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# Identifying the Depreciation Rate of Durables from Marginal Spending Responses*

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**Abstract**

This paper presents a novel method to estimate the depreciation rate of durable goods using a combination of identified marginal and average spending shares. We apply our method to Chinese spending responses to disposable income changes induced by monetary policy in 2008-2009. The marginal spending response is 0.40. Durable goods make up about 45% of this marginal spending response. By combining this marginal spending share on durables with an average spending share of 14%, we estimate the annual depreciation rate of durables in China to be 0.16.

**Keywords:** Consumption, Durables, Monetary Policy
**JEL Classification:** E21, E52

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# 1 Introduction

Several authors argue that spending on durable goods plays an important role in explaining business cycle dynamics and the transmission of economic policies. For example, Berger and Vavra (2015) show that durable spending and thus aggregate demand is less responsive to income shocks during recessions. Similarly, Barsky, House, and Kimball (2007) argue that combinations of the relative stickiness of prices and the depreciation rate of durable goods crucially matter for aggregate transmission of monetary policy in sticky-price models. Importantly, these results depend on the depreciation rate of durable goods where direct empirical evidence remains scarce. This paper provides a new method to identify the depreciation rate of durable goods from marginal spending responses.

Our method starts from a standard consumption-saving model with preferences over non-durable and durable consumption goods. With this model, we show how to identify the depreciation rate of durables using a combination of marginal and average spending shares. In contrast to methods typically applied, our novel approach does not rely on finding the depreciation rate of specific types of goods and weighing these together. We instead identify the depreciation rate from the revealed behavior of household spending in response to income changes. We argue that our approach estimates the relevant weighted average depreciation rate on the set of durable goods that households purchase.

We illustrate our method using data on how Chinese households adjust their spending to changes in disposable income induced by monetary policy. More specifically, we focus on five cuts of monetary policy rate introduced by the People's Bank of China (PBoC) during the fall of 2008 as a response to the global financial crisis. These policy rate cuts led in total to a fall of 216 basis points in the one-year benchmark loan rate. The Chinese mortgage markets' so-called semi-floating rate institutional framework implies that mortgage rates follow changes in the key monetary policy rates but are adjusted only once a year. As a result, the cumulated change of the monetary policy rate during 2008 was implemented as one large mortgage rate change on January 1st, 2009. It then stayed constant throughout 2009. We combine this large interest rate reduction with detailed survey data on Chinese households' income and spending from the Urban Household Survey to estimate spending responses. Our identification follows a Bartik design: we instrument the change in disposable income by households' debt exposure interacted with the interest rate change. Hence, we identify a cash-flow channel of monetary policy by comparing the consumption response of households with high debt exposure to those with low debt exposure.

In order to estimate the depreciation rate using our model we need estimates of the

households' spending response to the change in disposable income, and how this spending response is allocated between durables and non-durables. We find that households increase spending on total consumption when interest costs fall due to lower mortgage rates. Our evidence thus provides support for the importance of the cash-flow channel in aggregate monetary transmission emphasized in the literature.[1] We estimate an implied marginal propensity to spend of 0.40 (s.e = 0.20). This spending response is large compared with standard models of household behavior (e.g., the permanent income hypothesis), but comparable in size to the literature on marginal spending responses to unanticipated transitory income changes.[2]

We also need an estimate of the marginal spending on durables. We find that durables account for around 45% of the marginal spending response while around 55% is due to spending on non-durables. This implies that the marginal spending response is primarily driven by spending on non-durables. This finding is important for the literature relying on imputed consumption spending from administrative data on income and wealth (see, e.g., Fagereng et al., 2021, Baker, Kueng, Meyer, and Pagel, 2021). Since imputed consumption is constructed as income not saved, it is not possible to say what type of goods or services they acquire. One suggested way of squaring the high marginal spending responses in the empirical literature with standard consumption models is to claim that a large share of the spending response is due to durables.[3] Our findings only partially support such an interpretation since a large part of the marginal spending is still due to non-durables.[4]

Based on the above estimates we achieve our main empirical contribution: the estimation of the depreciation rate of durable goods (vehicles, household appliances, and furniture) in China. We estimate the annual depreciation rate to be 0.16 (s.e. 0.10) by combining a marginal spending share on durable of 45% with an average spending share of 14%. This estimated depreciation rate is higher than usually assumed in durable goods models. However, it is close to what studies using similar definitions of durables find

[1] See for example Holm, Paul, and Tischbirek (2021), Flodén, Kilström, Sigurdsson, and Vestman (2020), Jappelli and Scognamiglio (2018), Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, and Yao (2017), and La Cava, Hughson, and Kaplan (2016).

[2] See, e.g., Fagereng, Holm, and Natvik (2021) and Golosov, Graber, Mogstad, and Novgorodsky (2021) for spending responses to lottery prizes, and Johnson, Parker, and Souleles (2006) and Parker, Souleles, Johnson, and McClelland (2013) for spending responses to tax rebates.

[3] See, e.g., the mapping from spending responses to consumption responses in Laibson, Maxted, and Moll (2021). Tauber and Van Zandweghe (2021) also discuss the overproportional spending on durables during the Covid-pandemics.

[4] The role of non-durables in the spending response to changes in mortgage-related shifts in disposable income has also been highlighted by Tracey and Van Horen (2021) who examine the consumption effects of changes in the required downpayments in the U.K. They find that spending on non-durables represents a larger share of the spending response. Their study, just as ours, enriches the findings of Di Maggio et al. (2017) which are exclusively focused on how changes in mortgage expenses affect durable spending (spending on cars, in particular).

using U.S. data. For example, Harmenberg and Öberg (2021) calibrate their depreciation rate using cars, furniture, and appliances and find a *quarterly* depreciation rate of 0.023.[5] In contrast, papers that include housing as part of durable consumption typically use lower depreciation rates.[6] Hence, the message here is that given the large difference between the Chinese and U.S. economy, our estimated depreciation rate from Chinese data is surprisingly similar to existing estimates using U.S. data.

The rest of the paper proceeds as follows. Section 2 presents a model of non-durable and durable spending and shows how to use this model to identify the depreciation rate of durable goods. Section 3 describes the institutional setting and the data. Section 4 lays out our empirical strategy. Section 5 presents our main results. Section 6 concludes.

## 2 Identifying the Depreciation Rate of Durables

This section presents a standard consumption-saving model with preferences over durable and non-durable consumption. The main theoretical result is to map average and marginal spending shares to the depreciation rate of durable goods.

**The model.** Households maximize their discounted flow of utility from consumption

$$\max_{\{c_{n,t},c_{d,t}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U\left(\overbrace{c_{n,t}^{\alpha} c_{d,t}^{1-\alpha}}^{C_t}\right)$$

subject to

$$b_{t+1} = w_t + (1+r)b_t - p_{n,t}c_{n,t} - p_{d,t}d_t$$
$$c_{d,t+1} = (1-\delta)c_{d,t} + d_t$$

where $c_{n,t}$ is non-durable consumption, $c_{d,t}$ is durable consumption, $b_t$ is a bond, $w_t$ is the wage, $d_t$ is purchase of durable goods, $p_{n,t}$ and $p_{d,t}$ are prices, $r$ is the interest rate, $\delta$ is the depreciation rate of the durable good, $\alpha$ is the weight on non-durable consumption, and

[5] Similarly, Bils and Klenow (1998) also use comparable depreciation rates for similar goods and Browning and Crossley (2009) employ an even higher annual rate of depreciation of 0.34 in a sample that also includes less durable goods such as clothing.

[6] For example, Berger and Vavra (2015) and Zorzi (2020) use a quarterly depreciation rate of 0.018, and McKay and Wieland (2021) use an annual depreciation rate of 0.068. All these papers are calibrated to the Bureau of Economic Analysis's definition of fixed assets, which includes housing. Similarly, Sterk and Tenreyro (2018) use an annual depreciation rate of 0.04. Their estimate is taken from Baxter (1996) who adjust Bernanke (1985)'s high (22%) annual depreciation rate for housing).

$\beta$ is the discount factor. Following Ogaki and Reinhart (1998), we assume an elasticity of substitution between non-durable and durable consumption goods equal to 1.

The model can be generalized to a version with a continuum of durable goods with different durability. Therefore, one should not think about the durable good as a specific durable good like cars but instead some aggregated durable good. It also implies that the parameter $\delta$ in the model does not represent the depreciation rate of a specific good but rather a weighted average of the depreciation rate of all durable goods.

There are two ways to solve this model: one can directly solve the model as specified above or rewrite the model by redefining wealth as $a_t = b_t + p_{d,t}c_{d,t}$. We follow the second path here. The budget constraint is then

$$a_{t+1} = w_t + (1+r)a_t - p_{n,t}c_{n,t} - \underbrace{p_{d,t}(r+\delta)}_{\hat{p}_{d,t}} c_{d,t}$$

where one can now think of the durable consumption good like a non-durable good with the price $\hat{p}_{d,t} := p_{d,t}(r+\delta)$. Intuitively, $r+\delta$ is the user cost of durables such that $\hat{p}_{d,t}$ is the implicit rental price. If $\delta < 1 - r$, the relevant price $\hat{p}_{d,t}$ is lower than the price you pay per unit $p_{d,t}$ since durable goods last multiple time periods. Importantly, the household compares $p_{n,t}$ and $\hat{p}_{d,t}$ when deciding how to allocate spending between non-durables and durables. The demand for non-durable and durable goods are

$$c_{n,t} = \alpha p_{n,t}^{-1} C_t, \qquad c_{d,t} = (1-\alpha)\hat{p}_{d,t}^{-1} C_t.$$

**Main results.** We can now compute the spending shares on non-durable and durable goods. Since there are durable goods included in the consumption basket, the *marginal* and *average* spending shares will differ. Proposition 1 first presents the *marginal* spending shares.

**Proposition 1.** *The marginal spending shares are*

$$\frac{p_{n,t}c_{n,t}}{p_{n,t}c_{n,t} + p_{d,t}d_t} = \frac{\alpha}{\alpha + (1-\alpha)\frac{1}{r+\delta}}, \qquad \frac{p_{d,t}d_t}{p_{n,t}c_{n,t} + p_{d,t}d_t} = \frac{(1-\alpha)\frac{1}{r+\delta}}{\alpha + (1-\alpha)\frac{1}{r+\delta}}. \tag{1}$$

*Proof.* The marginal spending on durable goods are

$$p_{d,t}c_{d,t} = (1-\alpha)p_{d,t}\hat{p}_{d,t}^{-1} C_t = \frac{1-\alpha}{r+\delta} C_t.$$

At the margin, we must have that $d_t = \Delta c_{d,t}$ such that we can replace $c_{d,t}$ with $d_t$. The

marginal spending on non-durable goods is

$$p_{n,t}c_{n,t} = \alpha C_t.$$

The two equations imply the spending shares in (1). □

The marginal spending shares depend on the utility weights on each good and the depreciation rate of durables. The household wants to raise consumption on non-durables and durables in response to income changes. However, since it is infinitely-lived, it only wants to increase non-durable consumption by a small amount to be able to also increase non-durable consumption in the future. The household thus increases spending on non-durables in each period proportionally to its composite consumption path ($C_t$-path). For durables, to smooth consumption, the households wants to raise the stock of durables and keep it elevated. Hence, spending on durables makes up a disproportionately large share of the marginal spending response.

Proposition 2 presents the average spending shares in the prior period.

**Proposition 2.** *The average spending shares in period t are*

$$\frac{p_{n,t}c_{n,t}}{p_{n,t}c_{n,t} + p_{d,t}d_t} = \frac{\alpha}{\alpha + (1-\alpha)\frac{\delta+\pi_{d,t}}{r+\delta}}, \qquad \frac{p_{d,t}d_t}{p_{n,t}c_{n,t} + p_{d,t}d_t} = \frac{(1-\alpha)\frac{\delta+\pi_{d,t}}{r+\delta}}{\alpha + (1-\alpha)\frac{\delta+\pi_{d,t}}{r+\delta}}. \tag{2}$$

*Proof.* In the steady state, $\delta c_d = d$. If prices were fixed forever, we could proceed and compute the spending shares. However, since relative prices may change, we want to adjust the spending shares to allow for prior movements in relative prices. In particular, if relative prices changed in the previous period, the spending share in that period will be a combination of the steady state and marginal spending share. Spending on durable goods will in this case be

$$p_{d_t}d_t = \underbrace{p_{d,t}\delta c_{d,t}}_{\text{Steady state}} + \underbrace{p_{d,t}\frac{\partial c_{d,t}}{\partial p_{d,t}}(p_{d,t} - p_{d,t-1})}_{\text{Prior relative price change}} = p_{d,t}\delta c_{d,t} + p_{d,t}c_{d,t}\pi_{d,t} = (1-\alpha)\frac{\delta+\pi_{d,t}}{r+\delta}C_t$$

and the spending on non-durable goods is

$$p_{n,t}c_{n,t} = \alpha C_t.$$

The two equations imply the spending shares in (2). □

The marginal spending shares are not equal to the average spending shares because

the household spends more on durables at the margin than on average. On average, the household acquires durables to replace depreciated durable goods and because relative prices may have changed in the previous period. At the margin, on the other hand, the household has to raise its stock of durables to a new level, thus spending a relatively large share on durables.

**Identifying the depreciation rate.** The ratio between marginal and average spending shares in (1) and (2) allows us to identify the depreciation rate of durables goods. We define two data moments:

$$\hat{m}_1 = \text{marginal spending share on non-durables,}$$
$$\hat{m}_2 = \text{average spending share on non-durables.}$$

A direct calculation gives

$$\frac{\frac{1-\hat{m}_2}{\hat{m}_2}}{\frac{1-\hat{m}_1}{\hat{m}_1}} = \hat{\delta} + \pi_{d,t}. \tag{3}$$

where one could alternatively also use the average and marginal spending shares on durable goods. Hence, a combination of marginal and average spending shares allows us to identify the depreciation rate independently of all other model parameters, including the interest rate $r$, the discount rate $\beta$, and the utility weight $\alpha$.

Models of durable goods typically include two additional components: lumpy goods and adjustment costs. For example, cars are typically considered to be lumpy since households cannot buy an infinitesimal share in a car. Furthermore, adjustment costs may be prevalent, particularly when considering housing transactions that entail large moving costs. To identify the depreciation rate, we implicitly assume that durable goods can be bought incrementally and have no adjustment costs. We argue that this is a reasonable approximation when considering the set of durables in our data, which includes cars, household appliances, and furniture. However, in settings where goods are discrete or where there are substantial adjustment costs, our method may be less applicable.

The rest of this paper applies the approach described above to estimate average and marginal spending shares and identify the depreciation rate of durable goods using Chinese household consumer survey data.

# 3 Background and Data

This section describes the institutional framework for monetary policy and debt contracts in China, provides some background on how the financial crisis affected China, and presents the data and summary statistics.

## 3.1 Institutional Framework

According to the Law of the People's Republic of China on the People's Bank of China (PBoC), the central bank "shall, under the leadership of the State Council, formulate and implement monetary policy." The aim of monetary policy is "[...] to maintain the stability of the value of the currency and thereby promote economic growth." The PBoC uses M2 growth as its intermediate target for monetary policy (Chen, Ren, and Zha, 2018). The PBoC adopts a set of quantity-based and price-based instruments to achieve its target, including open market operations, reserve ratios, liquidity support, and benchmark interest rates.[7] Chinese economic policy is formulated such that it is the annual assembly makes the annual target for GDP growth of the National People's Congress (NPC). Each year, the People's Bank of China reports its decisions on the annual money supply, interest rates, and foreign exchange rates to the State Council to receive approval from the NPC.

During the run-up to the 2007-2009 global financial crisis, China was initially largely unscathed. Contrary to most major economies, the PBoC increased its key policy rate six times in 2007 to fight inflation. However, as the subprime crisis became a global financial crisis after the collapse of Lehman Brothers in September 2008 and in response to a slowdown of the Chinese economy, the PBoC swiftly made five aggressive cuts in the key policy rate within 14 weeks before the end of 2008. Table 1 illustrates that these policy rate cuts resulted in a 216 basis points reduction in the one-year benchmark loan rate or 189 basis points in the mid-to-long-term benchmark loan rate. These reductions are the largest ones introduced by the PBoC in a single year since the Asian financial crisis in 1997. The Chinese economy recovered during 2009 and the PBoC eventually raised the interest rates in October 2010.

Unlike in the U.S. or Europe, where household loans typically have a fixed or adjustable rate, commercial banks in China mainly offer only one type of loan: a loan with a semi-floating rate. The loan rate of Chinese households is determined when a loan application is approved and is equal to the PBoC's benchmark loan rate plus a borrower-specific

[7] Since the mid-2010s, the PBoC started to use more market-based tools to manage liquidity in the banking system, such as repo/reversed repo, medium-term lending facility (MLF), and standing lending facility (SLF), to ensure a tighter control on market interest rates.

| Dates | One-year | Δ One-year | >5-year | Δ >5-year |
|---|---|---|---|---|
| September 16, 2008 | 7.20% | -27bps | 7.74% | -9bps |
| October 8, 2008 | 6.93% | -27bps | 7.47% | -27bps |
| October 30, 2008 | 6.66% | -27bps | 7.20% | -27bps |
| November 27, 2008 | 5.58% | -108bps | 6.12% | -108bps |
| December 23, 2008 | 5.31% | -27bps | 5.94% | -18bps |
| Total Δ | | -216bps | | -189bps |

**Table 1:** Cuts in PBoC benchmark loan rates, 2008

risk premium. The mortgage rate is adjusted to any changes in the benchmark loan rate only on January 1st each year. The yearly adjustment reflects the cumulated policy rate changes during the past year. The uniform, simultaneous, and substantial rate adjustment on household debt on January 1st, 2009, provides us with a plausibly exogenous and large variation in interest cost changes that affect all households simultaneously, allowing us to identify the effects of expansionary monetary policy on household consumption.

## 3.2 Data

To examine the households' consumption response to the changes in disposable income induced by the monetary policy shift, we use annual data from China's Urban Household Survey (UHS).[8] The UHS covers most provincial regions in China based on stratified random sampling and has been used extensively in research.[9] Households participate in the survey in a rotating panel data manner. One-third of households are replaced each year with new entrants. Hence, each household stays in the survey for three years. The households included in the survey record detailed breakdowns of spending and income. The survey also contains information on household characteristics such as age, education, and the number of household members.

[8] See Fang, Wailes, and Cramer (1998) for an overview of the UHS.

[9] See, e.g., Han, Liu, and Zhang (2012), Chamon, Liu, and Prasad (2013), Edlund, Li, Yi, and Zhang (2013), Anderson, Farcomeni, Pittau, and Zelli (2016), and Ge, Yang, and Zhang (2018) for recent examples.

**Sample selection.** We start by restricting our sample to include only households included in both the 2008 and 2009 waves of the UHS. Since our identification relies on comparing households with different levels of mortgage debt, we focus only on households with mortgages (5% of households). Since we only observe flow expenses related to mortgages, we drop the top and bottom 1% in the distribution of changes in mortgage expenses since these households likely adjusted their debt levels. We also drop outlying observations in gross income (top and bottom 1%), observations with negative disposable income, and observations with very high mortgage expenses to gross income (top 1%). Further, since health expenses typically are related to adverse events that affect households severely, we drop households with very high health expenses (top 1%). We also exclude households with equity and households receiving income from their own business since they are more directly exposed to the financial crisis. After imposing these restrictions, our sample consists of 1,236 unique households and 2,472 household-year observations (4% of the total sample).

**Variable definitions and summary statistics.** The outcome variables in our study are total, non-durable, and durable goods spending. We define *total spending* to be the sum of spending on non-durables and durables.[10] Non-durable spending includes food, clothing, articles for daily use, cultural and recreational activities, books and magazines, medicine, and fuel. Durable spending includes vehicles (e.g., cars, motorcycles, and bicycles), household appliances (e.g., washing machines, showers, refrigerators, and TV sets), and furniture. We define *disposable income* as the sum of wages, other income, and transfer income (all net of taxes), net of mortgage expenses (interests and amortization). We define *debt exposure* as mortgage expenses as a share of gross income.

Table 2 presents the summary statistics for the main variables included in our analysis. Households spend on average RMB 38,771 (USD 5,035) per capita on consumption. Importantly for our analysis, around 86% of total consumption spending is spent on non-durables while the remaining 14% is spent on durables. These average shares will be necessary for identifying the depreciation rate of durable goods.

[10] Implicitly, we exclude two spending categories (health and education) from total spending.

| | Mean | S.D. | P10 | P50 | P90 |
|---|---|---|---|---|---|
| *Panel A: Household Characteristics* | | | | | |
| Age | 43.23 | 11.23 | 30 | 41 | 59 |
| Household members | 2.98 | 0.84 | 2 | 3 | 4 |
| *Panel B: Income and Spending* | | | | | |
| Gross income | 65,681 | 32,503 | 32,630 | 57,653 | 108,335 |
| Loan payment (interest + amortization) | 13,843 | 10,820 | 3,600 | 11,012 | 27,463 |
| Disposable income | 51,838 | 28,629 | 23,604 | 45,040 | 89,141 |
| Total spending | 38,771 | 30,631 | 16,218 | 30,991 | 67,527 |
| Non-durables | 31,449 | 20,945 | 13,951 | 26,083 | 55,171 |
| Durables | 7,322 | 15,165 | 723 | 3,441 | 13,432 |
| *Panel C: Shares* | | | | | |
| Non-durables to total spending | 0.855 | 0.123 | 0.701 | 0.889 | 0.966 |
| Durables to total spending | 0.145 | 0.123 | 0.034 | 0.111 | 0.299 |
| Loan payment to gross income | 0.218 | 0.136 | 0.064 | 0.193 | 0.412 |

**Table 2:** Summary Statistics (N = 1,236) in 2008. Values are in RMB (RMB/USD $\approx$ 7.7 in 2008). Age is the age of the household head.

# 4 Empirical Setup

To identify the effects of income changes induced by monetary policy on consumption spending, we estimate the following equation

$$\frac{C_{i,t} - C_{i,t-1}}{Y_{i,t-1}} = \beta_0 + \beta_1 \frac{Y_{i,t} - Y_{i,t-1}}{Y_{i,t-1}} + \beta_2 \mathbf{X}_{i,t-1} + \alpha_p + u_{i,t} \tag{4}$$

where $C_{i,t}$ is spending on either total, non-durable, or durable consumption goods, $Y_{i,t}$ is disposable income, $\mathbf{X}_{i,t-1}$ is a set of predetermined controls, and $\alpha_p$ captures province-fixed effects. Note that since our data only contains two years, so that we have only one observation of the consumption change per household, household and time-fixed effects cannot be employed. To account for unobserved heterogeneity across provinces, we cluster our standard errors at the province level (Abadie, Athey, Imbens, and Wooldridge,

2017).

Importantly, $\frac{Y_{i,t}-Y_{i,t-1}}{Y_{i,t-1}}$ is potentially endogenous as it may be affected by consumption and by potential confounders. We therefore rely on an instrument variable setup in which we instrument $\frac{Y_{i,t}-Y_{i,t-1}}{Y_{i,t-1}}$ with household $i$'s exposure to debt (mortgage expenses as a share of gross income) in year $t-1$. This setup essentially follows a Bartik identification scheme. In the context of this scheme, our underlying identifying assumption is related to the exogeneity of household debt exposure (this is analogous to the industry shares in the classical Bartik setup described by Goldsmith-Pinkham, Sorkin, and Swift, 2020). There are three necessary assumptions that are important for our identification. First, debt exposure has to affect disposable income. Second, debt exposure has to affect consumption changes only through disposable income. Third, no confounding variables affect both debt exposure and consumption growth. We discuss each of these three assumptions below.

Starting with the first assumption, we show in Panel A of Table 3 that debt exposure does affect households' disposable income growth. The effect is sizeable and significant, with an F-statistics of 69.49 in the benchmark specification (4).

Concerning the second assumption, our identification assumes that debt exposure affects consumption only through its effect on disposable income. One potential issue with this specification might arise if debt exposure is correlated with housing wealth and, therefore, affects consumption also via housing wealth effects induced by monetary policy. To address this issue, we first note that house prices were flat during most of 2009. Next, we highlight that adding home values as a control in our regression does not affect our results.

An additional concern here is that the interest rate changes were announced in the fall of 2008 so that households could potentially adjust their debt levels to the lower future interest rates before the mortgage rate changes became effective in 2009. However, most debt consists mortgages linked to houses and is determined prior to 2008. Furthermore, the aggregate debt level did not move much in the fourth quarter of 2008, suggesting no systematic pattern of debt accumulation in late 2008. Furthermore, we drop households where the mortgage expenses changed materially between 2008 and 2009. Our sample thus consists of households with relatively stable loan payments and thus debt levels in 2008 and 2009.

Finally, addressing the third identifying assumption regarding the potential confounders in the analysis, we control for multiple observable variables that potentially affect both debt exposure and consumption growth. Specifically, we control for a second order polynomial in age, an indicator for whether the household works in the private sectors, household size, and a complete set of education and province dummies.

# 5 Results

This section presents the main results on how monetary policy changes affect household consumption spending. Table 3 presents our main empirical results. We highlight three findings: the estimated total spending response, the marginal spending shares, and the estimated depreciation rate.

Our first finding is that the total spending responses are large, suggesting that cash-flow effects of monetary policy are important. About 40% of the change in disposable income induced by the interest rate change is spent on consumption. This finding is consistent with the literature that finds significant cash-flow effects of monetary policy (Holm et al., 2021; Flodén et al., 2020; Jappelli and Scognamiglio, 2018; Di Maggio et al., 2017; La Cava et al., 2016). This spending response is also consistent with an extensive literature on estimated spending responses to unanticipated and transitory income movements (Fagereng et al., 2021; Golosov et al., 2021; Parker et al., 2013; Johnson et al., 2006). However, a comparison with this literature should acknowledge that the income movements we are exploring might be interpreted as persistent rather than transitory. In particular, given that the interest rate on mortgages changes only once per year and the interest rate change in 2008 was in response to a global financial crisis, the change should be expected to last somewhat longer than one year.

Our second finding is that around 55% of the total spending response is due to non-durables, while durables make up about 45%. Hence, a large share of the spending response is due to durables. Notably, the marginal spending shares are different from the average spending shares in Table 2. In 2008, households spent around 14% on durables, while durables make up around three times as large a share (45%) of the marginal spending response. These relative shares are consistent with the model framework in Section 2 where durables make up a disproportionately large share of the marginal spending response.

The third finding is that the implied depreciation rate of durables is 0.16. This depreciation rate is computed using (3), taking into account that the relative price of durables declined by 4% in 2008 in China.[11] Since our data is annual, this is an estimate of the annual (weighted) average depreciation rate of durable goods.

Compared with the theoretical literature, an annual depreciation rate of 0.16 is higher than typically assumed in models of durable goods. However, it is important to compare the results with papers that use a similar definition of durables. In our data, durable goods are defined as vehicles, household appliances, and furniture. Specifically, it does

[11] We compute the relative price change as the difference in annual inflation for total consumption (5.6%) and durable consumption (1.6%) in 2008.

not include housing. Indeed, the annual depreciation rate we find is similar to papers using similar definitions of durables. For example, Harmenberg and Öberg (2021) find a *quarterly* deprecation rate of 0.023 using data on cars, furniture, and appliances (which implies an annual depreciation rate of around 0.10). In contrast, papers that include housing in durable goods typically find a lower depreciation rate.[12]

Although the estimated deprecation rate is comparable to studies using similar definitions of durables, the estimated depreciation rate is still higher than some well-established depreciation rate values in literature. There are two reasons why that may be. First, most papers calibrate the depreciation rate to U.S. data while we use Chinese data. One concern is that Chinese households may differ from U.S. households in their durable consumption dynamics.[13] We estimate the implied depreciation rate by applying our method on U.S. data to alleviate this concern. More specifically, we employ data on the spending responses to the U.S. tax rebates in 2008 from Parker et al. (2013). The results of this estimation is presented in Table A.1 in Appendix A.1. While statistically insignificant, we estimate the *quarterly* depreciation rate to be 0.04-0.10 in the U.S., which is higher than the depreciation rates typically applied in the literature. With the caveat that the results are insignificant and at best indicative, they do *not* indicate that the relevant average depreciation rate of durable goods is different between the U.S. and China.

A second reason why our estimated depreciation rate may be higher than comparable studies is that the methods differ. Our method identifies the depreciation rate using the revealed behavior of households in response to income innovations. Comparable studies compute the depreciation rate using average spending shares and estimated depreciation rates within spending categories. Which method is more relevant depends on the research question one may want to address. One concern, however, is that average spending shares on specific goods may differ from marginal spending shares to specific income innovations. Hence, we argue that since our method relies on revealed behavior from marginal spending responses, it may be the more relevant measure of depreciation rates when one wants to study short-run fluctuations in durable purchases.

[12] See, e.g., Berger and Vavra (2015), Zorzi (2020), and McKay and Wieland (2021) who include housing in their definition of durable goods and find a quarterly depreciation rate of 0.018 or an annual depreciation rate of 0.068.

[13] For example, the spending share on durables in China is 14% but 23% in the U.S. in the time period considered here (see Appendix A.1).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *Panel A: Total Spending* | | | | |
| $MPX_{Total}$ | 0.411 | 0.380 | 0.435 | 0.401 |
| | (0.206) | (0.200) | (0.208) | (0.202) |
| *Panel B: Non-durables* | | | | |
| $MPX_{Non-durables}$ | 0.211 | 0.206 | 0.225 | 0.219 |
| | (0.133) | (0.132) | (0.132) | (0.131) |
| Marginal Spending $Share_{Non-durables}$ | 0.514 | 0.542 | 0.518 | 0.546 |
| | (0.129) | (0.139) | (0.104) | (0.112) |
| *Panel C: Durables* | | | | |
| $MPX_{Durables}$ | 0.200 | 0.174 | 0.210 | 0.182 |
| | (0.097) | (0.094) | (0.092) | (0.089) |
| Marginal Spending $Share_{Durables}$ | 0.486 | 0.458 | 0.482 | 0.454 |
| | (0.129) | (0.139) | (0.104) | (0.112) |
| *Panel D: Annual Depreciation Rate of Durables* | | | | |
| $\hat{\delta}$ | 0.139 | 0.161 | 0.142 | 0.164 |
| | (0.098) | (0.120) | (0.081) | (0.099) |
| First-stage F-test | 87.39 | 76.92 | 74.58 | 69.49 |
| Controls | ✗ | ✗ | ✓ | ✓ |
| Province FE | ✗ | ✓ | ✗ | ✓ |
| Observations | 1,236 | 1,236 | 1,236 | 1,236 |

**Table 3:** Marginal propensities to spend out of disposable income changes induced by monetary policy.

# 6 Conclusion

This paper provides a novel method to estimate the depreciation rate of durable goods using a combination of identified marginal and average spending shares. The main advantage of our method is that we rely on revealed behavior to identify the depreciation rate rather than computing a depreciation rate by weighing together sector-specific depreciation rates using average spending shares. We apply our method to Chinese spending responses to disposable income changes induced by monetary policy in 2008-2009. The marginal spending response is 0.40. Durable goods make up about 45% of this marginal spending response. By combining this marginal spending share with an average durable spending share of 14%, we estimate the annual depreciation rate of durables in China to be 0.16. This estimated depreciation rate is comparable with what has been estimated using U.S. data as long as one uses the similar definitions of durable goods.

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# A Online Appendix

## A.1 Depreciation Rates of Durable Goods in U.S. data

This section presents estimates of the depreciation rate of durable goods in U.S. data. The analysis builds on Parker et al. (2013) who combines information from the households expenditure survey and interview questions to identify the marginal spending responses to the tax rebates in 2008. Our estimation follows Parker et al. (2013) and builds on the replication package in that paper. Hence, all the marginal spending responses on total and non-durable spending in Table A.1 can be found in Table 2 and 3 in Parker et al. (2013). In particular, column (1) refers to the results in Table 2, while column (2)-(4) refer to results in Table 3 in Parker et al. (2013).

There are two additions to Parker et al. (2013) needed to provide an estimate of the depreciation rate of durables. First, we explicitly compute the marginal spending shares on non-durables and durables. Second, we note that the sample's average spending share on non-durables in December 2007 was 77%. We estimate the quarterly depreciation rate of durables to be between 0.04 and 0.10, taking into account that the relative price of durables declined by 5.5% in 2008.[14]

[14]We use data for U.S. consumer prices to compute inflation in the relative price of durables as the change in the price index for durables (DDURRG3M086SBEA in FRED) divided by the price index for total consumption (PCEPI in FRED). This number is also approximately equal to the change in the relative price of investment goods (PIRIC) and relatively stable around -5% during the 10-15 years before 2008.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | All | All | Only Receivers | Only on Time |
| *Panel A: Total Spending* | | | | |
| $MPX_{Total}$ | 0.523 | 0.509 | 0.866 | 0.911 |
| | (0.219) | (0.253) | (0.328) | (0.341) |
| *Panel B: Non-durables* | | | | |
| $MPX_{Non-durables}$ | 0.128 | 0.123 | 0.252 | 0.308 |
| | (0.071) | (0.081) | (0.103) | (0.112) |
| Marginal Spending $Share_{Non-durables}$ | 0.246 | 0.242 | 0.292 | 0.338 |
| | (0.130) | (0.153) | (0.124) | (0.135) |
| *Panel C: Durables* | | | | |
| $MPX_{Durables}$ | 0.394 | 0.386 | 0.613 | 0.603 |
| | (0.199) | (0.230) | (0.300) | (0.312) |
| Marginal Spending $Share_{Durables}$ | 0.754 | 0.758 | 0.708 | 0.662 |
| | (0.130) | (0.153) | (0.124) | (0.135) |
| *Panel D: Depreciation Rate of Durables* | | | | |
| $\hat{\delta}$ | 0.042 | 0.040 | 0.068 | 0.097 |
| | (0.098) | (0.120) | (0.081) | (0.099) |
| Observations | 17,478 | 17,478 | 11,239 | 10,488 |

**Table A.1:** Quarterly marginal propensities to spend out of disposable income changes induced by tax rebates in the U.S. in 2008.