (5), with different price indices in each column. Standard errors are in parentheses. Column (I) is based on an estimate of the log of Price Index 1 (which does not allow for substitution across UPCs) on the various shopping activities in the table. Column (II) uses the log of Price Index 2, which does allow for substitution between UPCs within a product category. The regressions are based on approximately 4 million household-month observations, includes controls for household fixed effects and household time-varying demographics (age, employment status, marital status and county of residence of the head of household, and household income), and are estimated using instrumental variables. See text for more detail. 

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and Hurst (1997), Rupert, Rogerson and Wright (1995), Greenwood and Hercowitz (1991) and others. The basic intuition behind these models of home production is that individuals substitute between home produced and market produced 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 and time-use data.

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 \( p(s, N) \), where \( \frac{\partial p}{\partial s} < 0 \) and \( \frac{\partial^2 p}{\partial s^2} > 0 \). 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 \( N \). Total expenditure on the quantity \( Q \) of market goods purchased is given by

\[
p(s, N)Q
\]

We assume that the quantity of purchased market goods is converted into consumption goods \( C \) using a home production technology \( K(h, Q) \). Households combine time \( h \) spent on home production with the quantity of market goods \( Q \) to produce \( C \), which enters 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 household’s cost minimization problem (dropping the household subscript):

\[
\min_{s, h, Q} p(s, N)Q + \mu_t(s + h)
\]

subject to

\[
K(h, Q) = C_t
\]

where \( \mu_t \) is the opportunity cost of time in period \( t \).\(^{13}\) We consider interior solutions to the

\(^{13}\)Note that the other choices made by the household are reflected in \( \mu_t \) and \( C_t \), including decisions about labor supply and inter-temporal allocation of consumption.
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

\[ \mu_t = -\frac{\partial p_t}{\partial s_t} Q_t \]  

(7)

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

The first-order condition for home production is

\[ \mu_t = \frac{\partial K_t}{\partial h_t} \lambda_t \]  

(8)

where \( \lambda_t \) is the multiplier on the constraint. The first-order condition for \( Q_t \) is

\[ \lambda_t \frac{\partial K_t}{\partial Q_t} = \frac{\partial p_t}{\partial Q_t} Q_t + p_t \]  

(9)

where \( Q_t \) is an element of \( N_t \). Combining with the intra-temporal conditions (7) and (8) gives the marginal rate of transformation between time and market goods in home production:

\[ \frac{\partial K_t/\partial h_t}{\partial K_t/\partial Q_t} = -\frac{\partial p_t}{\partial s_t} Q_t \]  

(10)

Therefore, the first-order conditions from the household’s cost minimization problem allows us to recover their opportunity cost of time, and the elasticity of substitution between time and market goods in home production, which we estimate in the following section.

5.1 Implications for the Opportunity Cost of Time

Equation (7) implies that the opportunity cost of time can be estimated from the returns to shopping, which can be rewritten as (dropping the household \( h \) subscript):

\[ -\frac{\partial p_t}{\partial s_t} Q_t = -\frac{\partial \ln p_t}{\partial s_t} \cdot p_t Q_t = -\frac{\partial \ln p_t}{\partial f_{it}} \cdot \frac{\partial f_{it}}{\partial s_t} \cdot X_t \]  

(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 counterpart of $p_t$ is the composite price index (defined in Section 4) for one real composite food unit $Q$. To allow for comparison across time and across households, the composite food unit $Q$ is empirically constructed as the average market value of goods, deflated by average market inflation:

$$Q_m^h = \sum_{j \in J} \sum_{j \in J, t \in m} \bar{p}_{j,m} q_{j,t}^h / \Pi_t$$

where $J$ denotes the set of all UPCs within $D$, the set of all product categories in the sample. $ar{p}_{j,m}$ is the expenditure-weighted average price paid for item $j$, where the average is taken across all households who made a purchase of $j$ in month $m$. As described in Section 4, we consider two different average price indices: one defined as the average price at a UPC-level, and the second as the average price over all UPCs within a product category. $\Pi_t$ is the BLS inflation index for food.

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 from the Homescan data). To recover the cost of time, we also need to know how the shopping activities change when the household engages in an extra unit of shopping time, denoted by $\partial f_{it} / \partial s_t$. We assume that $\partial f_{it} / \partial s_t$ is equal to $\gamma_i / f_{it}$. This assumption is intuitive as it implies that there is decreasing returns to search associated with each shopping activity. For example, a household that already engages in a large amount of coupon usage will be less likely to substantially increase their coupon usage further by spending another hour searching for coupons, compared with a household that initially uses less coupons. One reason for this is that there may be a limit in the supply of store coupons. Under this assumption, the opportunity cost of time is given by

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

which is equal for all shopping activities (coupon usage, purchase of sale items, purchase of large items, buying generic products, and shopping at Big Box stores), because at the optimum households equate the marginal return from each shopping activity. Thus, equation (12) can be recovered using the shopping return estimates in Section 4 (Table 2), combined with Homescan data for $X_t$ and $f_{it}$. Note that the scalar term $\gamma_i$ drops out when we consider the change in cost of time.
The change in the opportunity cost of time is given by

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

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

$$\Delta \mu_{t+1} = \hat{\Delta} \mu_{t+1} + \epsilon_{i,t+1} \hspace{1cm} (14)$$

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

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

where \( \beta_0 = (-\ln X_{t+1}/X_t + \ln \Delta x_{t+1}) \) is the constant which can estimated from a regression of equation (15). We can therefore recover the underlying change in cost of time \( \hat{\mu}_{t+1} \) from an estimate of \( \beta_0 \). The error term is denoted by \( \eta_{i,t+1} \).

To estimate equation (15), we construct the empirical counter-part of the dependent variable from our estimates of \( \partial \ln p_{it}/\partial f_{it} \) from Table 2 (columns I and II). This is combined with an estimate of the average fraction of expenditure for each shopping activity \( i \), denoted \( f_{it} \), where the average is computed from the Homescan data across all households-months within time period \( t \). To recover the cost of time \( \hat{\mu} \), we also need \( -\ln \Delta x_{t+1} \), the log of the change in total expenditure during the recession period. We construct the empirical counterpart for this by taking the log of the average ratio of total expenditure during the recession period relative to total expenditure during the pre-recession period, where the average is computed from the Homescan data across all households in the sample. We compute the standard errors around the opportunity cost of time based on the estimated standard errors of the shopping returns from Table 2 for the coefficients of \( \partial \ln p_{i,t}/\partial f_{i,t} \).

Table 3 displays the estimated change in the opportunity cost of time during the recession. The estimates in column I use our preferred measure of the estimated shopping returns from
Section 4 (Table 2, column I). We observe a decline in the households’ opportunity cost of time of 30 percent during the recession (Table 3, column I). The decline in cost of time can be decomposed into three factors (as seen in equation 13): variation in shopping returns, in shopping activities, and in expenditure. If we assume there is no change in the returns to shopping during the recession, then we would estimate a decline in the opportunity cost of time of 14 percent (Table 3, column II). This implies that around half of the decline in the overall cost of time was due to changes in expenditure and shopping activities (computed as 14%/30%), while lower returns to shopping accounted for the remaining half.

To put these changes into context, Aguiar and Hurst (1997) 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 (2013). It is 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 co-movement in market work and household expenditure over the business cycle based on the substitution between time and expenditure.

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.\footnote{Models that explain the joint variation in aggregate variables based on the inclusion of a home production sector include Benhabib, Rogerson and Wright (1991), Baxter and Jermann (1999), Chang and Schorfheide (2003), Greenwood and Hercowitz (1991), and Rupert, Rogerson and Wright (1995).} For example, Karabarbounis (2014) 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
Table 3: Implied Change in the Opportunity Cost of Time

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated change in cost of time:</td>
<td>-0.297</td>
<td>-0.137</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Using the estimated returns from:</td>
<td>Table 2,</td>
<td>Assuming no</td>
</tr>
<tr>
<td></td>
<td>Column I</td>
<td>change in returns</td>
</tr>
<tr>
<td>(Price Index II)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: This table reports the recovered opportunity cost of time, using data on household expenditure, and returns to shopping, estimated in Section 4. Column I uses estimated returns from price index II (product-level). Columns II reports the estimated change in cost of time assuming no change in returns. Standard errors are in parentheses.

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. It allows us to control for unobserved, time-invariant household heterogeneity with household-group fixed effects, which could bias the estimates of the home production parameters. Moreover, we can allow for variation in returns to non-market work (and therefore opportunity cost of time) across households and time. Our second contribution is to use the time variation in the data 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:

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

for some positive constant $\phi$. 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 previous estimates in the literature. 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

$$\sigma \equiv \frac{1}{1 - \rho},$$

where $\rho$ is a positive constant parameter, which we estimate below. Under this form, the marginal rate of transformation (MRT) is given by

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

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

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

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 split the sample into two non-overlapping periods, $t=1$ (year 2004-2007) and $t=2$ (years 2008-2010), 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 I, based on price index II), and an estimate of the price elasticity $\partial \ln p / \partial \ln Q$.\textsuperscript{15}

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

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

\textsuperscript{15}The 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 $\partial \ln p_{jt}/\partial \ln Q_{jt}$ therefore equals $\alpha_{Q1}$ for $t=1$, and $\alpha_{Q1} + \alpha_{Q2}$ for $t = 2$.\textsuperscript{29}
for household-group $j$ (defined based on age, gender, and marital status) in period $t$. We control for household-group fixed effects using $\lambda_j$, and time fixed effects using $\lambda_t$ (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 $\phi$ is recovered from $\beta_0 = \sigma \ln(\phi)$. We test for changes in $\sigma$ over the business cycle based on $\beta_2$. A significant $\beta_2$ would imply the existence of shocks to home production during the recession.

Column I in Table 4 gives the between-household 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 (column II).

Our estimates are consistent with other micro and macro estimates of the elasticity.\textsuperscript{16} 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 (2014) 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”). 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.

Our estimates also allow us to examine a second question: 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 eco-

\textsuperscript{16}For example, Rupert, Rogerson and Wright (1995) 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 (1997).
Table 4: Elasticity of Substitution in Home Production

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Interpretation</th>
<th>(I)</th>
<th>(II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-\beta_1$</td>
<td>$\sigma$ (elasticity of substitution between time and goods in home production)</td>
<td>1.205</td>
<td>1.708</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.389)</td>
<td>(0.481)</td>
</tr>
<tr>
<td>$-\beta_2$</td>
<td>$\sigma \cdot 1$(recession)</td>
<td></td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.080)</td>
</tr>
</tbody>
</table>

Estimation                  Between-effects     Fixed-effects
Additional controls          Marital status     None
Number of groups             27               54

Note: 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 parenthesis. See text for additional details.

Nomically insignificant coefficient ($\beta_2$) on the interaction term from equation (19) in our fixed-effects estimates (Table 4, column II). 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 (2013), 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. If households can substitute between income and time, then during recessions they can smooth part of the income shock by taking advantage of the lower opportunity cost of time. The idea that household can smooth consumption by
changing their behavior is not new. For example, Blundell, Pistaferri and Saporta-Eksten (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: 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, 2013). In Section 3, we showed that households did indeed increase their shopping activities. In Section 4, we showed that the increase in shopping activities was not driven by higher returns, and instead implied a decline in opportunity cost of time. 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). The percentage change in consumption is given by

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

(20)

where

\[ \theta \equiv \frac{\phi h^p}{\phi h^p + Q^p} \]  

(21)

As in Aguiar and Hurst (1997), we can decompose the change in consumption during the recession relative to expenditure into home production substitution and price savings from shopping.\(^{17}\) Specifically, we can rewrite equation (20) as

\[ \hat{C} - \hat{X} = \theta \left( \hat{h} - \hat{X} \right) - (1 - \theta) \hat{p}. \]  

(22)

where percentage change in expenditure on market goods is denoted by \( \hat{X} = \hat{p} + \hat{Q}.\(^{18}\) The

\(^{17}\)This decomposition was also taken in Aguiar and Hurst (1997), where they focused on the variation across households by age. Here, we shift the focus to the variation that occurred during the Great Recession period to understand the ability of households to further smooth consumption beyond market expenditure by varying their time use.

\(^{18}\)The expenditure is deflated by an aggregate inflation index for food 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 \( \hat{p}. \)
decomposition in equation (22) shows that households can smooth consumption 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.

We empirically compute the corresponding terms of equation (22) for the two distinct periods of 2006-07 and 2008-10. Specifically, for each of the two time periods, we calculate each term on the right hand side of (22) using the observed household averages for \(h\) (from the American Time Use Survey), \(Q\) and \(X\) (from Homescan data), together with our estimates of \(\rho\) and \(\phi\) (from Section 5.2) and price savings (estimated using Homescan data and shown in Section 4). The average price savings across households and shopping activities is computed as \(\hat{p} \equiv \sum_i \hat{f}_i \cdot (\partial \ln p / \partial f_i)\), 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 II). The parameter \(\theta\) is computed based on equation (21) using the average \(h\) and \(Q\) over period \(t = 1\) (years 2006 and 2007), combined with our estimates of the home production parameter for \(\rho\). This gives a value of 0.35 for \(\theta\).

Table 5 shows the decomposition of the change in consumption relative to market expenditure, based on an estimated \(\theta\) of 0.35. 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 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.\(^{19}\)

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

\(^{19}\)The 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 \(-(1 - \theta)\hat{p} / (\hat{C} - \hat{X})\).
Table 5: Percentage change over 2008-2010, relative to 2006-2007

<table>
<thead>
<tr>
<th></th>
<th>(\hat{X}) (I)</th>
<th>(\hat{p}) (II)</th>
<th>(\hat{Q}) (III)</th>
<th>(\hat{h}) (IV)</th>
<th>(\hat{C}) (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>-8.83</td>
<td>-1.13</td>
<td>-7.70</td>
<td>3.77</td>
<td>-3.65</td>
</tr>
</tbody>
</table>

Note: This table reports the percentage changes from 2008-2010 relative to 2006-2007 in market expenditure (computed from \(\hat{p} + \hat{Q}\)), price paid (using from results from Section 4, Table 2), quantity of market goods purchased (computed using the Homescan data), home production time (computed using data from the American Time Use Survey), and consumption (computed from equation (20) using data from Homescan and the American Time Use Survey, combined with the estimated parameters of the home production function from Section 5.2, Table 4). See text for more detail on the computation.

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. Nonetheless, the ability to shop for bargains and utilize other means of home production can also apply to broader classes of goods. We expect that the ability to substitute between time and market expenditure can also play an important role in smoothing various non-food household consumption when households are faced with unanticipated income shocks.

6 Robustness

In this section, we show that the main results of the previous section are qualitatively robust to alternative sample period and functional form specifications.

We first consider the sensitivity of our results to the inclusion of the 2007 in the estimation. This was a year with significant food price increases, due to increased demand in China and a drought in Australia, which were arguably unrelated to the business cycle. Excluding 2007 does not qualitatively change the finding that households’ marginal value of time fell
during the recession. Specifically, we find that the cost of time declined by 28 percent, compared with a decline of 30 percent when 2007 is included (Column II of Table 6 and Column I of Appendix Table 7). The estimated elasticity of substitution between market spending and time spent on home production is smaller in magnitude when 2007 is excluded (0.965 compared with 1.7), but the difference is statistically insignificant. As in our main results, we find that consumption declined by less than market expenditure over 2008-2010.

Next, in Column (III), we study whether the results change if we adjust for changes in quality associated with shifts in shopping behavior. To do so, we consider an alternative price index that takes into account changes in quality associated with the shifts from non-generic to generic products. The index is constructed using the methodology described in Section 4, but allows for two different average prices paid in each month: one for generic products, and one for non-generic products. This differs from our base case price index II which computes the average price based on all UPCs within a product category. The estimated returns to shopping from the quality-adjusted price index are slightly lower than our base case returns (Appendix Table 6, column II). However, we still find that returns to each shopping activity declined during the recession period, implying a decline in cost of time that is comparable to our base results (Table 6, column III). The estimated elasticity of substitution between market spending and time spent on home production is comparable to our base result, and again imply that consumption declined by significantly less than market expenditure over 2008-10.

Lastly, we also explored the sensitivity of our results to our assumption on the relationship between shopping activity and shopping time. In Section 5.1-5.2, we computed the opportunity cost of time and estimated the home production parameters assuming that

$$\partial f_{it}/s_t = \gamma_i/f_{it}$$

where $f_{it}$ denotes the fraction of shopping activity $i$ as a share of total items bought by the household in month $t$, $s_t$ denotes the shopping time, and $\gamma_i$ is a constant term. We consider a range of alternative Box-Cox functional forms for $f(s)$ with varying $\lambda$:

$$f(s) = (s^\lambda - 1)/\lambda$$

In columns (IV-VI) of Table 6, we present the results for the cases $\lambda = -1$, $\lambda = 0$ (i.e. $f(s) = \log(s)$), and $\lambda = 1$. We find that the decline opportunity cost of time is qualitatively

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20For example, Bils (2009) and Bils and Klenow (2001) show that measured inflation may be biased if product quality improvements are not taken into account.
robust across the various Box-Cox functional forms, with the change decreasing in the size of $\lambda$. Similarly, we estimate a high elasticity of substitution between home production time and market spending, which rises in $\lambda$, and a widening of the gap between implied consumption and measured market spending during the Great Recession.

In summary, we find that our results are qualitatively robust to alternative sample periods and functional form specifications: we find lower returns to shopping during the recession, a sizable reduction in opportunity cost of time, and significant elasticity of substitution between home production and market expenditure. These estimates imply that consumption declined by less than market expenditure during the recession, in part because households lowered the price they paid and engaged more in home production.

7 Conclusion

In this paper, we study how households substitute between time and money during the recent recession, and compute 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.

Specifically, using scanner data from Nielsen, we document that during the recent recession, households increased their shopping intensity by purchasing more on sale, using more coupons, buying larger sizes, switching to generic products and shopping more at Big Box stores. These activities allowed households to lower the prices paid. However, we also find that the returns to shopping declined during the recession. The lower returns imply a sizable decline in households’ opportunity cost of time of 25-30 percent over 2008-2010. The change in opportunity cost of time is consistent with a high elasticity of substitution between market goods and time in home production, indicative of a high degree of complementarity between leisure and consumption. We find households were able to smooth a sizable portion of their consumption during recessions by varying their intra-temporal allocation of time.
### Table 6: Robustness Results under Varying Assumptions

<table>
<thead>
<tr>
<th></th>
<th>Base Results</th>
<th>Excluding Year 2007 Price Index</th>
<th>Alternative Price Index</th>
<th>Box-cox form for ( f(s) ) ( \lambda = -1 )</th>
<th>( \lambda = 0 )</th>
<th>( \lambda = 1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robustness for Section 5.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in cost of time:</td>
<td>-0.297</td>
<td>-0.281</td>
<td>-0.237</td>
<td>-0.216</td>
<td>-0.201</td>
<td>-0.191</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.043)</td>
<td>(0.07)</td>
<td>(0.075)</td>
<td>(0.077)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>Robustness for Section 5.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elasticity of substitution:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \sigma )</td>
<td>1.708</td>
<td>0.965</td>
<td>1.64</td>
<td>1.553</td>
<td>1.655</td>
<td>1.709</td>
</tr>
<tr>
<td></td>
<td>(0.481)</td>
<td>(0.356)</td>
<td>(0.498)</td>
<td>(0.38)</td>
<td>(0.399)</td>
<td>(0.413)</td>
</tr>
<tr>
<td>( \sigma \cdot 1(\text{recession})</td>
<td>0.024</td>
<td>-0.05</td>
<td>-0.027</td>
<td>0.002</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.076)</td>
<td>(0.081)</td>
<td>(0.06)</td>
<td>(0.063)</td>
<td>(0.065)</td>
</tr>
<tr>
<td>Robustness for Section 5.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption decomposition (percent change over 2008/10):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \hat{p} ) (price)</td>
<td>-1.13</td>
<td>-1.28</td>
<td>-0.69</td>
<td>-1.13</td>
<td>-1.13</td>
<td>-1.13</td>
</tr>
<tr>
<td>( \hat{Q} ) (quantity)</td>
<td>-7.70</td>
<td>-4.60</td>
<td>-7.92</td>
<td>-7.70</td>
<td>-7.70</td>
<td>-7.70</td>
</tr>
<tr>
<td>( \hat{h} ) (home production time)</td>
<td>3.77</td>
<td>3.97</td>
<td>3.77</td>
<td>3.77</td>
<td>3.77</td>
<td>3.77</td>
</tr>
<tr>
<td>( \hat{C} ) (consumption)</td>
<td>-3.65</td>
<td>-1.53</td>
<td>-3.80</td>
<td>-2.96</td>
<td>-3.78</td>
<td>-4.35</td>
</tr>
<tr>
<td>( \hat{C} - \hat{X} )</td>
<td>5.18</td>
<td>4.35</td>
<td>4.82</td>
<td>5.87</td>
<td>5.05</td>
<td>4.48</td>
</tr>
</tbody>
</table>

Note: This table gives the results under various robustness checks. Column (I) reproduces the base results from Section 5, based on price index II. Columns (II)-(VI) show the results under alternative assumptions: (II) excludes year 2007, (III) uses an alternative price index which controls for the decline in quality due to the switch from non-generic to generic products, (IV)-(VI) assume varying Box-Cox functional forms for \( f = (s^\lambda - 1)/\lambda \). Standard errors are given in parentheses. See text for more details.
References


A Online Appendix: Additional Results

A.1 Additional Figures of Shopping Activity

Figure 9: Behavior by employment transitions (Share of total household expenditure)

Figure 10: Concentration of expenditure by store (Share of total household expenditure)
### A.2 Returns to Shopping

Table 7 gives the estimated returns to shopping under two different robustness checks. In Column (I), we estimate the returns excluding the year 2007. In Column (II), we estimate the returns using an alternative price index (described in the main text) which controls for the decline in quality due to a shift from non-generic to generic products.

<table>
<thead>
<tr>
<th></th>
<th>Exclude 2007 (I)</th>
<th>Alternative Price Index (II)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sale</strong></td>
<td>-0.037 (0.0036)</td>
<td>-0.065 (0.0034)</td>
</tr>
<tr>
<td><strong>Coupon</strong></td>
<td>-0.294 (0.0069)</td>
<td>-0.259 (0.0061)</td>
</tr>
<tr>
<td><strong>Big box</strong></td>
<td>-0.113 (0.0024)</td>
<td>-0.094 (0.002)</td>
</tr>
<tr>
<td><strong>Generic</strong></td>
<td>-0.259 (0.004)</td>
<td>0.047 (0.0035)</td>
</tr>
<tr>
<td><strong>Large sizes</strong></td>
<td>-0.456 (0.004)</td>
<td>-0.449 (0.0034)</td>
</tr>
<tr>
<td><strong>Sale · 1(yr&gt;2007)</strong></td>
<td>0.012 (0.0034)</td>
<td>0.024 (0.0026)</td>
</tr>
<tr>
<td><strong>Coupon · 1(yr&gt;2007)</strong></td>
<td>0.029 (0.0072)</td>
<td>0.011 (0.0057)</td>
</tr>
<tr>
<td><strong>Big box · 1(yr&gt;2007)</strong></td>
<td>0.027 (0.0026)</td>
<td>0.014 (0.0021)</td>
</tr>
<tr>
<td><strong>Generic · 1(yr&gt;2007)</strong></td>
<td>0.028 (0.0044)</td>
<td>0.005 (0.0037)</td>
</tr>
<tr>
<td><strong>Large sizes · 1(yr&gt;2007)</strong></td>
<td>0.023 (0.0048)</td>
<td>0.021 (0.0042)</td>
</tr>
</tbody>
</table>

Note: Estimates in column (I) are based on a sample over the year 2004-2006 and 2008-2010 (i.e. it excludes 2007). The estimates are used to compute the results in Table 6, column (II). Estimates in column (II) are based on an alternative price index which controls for the decline in quality due to a shift from non-generic to generic products. The estimates are used to compute the results in Table 6, column (III). Standard errors are given in parentheses.