Consumption Tax Cuts in a Recession *

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Abstract

Consumption taxes are often used across OECD countries as fiscal stimulus tools during recessions. In this paper, I use an estimated structural life-cycle model featuring multiple consumption categories to assess the effectiveness of temporary cuts to the Value Added Tax (VAT) rates on non-durable luxuries and durables as stimulus instruments. I find a tax elasticity smaller than 1 for non-durable luxuries and a tax elasticity higher than 10 for durables. I show that the tax cut on non-durables has an intratemporal substitution effect on non-durables and an income effect on durables and savings, while the tax cut on durables acts through an intertemporal substitution mechanism in the purchase of durables that is stronger for high income, low liquidity constraints, and younger households. Due to the partial irreversibility feature of durables, this mechanism is dampened if households anticipate higher future aggregate uncertainty.

JEL Codes: D11, D15, E20, H20, H31.

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1 Introduction

Consumption taxes are frequently used to stimulate economies undergoing a recessionary shock. Both the UK and France implemented Value Added Tax (VAT) cuts with the aim of helping their economies to recover after the 2008 financial crisis. More recently, in the attempt to boost consumption after the first wave of the Covid-19 pandemic, Germany has put in place temporary cuts of the VAT standard and reduced rates (from 19% to 16% and from 7% to 6%, respectively).

When choosing between consumption tax cuts and alternative stimulus policies in a recession, it is crucial for policy makers to take into account several factors. First, how households react to VAT cuts on different types of goods, for instance non-durables versus durables. Second, whether, in response to a consumption tax cut, households only adjust their consumption of the targeted goods or modify their purchases of other goods and their saving behavior as well. Third, how heterogeneous households differently react to the same VAT rate reform depending on their income level, their liquidity constraints, the age at which they are hit by the reform, and the overall state of the economy that they face. Lastly, policy makers have to assess the long-run welfare impact of these reforms.

Despite the vast empirical literature on the impact of consumption tax cuts on prices, households' expenditure, and firms' profits that cleverly exploited actual tax reforms as natural experiments (see, for instance, Crossley et al. (2014) for the UK, and Benzarti and Carloni (2019) for France), there are still no quantitative studies that assess the effect of these reforms using dynamic structural models of household behavior.

In this paper, I study the effectiveness of temporary VAT cuts on different categories of consumption goods as fiscal stimulus tools in a recession by adopting a dynamic approach. This approach allows me to analyze the effects of such reforms both on households' intratemporal consumption choices and on their intertemporal decisions of investment in durables and financial assets, to assess the impact of these reforms across heterogenous households, and to quantifiy their welfare consequences over households' lifetime.

I set up a structural household life-cycle model of consumpion and saving that features three types of consumption goods that are taxed at different rates and react differently to changes in taxation: non-durable necessities, non-durable luxuries, and consumer durables. In particular, I integrate a static demand system for the choice between different categories of non-durables into a dynamic life-cycle model that properly accounts for durable investments and savings decisions in a context of income uncertainty and borrowing constraints. By doing so, I allow for non-homothetic preferences both between the two non-durable categories and between durables and the non-durable bundle. Moreover, durables play a twofold role in the model: on the one hand, they are consumption goods that deliver utility for multiple periods of time, on the other hand, they are consumption smoothing tools, alternative to financial assets, as they can be sold on the second hand market – subject to adjustment costs – and used as collateral for borrowing.

I structurally estimate the model combining two sources of micro data on a representative sample of Italian households: the Household Budget Survey, a repeated cross-section, that collects expenditures on disaggregated sets of commodities and the Survey of Household Income ad Wealth, a panel, that features data on income, savings, non-durable consumption, as well as stocks and flows of durable goods.

I then use the estimated model to conduct two experiments and assess the effectiveness of hypothetical 12-month VAT cut reforms as fiscal stimulus instruments in a recession. Modelling the recessionary shock as an aggregate negative income shock, I simulate first a temporary and unexpected cut of 6 percentage points (from 10% to 4%) to the VAT rate on non-durable luxuries – restaurants, hotels, and tourist services – and then a temporary and unexpected cut of 7 percentage points (from 22% to 15%) to the standard VAT rate on durables – mainly cars and furniture.

I find that the recession causes a drop in spending of 15% for non-durable luxuries and of 30% for durables. I show that the immediate consumption stimulus effect of the VAT cut on non-durable luxuries is much smaller than that of the VAT cut on durables. More precisely, I find an increase of around 1% in consumption of non-durable luxuries in response to the 6 percentage points cut in rate – a tax elasticity well below 1 – and an increase of around 80% in durables' purchases as a consequence of the 7 percentage points cut in rate – a tax elasticity just above 10. Hence, the VAT cut on non-durable luxuries cannot compensate for the negative effect of the recession on non-durable spending, while the VAT cut on durables more than offsets the drop in durables' purchases in the year of implementation.

I show that the VAT cut on non-durable luxuries acts through two channels. The first channel is intratemporal substitution between the two categories of non-durables; households increase their consumption of non-durable luxuries, that became cheaper due to the reform, and decrease their consumption of non-durable necessities. The second channel is a positive income effect on spending in non targeted goods – durables – and on savings in financial assets. Households use part of the extra resources in their budget, coming from the lower tax on non-durables, to increase their purchases of durables and their liquid savings. The presence of these two competing channels explains the small stimulus effect of the VAT cut on non-durable luxuries that I find.

The mechanism behind the large increase in durable spending immediately following the VAT cut on durables, instead, is one of intertemporal substitution: households bring forward purchases of durables that they would have made in the future to take advantage of the VAT cut. Indeed, in the simulated experiments, I show that the increase in purchases of durables at the time of the reform is followed by a drop in these purchases in the two following two years.

Therefore, the overall stimulus effect of the VAT cut on durables is still positive, but smaller than the one that takes into account only the year of implementation.

Moreover, I find that this intertemporal substitution effect is dampened if households expect higher aggregate uncertainty in the economy for the future, as it is often the case in a recession. This is due to the partial irreversibility feature that characterizes durable goods and makes households less willing to lock up their resources in an illiquid asset when the economic scenario that they face is more uncertain.

Looking at the effects of the two simulated reforms across heterogeneous households, I show that the income effect of the VAT cut on non-durables is stronger for households that are hit by the reform at the start of their working life, for low income households, and for low wealth households. These are the households that are starting to build up their durables' stock and will enjoy the utility from it for a longer time horizon. These households are also the most liquidity constrained and, therefore, those with higher propensity to spend extra income coming from a tax cut into durables. On the other hand, I show that the intertemporal substitution effect of the VAT cut on durables is stronger for households in the first half of their life-cycle, for high income households, and for households at the median of the wealth (both liquid and illiquid) distribution. These are households who are in the process of accumulating durables and who can afford to bring forward future purchases to today because they are not liquidity constrained.

Comparing the welfare implications of the two VAT reforms, I find that the temporary VAT cut on non-durable luxuries increases overall welfare, benefitting relatively more middle-aged households for whom the intratemporal substitution effect of the reform is stronger. While, the temporary VAT cut on durables only has a small positive impact on lifetime welfare as it shifts durables' consumption intertemporally without changing the total stock of durables that households decide to accumulate over the life cycle.

Lastly, I assess the effectiveness of these consumption tax cuts against an alternative and equally costly stimulus policy that provides households with a one-time cash transfer, while leaving VAT rates unchanged. I show that such alternative policy would have only a negligible positive effect on savings and no stimulus effect on either durable or non-durable consumption spending.

These findings are important for policy makers having to choose among different fiscal stimulus tools during recessions. Indeed, two of the main arguments in support of VAT temporary cuts in a recession are that, differently from cash transfers and personal income tax rebates, they would be spent instead of saved, thus boosting consumption, and that they could be used to target consumption in specific sectors that have been hit particularly hard by a recession (such as the tourism sector in the case of the pandemic). However, the quantitative analysis in this paper shows that the dynamic effect of such reforms is more nuanced: while a reduction of the standard VAT rate on durables would be effective in boosting durables purchases, even if mainly temporarily, a VAT cut on non-durable luxuries would not offset the drop in consumption of these specific goods caused by the recession as it would be partly saved or invested in durables. Hence, this suggests that policy makers willing to boost consumption should prefer temporary VAT cuts on durables rather than on non-durable goods, and that these cuts should be large and unanticipated in order to generate countercyclical effects on consumption.

This paper relates to two main strands of the literature. First, the model draws insights from the empirical and theoretical literature studying consumer durables adjustment and households' choice among different types of consumption goods. In seminal work, Grossman and Laroque (1990), Eberly (1994), and Attanasio (2000) model households' durable adjustment by means of (S,s) rules. More recently, Bertola et al. (2005) and Fernandez-Villaverde and Krueger (2011) study the dynamics of expenditure in non-durable and durable goods in presence of adjustment costs and uncertainty. While, Browning and Crossley (2000) explore the elasticity of intertemporal substitution for luxury non-durable goods, Aguiar and Hurst (2013) show heterogeneity in consumption patterns across non-durable consumption subcomponents, and Hai et al. (2020) set up a consumption and saving model with non-durable and memorable goods. I contribute to this literature by integrating an intratemporal static demand system for multiple categories of non-durables within an intertemporal dynamic model for durables and savings.

Second, the quantitative tax experiments contribute to the growing literature investigating dynamic effects of fiscal policies within life-cycle models: Adda and Cooper (2000) study the effect of subsidies on durable goods market using a dynamic stochastic household discrete choice model of car ownership; Aaronson et al. (2012) investigate the income, spending and debt responses to minimum wage hikes in the US in a model where households can use durables as collateral for borrowing and face durables adjustment costs; Kaplan and Violante (2014) measure household consumption response to income tax rebates in the US in a framework with liquid and illiquid assets; Berger and Vavra (2015) explore the response of durables spending to policy changes during recessions and Gavazza and Lanteri (2018) study the car purchases response to a durable-replacement subsidy, such as the "Cash for Clunkers" implemented in the US after the 2008 financial crisis; Baker et al. (2020) embed an inventory problem into a consumption-saving life-cycle model to assess the spending response to changes in sales tax rates in US. To my knowledge, mine is the first paper that studies the effects of temporary consumption tax reductions on consumption (durable and non-durable), saving, and welfare effects in a structurally estimated life-cycle model with uncertainty and borrowing constraint.

The rest of the paper is structured as follows. Section 2 briefly describes the poliy context. Section 3 sets up the model. Section 4 presents the data and Section 5 the estimation procedure.

Section 6 reports the simulated tax experiments and discusses the results. Section 7 concludes.

2 VAT schedules across countries

Consumption taxes account for about 30% of total tax revenues across OECD countries. In particular, VAT represents the most important consumption tax in all OECD countries, except for the US, and its tax base is total business value added minus investment expenses, thus coincides with the value of final consumption. The typical VAT schedule consists of differentiated rates applying to different categories of goods: reduced or zero rate on non-durable necessities, one or more intermediate rates on non-durable goods and services that are not necessities, and a standard rate on the rest of goods, mostly durables and semi-durables.

To give some examples, Germany has one reduced rate at 7% and a standard rate at 19%, the UK has a zero rate, an intermediate rate at 5% and a standard rate at 20%, while Sweden has a zero rate, two intermediate rates (6 and 12%) and a standard rate at 25%. In particular, the Italian VAT schedule, that will be the policy context of this paper, represents a midway case as it features three rates: a reduced rate of 4% applying to medicines and most food goods, an intermediate rate of 10% applying to restaurants, hotels, and touristic services, and a standard rate of 22% on semi durables and durables.

Differently from all other OECD countries, the US do not have VAT at the federal level, but state and local governments can levy sales taxes at different rates depending on goods and locations. While VAT is always included in the posted price of goods, the sale tax is usually excluded from them, thus making it less salient than VAT.

3 Life-cycle model with necessities, luxuries, and durables

Following Parodi (2020), I set up a dynamic life-cycle model of household consumption and savings decisions that allows to account separately for durable and multiple categories of non-durable consumption in a partial equilibrium framework with income uncertainty, borrowing constraints, and ex ante heterogeneity in education level.

Household problem. Households are born as working adults at age $t_0 = 30$, the first time period in the model. Retirement is exogenous and takes place with certainty at age $T_r = 60$, so that working life lasts from period t_0 until period $T_r - 1$. From age T_r the household is retired, receives a flat pension benefit from the government and faces an education specific, exogenous probability of death until age $T = 85$, at which everyone dies with certainty.

Households solve the dynamic optimization problem:

$$\max_{c_{1,t},c_{2,t},d_t,a_t} \mathbb{E}_{t_0} \sum_{t=t_0}^{T} \beta^{t-1} \tilde{u}(c_{1,t}, c_{2,t}, d_t) \tag{1}$$

Subject to a set of constraints: the durables law of motion

$$d_t = (1-\delta)d_{t-1} + x_t \tag{2}$$

the budget constraint

$$c_t + Q(x_t)x_t + a_t = (1+r)a_{t-1} + y_t \tag{3}$$

where, c_t is the total expenditure in non-durables:

$$(1+\tau_1^n)\tilde{p_1}c_{1,t} + (1+\tau_2^n)\tilde{p_2}c_{2,t} = c_t \tag{4}$$

and $Q(x_t)$ is the non-linear price function for durables:

$$Q(x_t) = \begin{cases} (1+\tau^d) & \text{if } x_t \geq 0 \\ \pi & \text{if } x_t < 0 \end{cases} \tag{5}$$

and the borrowing constraint

$$a_t \geq -\chi d_t \tag{6}$$

In each period households decide how to optimally allocate their total resources among two non-durable categories of goods $(c_{1,t}, c_{2,t})$, taxed at rate τ_1^n and τ_2^n respectively, durables (d_t) taxed at rate τ_d, and savings in financial assets (a_t).[1]

Durables. When making their durable consumption decision, households take into account that durables can be bought and sold on the second-hand market. Hence, they decide whether to sell, buy or keep their durable stock invariant[2]. If households are not inactive, they also decide how much to buy (or sell) of durables, where x_t represents the positive (or negative) variation in the amount of durable goods stock.

If the household decides to buy new durables ($x_t > 0$), it must pay the relative price of durables to non durables (normalized to one) times the VAT rate on durables, τ^d, for each unit

[1] I model the non-homogeneous non-durable consumption bundle (c_t) as consisting of two groups of goods as dictated by the need to represent the VAT schedule in place in Italy as in the majority of other European countries as accurately as possible, but it is worth noting that this model is easily generalizable to the case of n non-durable subcategories.

[2] I make the simplifying assumption that each household is either a net seller or a net buyer (with the limit case of inaction) in each period, this assumption seems to be largely supported by the data.

of durables purchased[3]. If, instead, the household decides to decrease its stock of durables by selling ($x_t < 0$), there are proceeds from selling durables on the second hand market that can be used to finance current non-durable consumption. However, households can actually sell at a value on the market only a fraction π of the amount of durable stock they would like to get rid of. Indeed, a fraction $1 - \pi$ of the durable stock represents those durable goods that are an irreversible investment for the household as they have virtually no second hand market due to the well-known Akerlof's Lemons problem[4]. This feature of the model allows to capture the varying degree of irreversibility of the different components of the durables stock that is observed in the data and therefore to better represent the constraints faced by households in reality.

The durables stock depreciates at the constant rate δ, which coincides with the proportion of the stock that captures the service flow of durables from which the household derives utility. For simplicity, I assume that there is no durable goods rental market and I abstract from housing as a durable good.

Financial assets. Households can also save and borrow in a risk free financial asset whose associated constant interest rate is r. Only collateralized debt is allowed, in particular agents can borrow up to a fraction χ of their durables stock in each period implying a limited role of some durables categories as collateral. Differently from durables, financial assets are modelled as completely liquid, therefore households can access and adjust their financial assets stock at any time without paying any transaction costs.

Earning process. The process governing earnings from labour is assumed to be exogenous and to differ across education level achieved by the head of the household (s: secondary or less, high school, college or more). Allowing the earnings process dynamics to depend on education level, intended as a proxy for lifetime socio economic conditions, allows to create ex-ante heterogeneity among households in the model. I assume that the logarithm of earnings

[3] I assume that when households buy durables they always pay VAT on them, regardless of whether they buy on the first-hand or on the second-hand market. This corresponds to assuming that when durables are sold on the second-hand market they must go through an intermediate dealer which provides some services and therefore charges VAT on the good again before reselling it.

[4] While for precious objects and, partly, for cars it is easy to have an external appraisal, this is not the case for furniture and household appliances. Because of asymmetric information about the actual quality of the good between the seller and the buyer, agents believe that certain durable goods offered on second-hand markets are on average such bad quality that they are only willing to pay very low prices for them so that the sellers with the good quality used durables are driven out of the market. Sellers of decreasing quality remain in the market until the willingness to pay of the potential buyers is driven down to zero and the market shuts down.

at age t can be modelled in the following way:

$$lnY_t^s = f^s(X_t, t) + y_t^s \tag{7}$$

$$y_t^s = z_t^s + \varepsilon_t^s \tag{8}$$

where, f captures the deterministic component as a function of age and demographic characteristics of the household, X_t, and y is the stochastic component which accounts for the dynamics in earnings that remain unexplained after taking into account the deterministic component. The stochastic component consists itself of a persistent shock, z, and a transitory shock, ε. Both the deterministic function and the persistency and variances of the stochastic shocks vary across education levels.

Solution. Following Gorman (1971) and Blundell et al. (1994), I solve the model exploiting the fact that, under weak separability between non-durables and durables, the intratemporal non-durable problem is completely characterized by the indirect utility function – the maximum level of utility achieved by optimally choosing how to allocate a given level of total expenditure on non-durables (c) between two non-durable categories at a given vector of non-durable prices (P) – up to a monotonic transformation. Therefore, the original life-cycle problem can be restated by replacing the direct utility from non-durable consumption with the corresponding indirect utility, thus linking intra and intertemporal decisions in a coherent way:

$$\max_{c_t, d_t, a_t} \mathbb{E}_{t_0} \sum_{t=t_0}^{T} \beta^{t-1} U(v(c_t, P_t), d_t) \qquad s.t. \tag{9}$$

Subject to constraints (2), (3) and (6).

The life-cycle intertemporal utility is a standard CRRA featuring Stone-Geary preferences between durables and non-durables:

$$U(v(c_t, P_t), d_t) = \frac{[(v(c_t/n_t, P_t))^{\theta}(\delta d_t - \epsilon^d)^{1-\theta}]^{1-\gamma}}{1-\gamma} \tag{10}$$

Where, $v(c_t, P_t)$ is the indirect utility capturing the optimal decisions of the intertemporal non-durable stage of the model as a function of total expenditure and prices. $\frac{1}{\gamma}$ is the elasticity of intertemporal substitution of consumption and θ is the expenditure share in non-durable goods. Non-durable consumption is adjusted by an equivalence scale n_t in order to capture changing needs over time and economies of scale in consumption depending on the number of members living in the household. ϵ^d is the Stone-Geary parameter that makes within period preferences non homothetic in non-durables and durables and captures the extent to which durables are to be considered as a luxury good with respect to the non-durable bundle. In principle, the household derives utility from the service flow of durables rather than from the durable stock itself. As common in this literature, I assume for simplicity that the service flow is a constant proportion, δ, of the stock in each period and therefore allow for the stock of durables to enter the utility function directly.

Conditional on the optimal total expenditure on non-durables chosen in the intertemporal problem, households decide on the optimal consumption quantities of the two non-durables by solving a static utility maximization problem:

$$\max_{c_1,c_2} u(c_1,c_2) \qquad s.t. \qquad (1+\tau_1^n)\tilde{p_1}c_1 + (1+\tau_2^n)\tilde{p_2}c_2 = c \tag{11}$$

where, $p_1 = (1+\tau_1^n)\tilde{p_1}$, $p_2 = (1+\tau_2^n)\tilde{p_2}$ and $P = [p_1, p_2]$ is the vector of non-durable prices inclusive of the VAT rates. I do not impose a specific functional form on the intratemporal direct utility $u(.)$. Instead, I model the indirect utility, $v(.)$, as the one resulting from the Almost Ideal Demand System (AIDS) model by Deaton and Muellbauer (1980).

Recursive formulation. All in all, the household's problem is:

$$V_t(a_{t-1}, d_{t-1}, y_t) = \max_{a_t,d_t}\{U(v(c_t,P_t),d_t) + \beta\,\mathbb{E}_{y_{t+1}|y_t} V_{t+1}(a_t,d_t,y_{t+1})\} \tag{12}$$

subject to the constraints (2), (3) and (6).

The problem is characterized by the following two Euler Equations:

$$u'_{c_t} = \beta\,(1+r)\,Eu'_{c_{t+1}} \tag{13}$$

$$u'_{x_t} = \beta Q\,(x_t)\,(1+r)\,E_t u'_{c_{t+1}} - \beta E_t\left[\beta\,(1-\delta)\,Q\,(x_{t+1})\,(1+r)\,E_{t+1}u'_{c_{t+2}} - (1-\delta)\,u'_{x_{t+1}}\right] \tag{14}$$

The problem is solved numerically as described in Appendix A.

4 The Data

I use two data sets: the Bank of Italy Survey on Household Income and Wealth (SHIW) and the Italian National Institute of Statistics Household Budget Survey (ISTAT HBS). Details on both dataset and on sample selection are are in Appendix B.

The SHIW is a longitudinal dataset collecting information on income, wealth and consumption for a representative sample of Italian households. The non-durable consumption measure definition includes expenditures in food, clothing, entertainment, medical expenses, housing repairs and imputed rents[5]. SHIW collects information on three categories of durable goods:

[5]while the PSID only started collecting data on non-durable consumption other than food since 1999, the non-durable consumption measure definition in SHIW has remained the same since its very first wave.

vehicles (such as cars, caravans, motorbikes, bicycles, boats), furniture (such as household electrical appliances and furnishings), jewellery (including jewellery, antiques, old coins and other precious objects). Households are asked to report the value of the stock and of the flow for each category (except for furniture).

Table 1: Mean durables flows and stocks (euros), SHIW

	Value of stock	Value of purchase	Value of sale
Vehicles	10,669.80	1,894.62	221.67
	(11,984.44)	(5,961.74)	(1,498.30)
Furniture	14,289.48	827.86	
	(16,767.61)	(2,816.99)	
Jewelry	4,884.12	168.31	16.02
	(17,537.89)	(1,999.85)	(560.71)

standard deviations in parentheses

ISTAT HBS is the most comprehensive cross sectional expenditure survey in Italy. It collects detailed information on the consumption of all commodities at the level of each single item purchased by the household during an average week and allows me to disaggregate non-durable consumption into its subcomponents according to their differential treatment in terms of consumption tax rates. I classify as non-durable necessities those goods that are currently taxed at the lowest rate (4%) and as non-durable luxuries those that are taxed at the intermediate rate (10%)[6]. Necessities include food at home, books and newspapers and some medical expenses. Luxuries include food away from home, hotels and holidays, housing repairs and additions, entertainment and personal care services and goods .

5 Estimation

In order to estimate the model, I adopt a two-step strategy, similar to the one used by Gourinchas and Parker (2002) and French (2005). In the first step, I estimate the parameters governing the intratemporal static non-durable consumption problem and the ones determining the dynamics of the earnings process outside of the life-cycle model. In the second step, taking the parameters estimated in the first step as given, I estimate the parameters governing intertemporal preferences and durables dynamics in the life-cycle model. Due to the set-up of the model, the parameters of household's preferences that determine the optimal allocation of

[6] The composition of the groups of goods taxed at the different rates was not subject to any relevant reforms over the period covered in the data.

Table 2: Average expenditure shares (%) in main non-durables categories, HBS

necessities		luxuries	
1. Food at home	90.04	1. Food away from home	63.28
2. Books and newspapers	8.62	2. Housing repairs	21.11
3. Medical expenses	1.34	3. Personal care	8.65
		4. Holiday and travel	4.61
		5. Entertainment	2.36
total	34.40	total	65.60

resources within each period and over the life-cycle are identified and estimated consistently from two different sets of moments and exploiting two different datasets.

5.1 First Step

Intratemporal demand system. I model the intratemporal problem of how to optimally allocate total expenditure in non-durable consumption between a non-durable necessity and a non-durable luxury according to the Almost Ideal Demand System (AIDS) model by Deaton and Muellbauer (1980). The desirability of this model rests in its great flexibility: the general functional form of the PIGLOG cost function on which AIDS is based implies that the demand functions derived from it are first-order approximations to any set of demand functions derived from utility-maximizing behavior. Hence, AIDS can nest different types of preferences, including non homothetic ones that are needed in order to be able to characterise goods as necessities or luxuries, without imposing restrictions on the direct utility functional form.

The indirect utility function characterizing the intratemporal problem according to AIDS takes the following form:

$$v(c,P) = exp\left\{\frac{ln(c) - ln(a(P))}{b(P)}\right\} \tag{15}$$

where, c is total budget for non-durable consumption in the two ($k = 2$) non-durable goods categories, P is the vector of prices including taxes, $ln(a(P))$ and $b(P)$ are the price index and the Cobb-Douglas price aggregator, respectively:

$$ln(a(P)) = \alpha_0 + \sum_{i=1}^{k} \alpha_i lnp_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} \eta_{ij} lnp_i lnp_j \tag{16}$$

$$b(P) = \prod_{i=1}^{k} p_i^{\beta_i} \tag{17}$$

Applying Roy's identity to (15) the Marshallian demand functions in each of the two category of goods c_i can be derived and, from there, the expenditure shares in each of the two categories, $w_i = \frac{p_i c_i}{c}$, as a function of total budget and prices are computed. These translate into the following demand system estimation equations:

$$w_{it} = \alpha_i + \sum_{j=1}^{k} \eta_{ij} ln p_{jt} + \beta_i ln \left\{ \frac{c}{a(p)} \right\} + e_{it} \tag{18}$$

Where, t denotes the observation index and e_{it} is assumed to represent unobservable components in demand, here assumed to be measurement error for simplicity.

The parameters to be estimates are α, β and η. Some restrictions on these parameters are required. $\sum_{i=1}^{k} \alpha_i = 1$, $\sum_{i=1}^{k} \beta_i = 0$, $\sum_{j=1}^{k} \eta_{ji} = 0$ must hold in order to satisfy adding-up, while $\sum_{j=1}^{k} \eta_{ij} = 0$ in order to satisfy homogeneity.

The estimation exploits ten subsequent waves of the HBS spanning years from 2003 to 2012. The price data, that are not included in the consumption survey, are obtained from ISTAT Consumer Price Index database. As the variability of prices for the same goods over time and across families is small, I use price data disaggregated at the regional level in order to create further variability.

The estimation equations in (18) is affected by an endogeneity problem because total expenditure in non-durables on the right hand side also features as the denominator of the dependent variable. To deal with this endogeneity issue, I use a grouping estimation strategy. In particular, I use a discrete instrument for the continuous endogenous variable total expenditure that consists of a group variable constructed as all possible combinations of the values taken by the demographic variables education, age (of head of household), year, region.

Moreover, since I want to take into account the fact that the number of household components may have an impact on consumption choices of different categories of non-durables, I transform total expenditure in equivalent terms using the equivalence scale (Appendix B.4) and estimate the AIDS on the equivalized expenditure.

Table 3: AIDS estimated parameters

	α_1	β_1	η_{11}	η_{12}
share c_1	0.8513 ***	-0.0587***	-0.0101	0.0101
	(0.0125)	(0.0014)	(0.0127)	(0.0127)

$N = 13,989$

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Once estimated the parameters of interest, I predict the expenditure shares and derive budget elasticities and compensated own- and cross-price elasticities.

Table 4: Predicted expenditure shares and elasticities at the means

	shares	budget elasticity	price 1	price 2
share c_1	0.337 ***	0.826***	-0.603 ***	0.603***
	(0.001)	(0.004)	(0.037)	(0.037)
share c_2	0.663***	1.088***	0.307***	-0.307***
	(0.001)	(0.002)	(0.019)	(0.019)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 shows that the non-durables taxed at 4%, c_1, are indeed necessities and the non-durables taxed at 10% , c_2, are a luxuries as their budget elasticities are smaller and greater than one, respectively. Table 4 also suggests that the necessity non-durables and the luxury non-durables are substitute of each other as the compensated cross-price elasticities are positive and significant. Compensated own-price elasticities are negative for both goods as predicted by the theory (Negativity property).

The estimation of the parameters of the AIDS demand system on the two non-durables allows to predict the bahavioural response of the two non-durable consumption shares to price changes (and therefore VAT reforms) taking into account substitution and income effect. Most importantly for the aim of this paper, estimation of AIDS delivers estimates of the price indices in (16) and (17) to be then used to compute the estimated indirect utility of the second-stage intratemporal consumption problem conditional on the total expenditure in non-durables chosen in the first stage intertemporal model as from (15). These price indices are precisely what links the within-period allocation (demand system) and the between-period allocation (life-cycle model) in a coherent way.

Earning process. I estimate the parameters governing the deterministic and stochastic parts of the earnings process of the household for three different education groups (secondary school or less/high school/ college or more) separately. The logarithm of earnings of household i whose head is aged t is modelled as follows :

$$ln(Y_{i,t}) = D_t + \beta_1 age_{i,t} + \beta_2 age_{i,t}^2 + \beta_3 status_i + \beta_4 reg_i + y_{i,t} \tag{19}$$

$$y_{i,t} = z_{i,t} + \varepsilon_{i,t} \tag{20}$$

$$z_{i,t} = \rho z_{i,t-1} + u_{i,t} \tag{21}$$

$$\varepsilon_{i,t} \sim (0, \sigma^2_\varepsilon), \qquad u_{i,t} \sim (0, \sigma^2_u), \qquad z_{i,0} \sim (0, \sigma^2_{z_0})$$

The deterministic part of the earnings process consists of year dummies and a quadratic in age conditional on marital status and region of residence. While, the stochastic part (y), that captures the effect of unobservables not included in the deterministic component, features a persistent component (z), following an AR(1) stochastic process with non constant variance, and a purely transitory component (ε) that represents measurement error. All in all, the parameters to be estimated are $\Psi = \{\beta_1, \beta_2, \beta_3, \beta_4, \rho, \sigma^2_u, \sigma^2_\varepsilon, \sigma^2_{z_0}\}$ and the approach to estimation is the one proposed by Guvenen (2009). Results from the estimation of the deterministic and stochastic components are presented in Figure 1 and Table 5. Identification and estimation details are reported in Appendix C.1.

Figure 1: deterministic profiles of log earnings by education

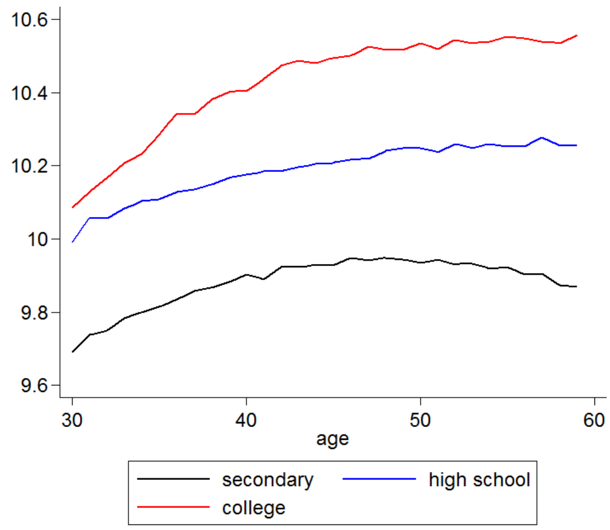


Table 5: Estimates of stochastic earnings process parameters by education

	Education level		
	secondary	high school	college
ρ	0.9682	0.9734	0.9428
	(0.0390)	(0.0300)	(0.0873)
σ_u^2	0.0068	0.0054	0.0136
	(0.0082)	(0.0052)	(0.0309)
σ_ε^2	0.0968	0.0697	0.0512
	(0.0174)	(0.0108)	(0.0229)
$\sigma_{z_0}^2$	0.0802	0.0579	0.2168
	(0.0422)	(0.0511)	(0.1519)
N	2,678	2,052	691

Bootstrapped standard errors in parentheses

5.2 Second Step

The second step of the two step estimation procedure consists in the structural estimation of the parameters characterizing the life-cycle model, those related to intertemporal preferences and those related to durables dynamics, via the Method of Simulated Moments (MSM). The estimation technique is explained in details in Appendix C.2.

The moments targeted in MSM estimation are the following: OLS coefficients on age polynomials during working life (age 30-59) of non-durable consumption, durables stock, non-durable consumption share of total consumption, financial assets, financial assets-durables ratio; means by age at end of working life (age 55-59) of non-durable consumption, durables stock, financial assets; covariances between non-durables and durables and covariances between financial assets and durables at ages 35, 45, 55; two moments related to durables dynamics.

The parameters to be estimated are $\Theta = \left\{\gamma, \theta, \beta, \epsilon^d, \pi, \chi, \delta\right\}$. Only two parameters are exogenously assigned values suggested by the literature: the interest rate, r, is set to 2.5% and the relative price of durables to non-durables, q, is set to 1. This results in 50 targeted moments and 7 estimating parameters, hence the model is overidentified. The second step estimated parameters are reported in Table 6 together with their asymptotic standard errors.

The estimates are all statistically significant.The estimated preference parameters γ, θ and β are in line with the existing literature. The large, negative value found for ϵ^d suggests that durables are luxury goods. The estimates of the parameters governing durables' dynamics, π, χ and δ, imply that about 50% of durables' stock can be sold on the second hand market, while only 11% has collateral value and that durables depreciate slowly at the 1% rate.

Table 6: Second step estimated parameters

Parameters	Value (annual)	Definition	SE
γ	3.72	Coeff. of relative risk aversion	1.6922
θ	0.85	Non-durable consumption share	0.0019
β	0.99	Discount factor	0.0016
ϵ^d	-476.42	Stone-Geary coeff. for durables	40.5815
π	0.47	Fraction of non irreversible durables	0.0089
χ	0.11	Fraction of collateralizable durables	0.0145
δ	0.01	Durables depreciation rate	0.0013

As it is usually the case in this kind of structural life cycle models, it is not possible to provide a formal proof for the identification of each parameter separately from the others. However, it is worth investigating which aspects of the data, and therefore which empirical moments, contribute more heavily to the identification of which estimated parameters.

The coefficient of relative risk aversion, γ, is identified from the mean life-cycle profile of financial assets and non-durable consumption as suggested by other studies (Cagetti (2003), Gourinchas and Parker (2002)). The higher the level of assets and the smoother the pattern of consumption over the life-cycle, the more risk averse are households and, therefore, the higher will be the estimated γ.

The weight of non-durable consumption in the utility function, θ, is identified by construction from the life-cycle profile of mean non-durable consumption share of total consumption and also from the covariances between non-durable and durable consumption.β, the discount factor, is identified from the mean life-cycle profiles of the two sources of wealth in the model (financial assets and durables). The larger the holdings of wealth at all stages of life, the more patient are households in discounting the future and the higher will be the estimated value of β.

The Stone-Geary durables parameter, ϵ^d, captures the extent to which durables are a luxury good and ensures that the marginal utility of consuming zero durables in each life period is finite. It is identified by the mean profile of durables over the life-cycle and also by the covariances between non-durable and durable consumption at different points in life. The slower households consumption of durables with respect to non-durables increases as they become wealthier from one period to the next of the life-cycle, the more durables are perceived as luxuries and the flatter the curvature of households' preferences in durables and, therefore, the higher (in absolute value) the estimated ϵ^d will be.

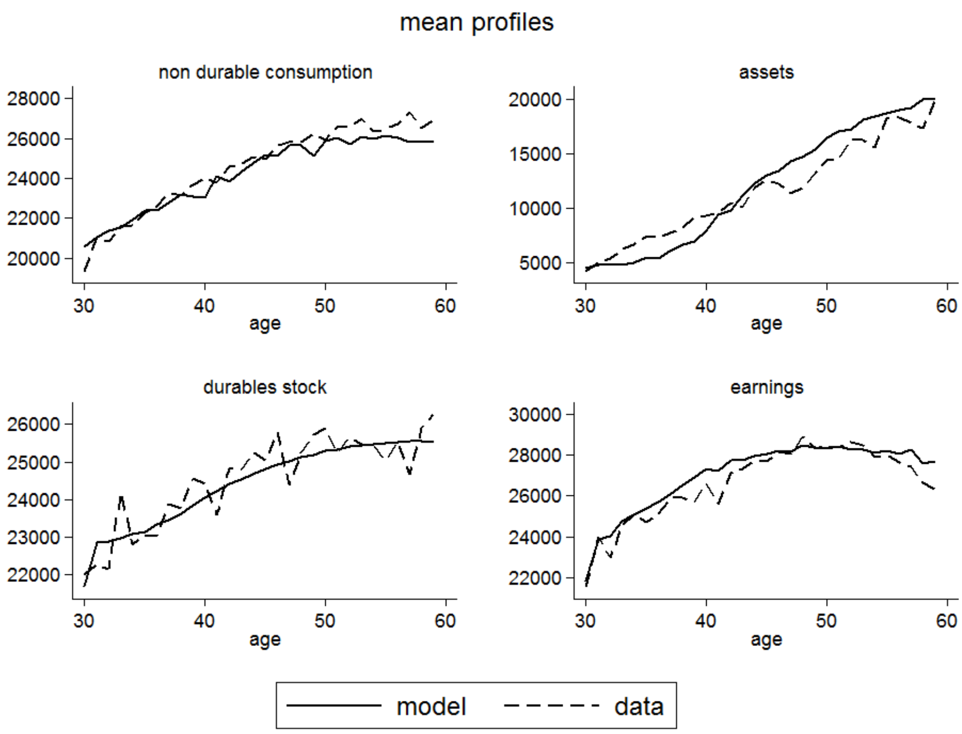
The fraction of durables stock that is collateralizable, χ, is identified by the mean patterns of financial assets and of financial assets-durables ratio over the life-cycle, especially at beginning of working life when individuals are more likely to borrow. Also, covariance between assets and durables at different stages of life helps in identifying this parameter. The more negative the mean assets early in life and the higher the ratio between assets liabilities and durables, the higher is the collateral value of durables and so the higher the estimated χ will be.

Finally, durables depreciation rate δ and reversibility rate π are closely interrelated in this model as they jointly determine the dynamics of durables accumulation over the life-cycle. The higher depreciation, the slower is durables accumulation, but also the more frequent are adjustments to the stock. The higher reversibility, the higher is the incentive to accumulate durables as a smoothing device, and again the more frequent are adjustments to the stock. The identification strategy for these two parameters relies on the availability of data on the value of both durables stock and durables flow in each wave of the panel data and is reported in Appendix C.2.

5.3 Model Fit

Figure 2 shows that the simulations produced by the estimated model fit the data very well in terms of mean life-cycle profiles of non-durable consumption, financial assets, durables stock and earnings. In particular, my model replicates very closely both the levels and the patterns over age observed in the data.

Figure 2: Fit of targeted moments between model and data



6 The VAT Cut Experiments

In this section, I use the estimated model to conduct two counterfactual exercises in order to shed light on the effectiveness of VAT temporary cuts as fiscal stimulus instruments in a recession. First, I simulate a temporary and unanticipated 6 percentage points cut of the intermediate VAT rate, the one that applies to non-durable luxuries, from 10% to 4%. Second, I simulate a temporary and unanticipated 7 percentage points cut of the standard VAT rate on durables from 22% to 15%[7]. I look both at the effect of these reforms on consumption of three categories of goods – necessities, luxuries, and durables – and on saving choices and at their welfare implications across households of different age, income, and wealth levels.

In particular, the timing of events is the following. At time -1 households receive an unexpected negative income shock, i.e. they are hit by a recession. As a consequence of this shock, income of all households is reduced by 20% of the median income in the sample for one period[8]. At time 0, an unexpected VAT cut is implemented on certain types of goods and it is announced that the cut will last only for one period (one year in the model), after which the pre-reform rates will be restored. I assume that each household can be hit by the reform only once at age 35, 45, or 55 and that the VAT cuts are fully passed through to consumers and, therefore, reflect one-to-one on final retail prices inclusive of VAT[9].

6.1 Temporary VAT cut on non-durable luxuries

Figure 3 shows the effects of the unanticipated negative income shock and of the subsequent temporary reduction of the VAT rate on non-durable luxuries with respect to the baseline scenario of no recession and no reform. As a response to the negative income shock, on average households reduce their purchases of non-durables necessities by around 10%, their purchases of non-durable luxuries by 15%, and their durables purchases by around 30%. They also reduce their savings in financial assets by around 5% with respect to the baseline scenario of no negative income shock.

The temporary VAT cut has two effects. First, it creates an intratemporal substitution effect between the two non-durable categories: households increase their consumption of non-durable luxuries that are now cheaper and decrease their consumption of non-durable necessities with

[7] The choice of these specific reductions – from intermediate rate to reduced rate and from ordinary rate to intermediate rate – is motivated by the tendency of policy makers to modify the rates towards uniformity when implementing VAT reforms.

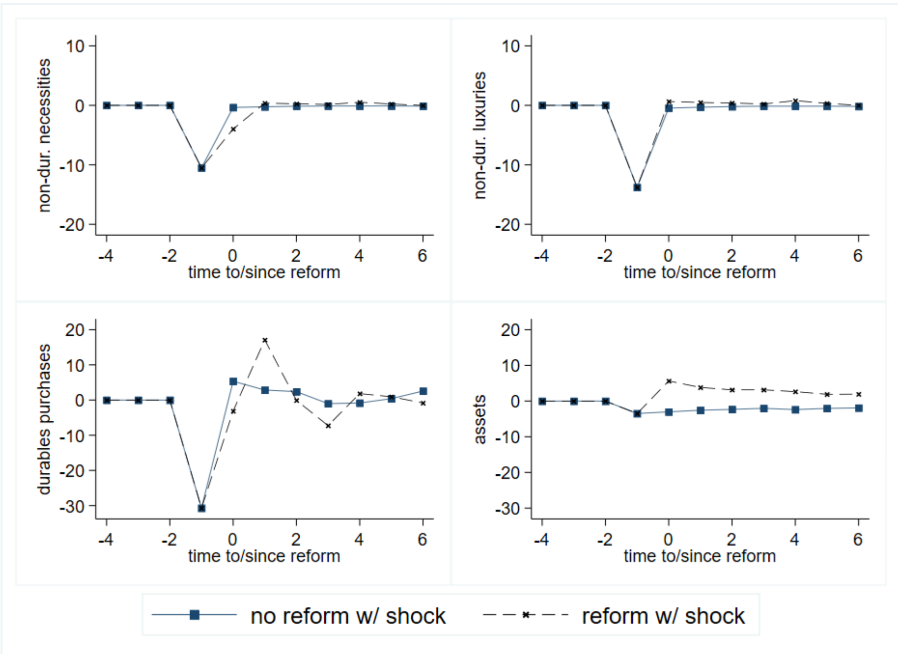
[8] The magnitude of this negative shock is, for instance, in line with a drop in GDP of around 20% experienced by most OECD countries during the Covid-19 lock-down and in the following months ((OECD, 2020))

[9] This assumption is supported by existing empirical literature studying pass-through across different commodities that have found that a large fraction of consumption taxes are borne by consumers with possible over-shifting of the tax in some cases (see Poterba (1996), Besley and Rosen (1998), and Kopczuk et al. (2016) among others).

respect to what they would have done in absence of the reform (solid lines). Second, it gives rise to a positive income effect on durable purchases and savings in financial assets: households devote part of the extra resources deriving from their now cheaper non-durable consumption basket to increase purchases of the non-targetes goods, durables, and savings.

The presence of these two competing channels – the intratemporal substitution effect that pushes towards an increase in the consumption of the targeted goods and the income effect that leads to an increase in non-targeted goods and savings – explains the small overall effect of this tax cut on the targeted goods. Indeed, consumption of non-durable luxuries only increases by about 1% in response to a 6 percentage points VAT rate cut, namely a tax elasticity well below 1. Hence, the cut of the intermediate VAT is only partly effective in stimulating consumption of non-durable luxuries (directly) and of durables (indirectly) and it cannot offset the drop in consumption due to the recession.

Figure 3: % changes in non-durable consumption, durables purchases, and savings



Looking at the effects across heterogeneous groups of households, Figures 4, 5, and 6 show how the income effect that the VAT cut on non-durables has on durables' purchases is mainly driven by young households (those hit by the reform at age 35), by households at the bottom of the lifetime income[10] distribution, and by households at the bottom of the total wealth, including both liquid (financial assets) and illiquid (durables) assets, distribution. These households are the most liquidity constrained and, young households in particular, are eager to accumulate their durable stock so to be able to use it as collateral for borrowing, hence their marginal propensity to consume durables out of an increase in their total resources, due to the fact that

[10]Measured as average of the income realizations over the life-cycle.

some non-durables became cheaper, is higher than for other groups.

Results for the effects of this reform on non-durable consumption and savings by age, income, and wealth levels of households are reported in Appendix D: the non-durable consumption response is overall homogeneous across groups with a stronger intratemporal substitution effect for older households, while the positive income effect on savings in financial assets, similarly to the one on durables, is stronger for younger and less wealthy households.

Figure 4: Effects of reform on durables purchases by age

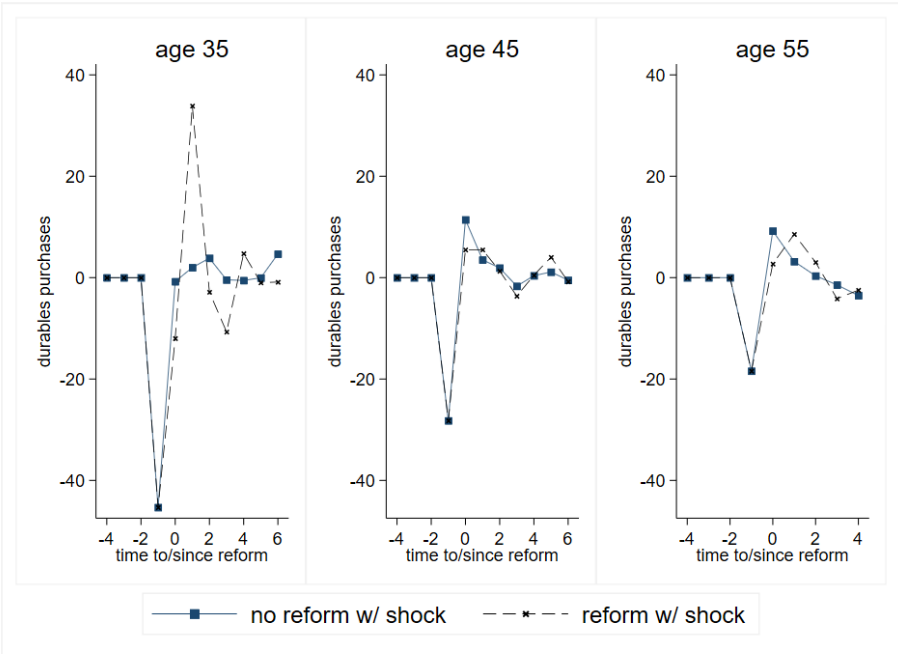


Figure 5: Effects of reform on durable purchases by terciles of total income

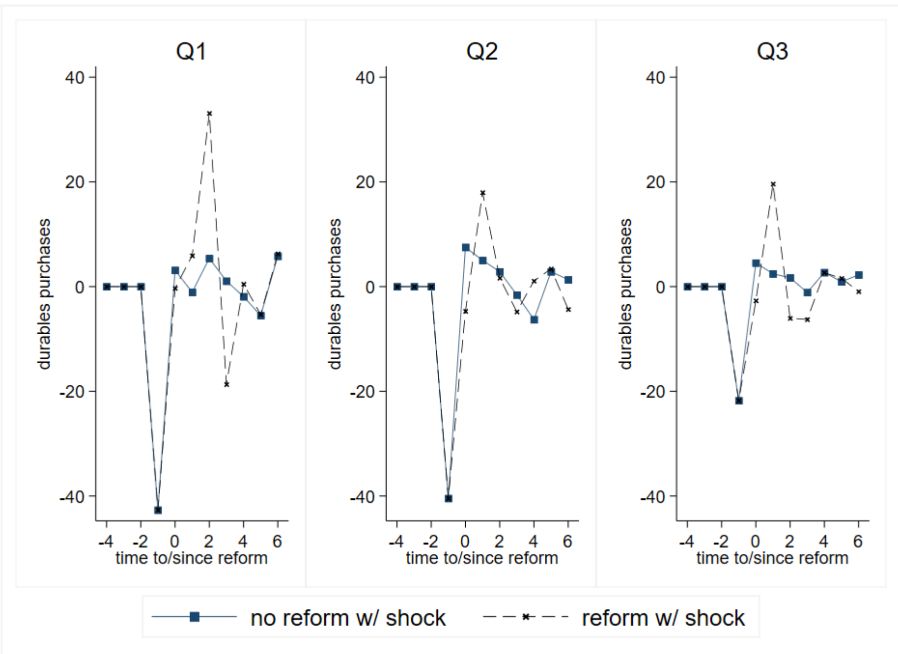
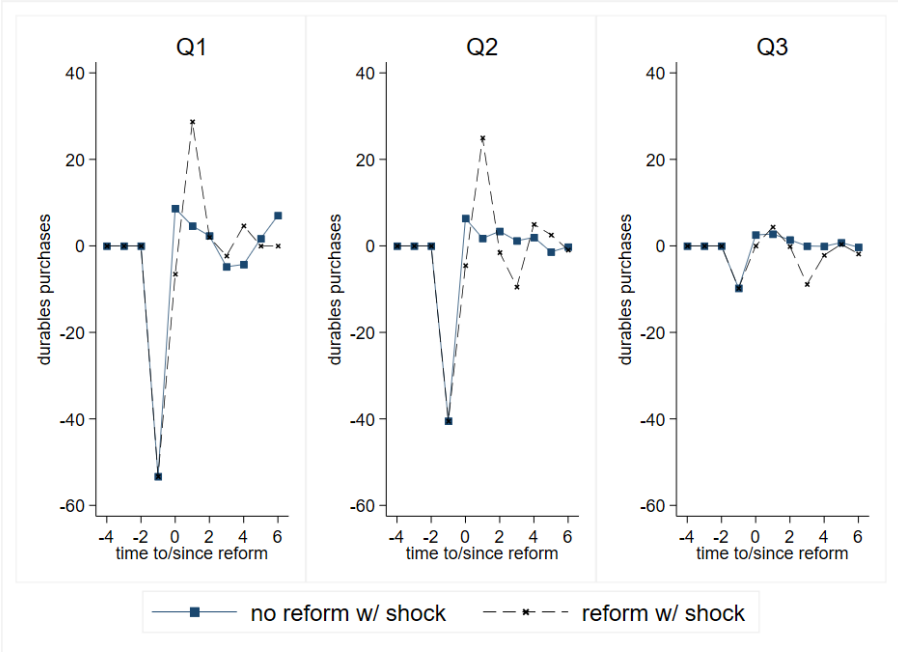


Figure 6: Effects of reform on durable purchases by terciles of total wealth



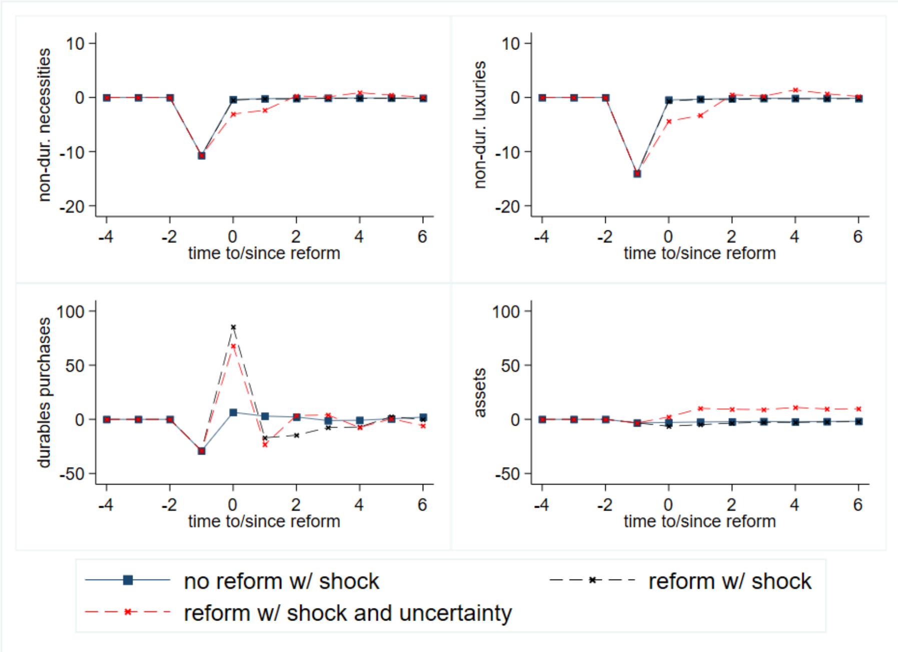
6.2 Temporary VAT cut on durables

The second counterfactual experiment consists of a temporary VAT cut of the standard rate, which applies, mainly, to durable goods. As mentioned earlier in the paper, durables are peculiar as they are both a consumption good and a saving tool, and they can be used as collateral for borrowing. Moreover, differently from non-durable consumption choices, durables consumption decisions are dynamic and characterized by some degree of irreversibility, in that households have to commit to a durable investment before future uncertainty is resolved.

Hence, in this subsection, I will look at the impact of a cut on durables VAT rate following a negative income shock, both without increased uncertainty (as before) and with increased uncertainty. In particular, I will consider a scenario in which, after having received the unexpected negative income shock in period -1, households expect income variance to be 50% higher for the next two periods.

Figure 7 shows a very large effect of the unanticipated VAT cut on durable purchases, that increase by around 80%, with respect to the no reform scenario (solid lines) in response to the 7 percentage points cut in VAT rate – a tax elasticity of around 10. This spike in purchases more than offsets the drop of approximately 30% due to the negative income shock at time -1. The higher tax elasticity of durables with respect to that of non-durables is in line with results in the existing empirical reduced-form literature: Cashin and Unayama (2016) and Cashin (2017) find strong temporary effects of VAT changes in Japan on durables' expenditures, Buettner and Madzharova (2019) show a significant increase in purchases of durables (household appliances) due to pre-announed VAT reforms across European countries, Agarwal et al. (2017)

Figure 7: % changes in non-durable consumption, durables purchases, and savings



find increases in spending on semi-durables (clothing and shoes) of up to 88% as a consequence of temporary sales tax holidays in the US and Baker et al. (2019) find that car purchases exhibit a tax elasticity of 8 in the context of pre-announced sales tax changes in the US.

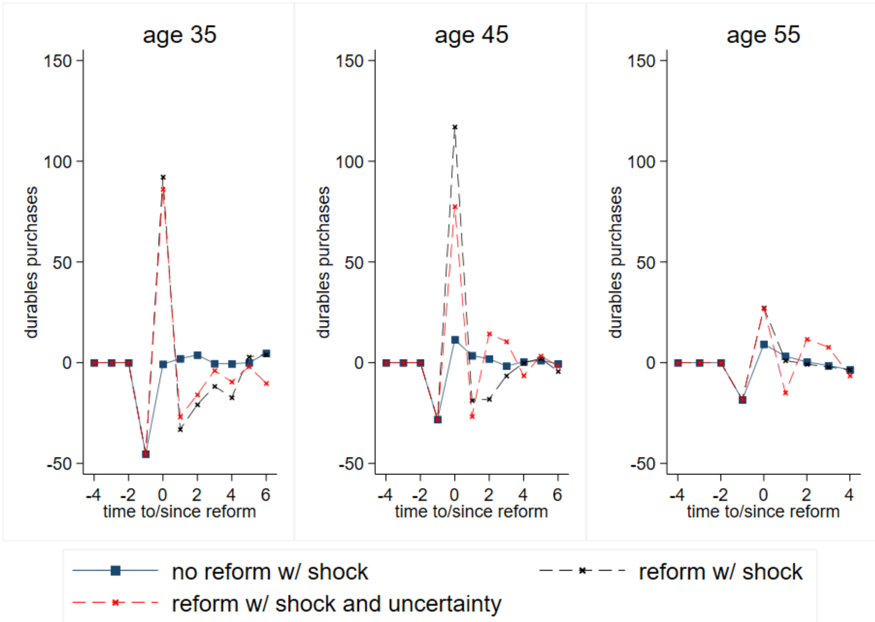
The sharp increase in durables' purchases at the time of the reform is followed by a drop in purchases in the years after the end of the tax cut. This suggests that the mechanism through which the VAT cut on durables operates is that of intertemporal substitution: when households learn about the tax cut, they bring forward purchases of durables that they would have made in the future.

In the scenario with no increased expected uncertainty, the reform also has an effect of substitution away from savings in financial assets as households prefer to invest in durables rather than in financial assets, when the former become cheaper. Whereas, the cut on the standard VAT rate has no relevant income effect on the demand for non-durables (necessities and luxuries).

In the scenario with increased expected aggregate uncertainty for the years following the reform (red dashed lines), the stimulus effect of the VAT cut on durables is dampened. When uncertainty is higher, households are less willing to lock up their resources in a partially illiquid asset such as durables and prefer, instead, to accumulate savings in liquid financial assets.

Figure 8: Effects of reform on durables purchases and savings by age

(a) durables purchases



(b) savings

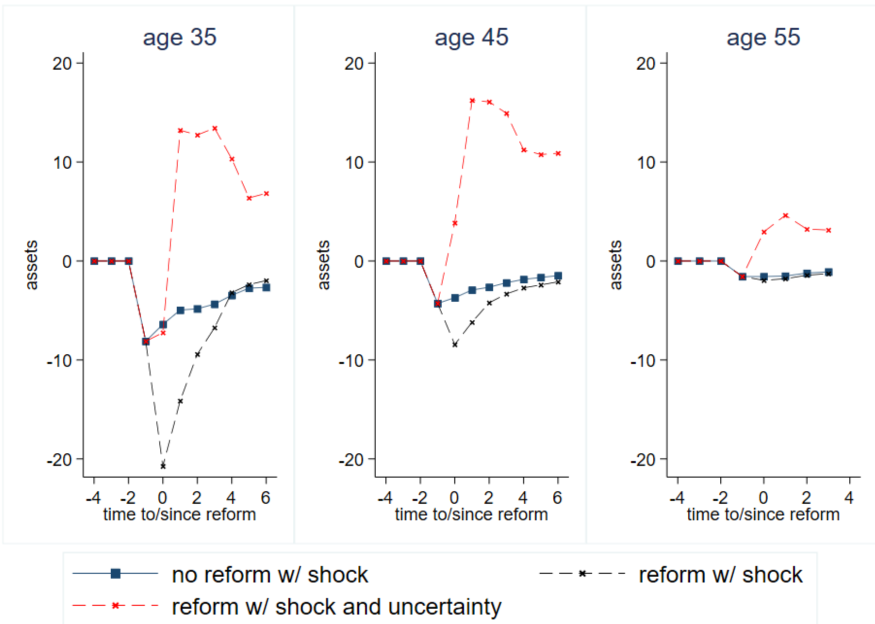
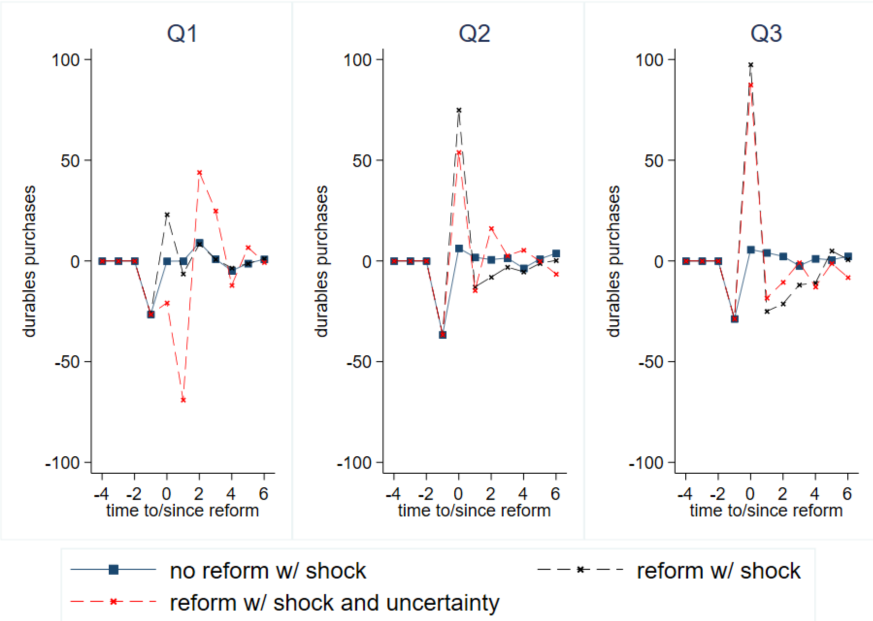


Figure 9: Effects of reform on durables purchases and savings by terciles of total income

(a) durables purchases



(b) savings

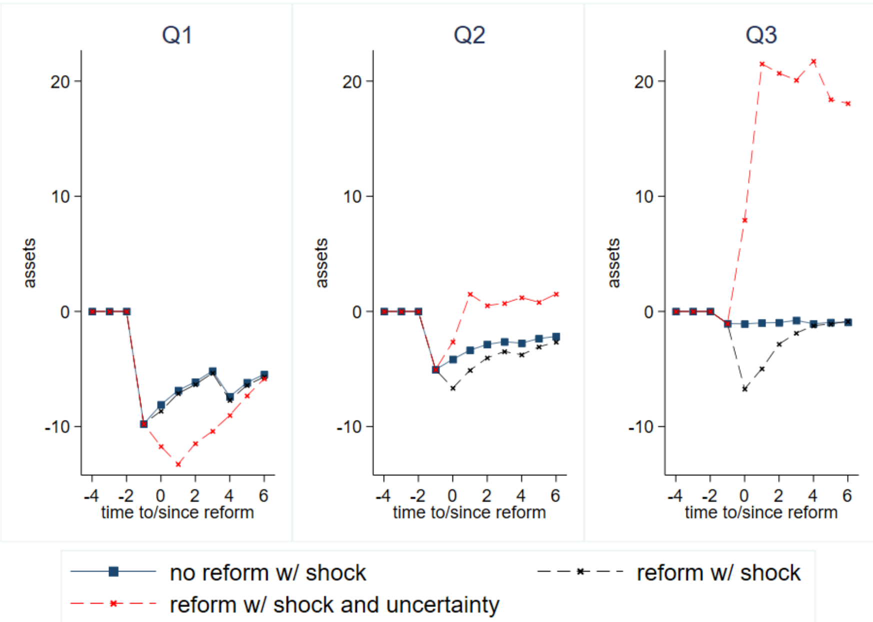
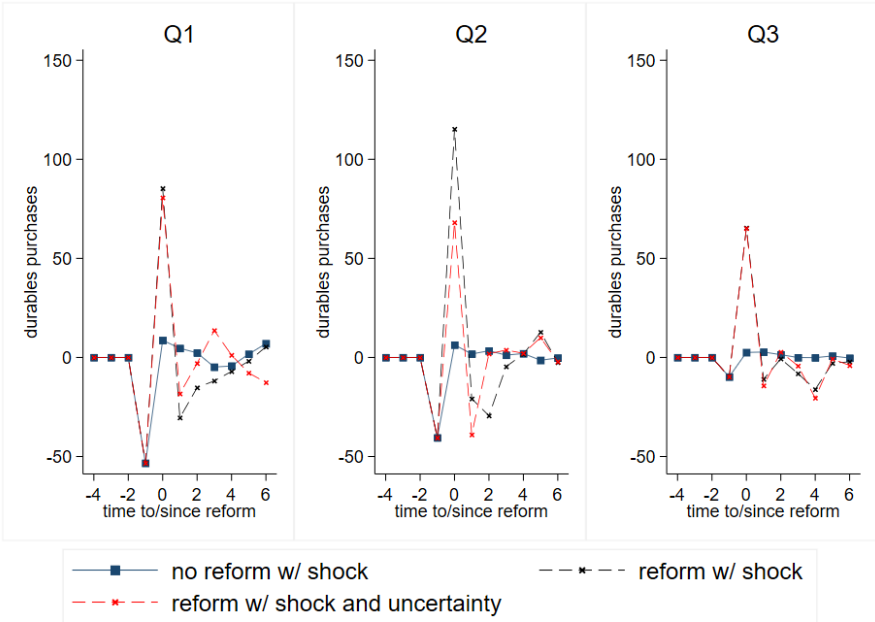
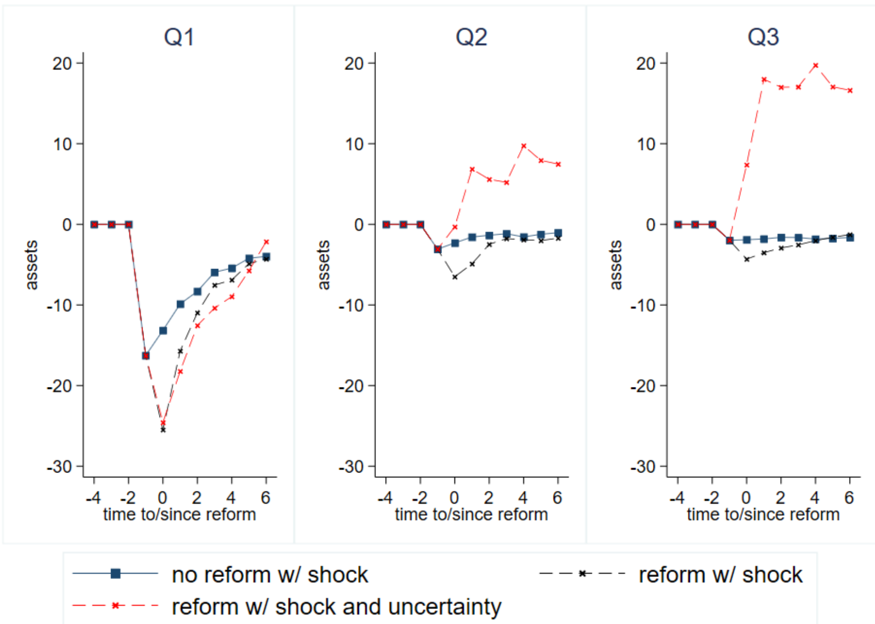


Figure 10: Effects of reform on durables purchases and savings by terciles of total wealth

(a) durables purchases



(b) savings



By looking across heterogeneous groups of households, I can explore the strength of the intertemporal substitution effect over the life-cycle and along the distribution of income and wealth. Figure 8 shows that the intertemporal substitution effect on durable purchases, as well as the substitution away from savings (in the scenario with no increased expected uncertainty), are stronger for households who are hit by the reform in the first half of working life. These are the households who are still in the process of building up their durables' stock and who will derive utility from durables purchased at the time of reform for a longer time horizon. These households turn out to also be the most sensitive to expected future aggregate uncertainty, as, in the high income variance scenario (red dashed lines), their durables purchases increase less as a response to the reform and their investment in financial assets jumps up, with respect to the scenario of no increased uncertainty.

Figure 9 suggests that it is mostly households at the top of the income distribution that increase durables purchases as a response to the VAT cut on durables and that increase savings in financial assets as a response to higher aggregate uncertainty post reform. Indeed, these are the least liquidity constrained households who can afford to perform more intertemporal substitution of resources. This result is in line with recent empirical evidence (Green et al., 2020) showing that liquidity constraints can substantially reduce the impact of a temporary incentive to purchase durables, especially during recessions.

In addition, figure 10 shows that intertemporal substitution on durables is stronger for households that belong to the median of the total wealth distribution. These are households who hold enough liquid assets not to be liquidity constrained, but, at the same time, still want to increase their stock of illiquid assets and, therefore, bring forward future durable purchases to take advantage of the tax cut.

This reform's effects on non-durable consumption do not significantly differ across households of different age, income, and wealth levels, as reported in Appendix D.

6.3 Welfare effects

Table 7 presents the distributional consequences of the two simulated VAT reforms across heterogeneous households in terms of consumption equivalent variation (CEV) with respect to a recession/no-reform scenario. Two main conclusions can be drawn from these tables. First, the temporary cut of the VAT rate on non-durable luxuries increases welfare of all groups, but it benefits middle-aged households more, as these are the households for whom the intratemporal substitution effect on non-durable luxuries is stronger. Second, the temporary cut of the VAT rate on durables only has a negligible positive effect on lifetime welfare and uniform across heterogeneous households as it create intertemporal shifting of durable consumption across periods of life without affecting the total amount of durables purchased over the life-cycle.

Table 7: CEVs with respect to recession/no reform scenario

	by age at reform			
	all	35	45	55
VAT cut of τ^{n2}	0.15	0.14	0.15	0.20
VAT cut of τ^{d}	0.01	0.01	0.01	0.01
	by income tercile			
	all	Q1	Q2	Q3
VAT cut of τ^{n2}	0.15	0.16	0.15	0.15
VAT cut of τ^{d}	0.01	0.00	0.01	0.01
	by total wealth tercile			
	all	Q1	Q2	Q3
VAT cut of τ^{n2}	0.15	0.16	0.16	0.15
VAT cut of τ^{d}	0.01	0.01	0.01	0.01

6.4 Alternative stimulus policy: cash-transfers

In order to assess the relative effectiveness of a temporary consumption tax cut – and in particular of a cut of the VAT standard rate on durales – with respect to alternative fiscal tools that can be used to stimulate economies undergoing a recession, in this section I consider a scenario in which the government makes a one-time cash transfer to households in the period after they are hit by the recession, while keeping VAT rates unchanged. For the sake of comparability, I set the amount of this cash transfer equal to the value that ensures revenue neutrality with respect to the VAT cut on durables reform presented in Section 6.2[11].

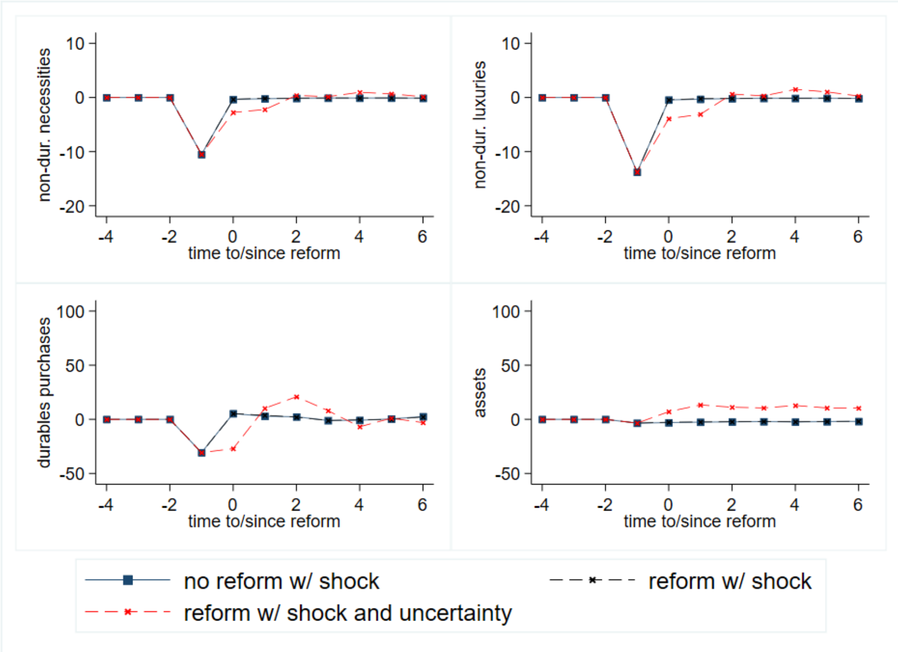
Figure 11 shows that, differently from the VAT cut on durables (Figure 7), in a framework without higher expected uncertainty, the revenue neutral cash transfer reform would have no relevant impact on non-durable consumption, durables' purchases, and savings in financial assets with respect to the baseline no-reform scenario. Moreover, this transfer reform would result in higher savings in financial assets than the VAT cut on durables in the context of higher expected uncertainty (red dashed lines).

Overall these results suggests that, keeping constant the government revenue loss, temporary VAT cut policies have a much larger consumption stimulus effect than cash transfer policies, especially in the context of a recession in which increased uncertainty leads households to

[11] To do so, I compute the cost in terms of lost revenues of the temporary VAT cut on durables analyzed in Section 6.2 and then divide this total amount by the number of simulated agents, taking into account the age distribution in the actual population. This results in a transfer of about $50 euros per household.

accumulate more savings.

Figure 11: % changes in non-durable consumption, durables purchases, and savings



7 Conclusions

In this paper, I set up and estimated a structural life-cycle model that integrates a static demand system for the choice between different categories of non-durables – necessities and luxuries – into a dynamic life-cycle model for saving and durable investment decisions. I use the model to conduct two counterfactual tax experiments and assess the effectiveness as post-recession fiscal stimulus tools of temporary cuts to the VAT rate on non-durable luxuries and on durables.

In the first experiment, I find that the cut of the VAT rate on non-durable luxuries is partly effective in stimulating consumption of non-durable luxuries, although not to the point of offsetting the drop in consumption due to the recession. This reform also has a positive income effect on savings and durables purchases. In particular, the durables' response is driven by young households and by households at the bottom of the total income distribution, who are the most constrained and eager to accumulate durable stock so to be able to use it as collateral for borrowing.

In the second experiment, I find a very large stimulus effect of the unanticipated cut of the VAT rate on durables on the purchases of this group of goods, that more than offsets the drop due to the negative income shock of the recession. This large direct effect is mainly driven by young and wealthy households, who can afford to bring forward durables purchases, but it is dampened when households anticipate higher aggregate uncertainty for the future, as it is often the case in a recession.

As for the distributional implications of the two reforms, I show that the temporary cut of the VAT rate on non-durable luxuries increases welfare of all groups, but it benefits middle-aged and wealthy households more. While, the temporary cut of the VAT rate on durables has very small effects on lifetime welfare as it mainly creates intertemporal substitution without changing the total amount of durables purchased over the life-cycle.

These results suggest that during recessions, when it is crucial for costly fiscal stimulus policies to be well targeted, policy makers willing to boost consumption should prefer temporary VAT cuts on durables rather than on non-durable goods, and that these cuts should be large and unanticipated in order to generate countercyclical effects on consumption.

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Appendices

A Computational Details

The model features a non convexity due to the irreversibility of a fraction of the durables stock which cannot be sold on the second-hand market and to the presence of VAT tax rate on purchases but not on sales of durables. These two characteristics make selling durables less profitable than it would otherwise be and, therefore, represent an implicit adjustment cost of selling durables stock for the household. Such non convex adjustment cost implies that the household's decision problem is not a well behaved convex dynamic programming problem and, therefore, the standard numerical approaches, relying on the differentiability of the value function, cannot be applied in this specific case. Instead, in order to solve the model, I adopt a discrete state-space dynamic programming technique.

I discretize the two endogenous states (financial assets and durables) over two finite logarithmically spaced grids. I first find and store the set of optimal choices of next period financial assets for each possible value of next period durables by maximizing the objective function over the assets grid conditional on durables. I then find the optimal choice of next period durables by picking the point on the durables grid that, together with the corresponding optimal asset choice, delivers the highest value of the objective function.

The continuous stochastic AR(1) process for the exogenous state, stochastic component of earnings, is discretized and approximated using a Markov chain over five grid points closely following Tauchen (1986). Finally, non durable consumption choice and durables' investment and disinvestment flows are implied by the budget constraint and by the durables law of motion.

Given a terminal value function equal to zero for the time period in which the household is dead, I iterate backwards in time and find the age-dependent optimal policy and value functions for each period of the household's life. Then, using these policy functions, I simulate life cycle patterns of non durable consumption, durables flow, durables stock and financial assets for many possible paths of the stochastic labour income process.

B Data

B.1 SHIW dataset

The SHIW was first conducted in 1965 and then repeated annually with time-independent samples (repeated cross sections) of households up to 1987. Since 1987 the Survey was conducted every other year (except for a three year interval between 1995 and 1998) and, starting from the 1989 wave, each wave includes households interviewed in previous years (panel households) in the sample. The overall sample comprises around 8000 households in each wave since 1987 and is representative of the Italian resident households population. The unit of analysis is the household, defined as the group of persons residing in the same dwelling who are related by blood, marriage or adoption. Institutional population is not included. The numerosity of the panel component has increased gradually over time and is now roughly 57% of the overall sample.

More in detail, SHIW collects the following information: socio-economic and demographic characteristics of the household; current occupational status and past employment history of adult household members; different sources of income including payroll and self-employment income, pensions, transfers, and property income of adult household members; household's wealth at the end of the year in terms of properties lived in or owned by the household, imputed rents, household financial and real assets and liabilities; household's expenditure in non-durables and durables during the year.

The sample for the survey is drawn in two stages: first, the municipalities (stratified by region and population) are selected; second, the households to be interviewed are selected within each municipality from civic registers. Panel households are selected according to a rotating-panel sampling design: households that had participated in at least two earlier surveys are all included in the sample, plus a fraction of those interviewed only in the previous wave are randomly selected to be interviewed again in the current wave, while a fresh sample is drawn in every wave. The adoption of this rotating-panel strategy allows to minimize drop-out problems and therefore reduces the problem of non random sample attrition. In the most recent wave of the survey the rate of response among contacted households was much higher for panel households (82,2%) than for non panel ones (35,8%) and non random attrition is reportedly not a major problem in the SHIW data.

Table 8 shows in some more detail the structure and numerosity of the the SHIW rotating panel by reporting the number of households interviewed in more than one wave. For instance, among the 8156 households in the last wave (2014), 13 participate since 1987, 64 since 1989, 166 since 1991 and so on. Table 8 also allows to pin down how many households are observed for, say, three subsequent waves in each year: in 2014 there are 579 households that have been interviewed in three subsequent waves, 806 households in 2012 wave, 856 households in 2010 wave, 995 households in the 2008 sample and so on.

Table 8: Structure of SHIW

Year first interview	Year of survey 1987	1989	1991	1993	1995	1998	2000	2002	2004	2006	2008	2010	2012	2014
1987	8027	1206	350	173	126	85	61	44	33	30	28	23	21	13
1989		7068	1837	877	701	459	343	263	197	159	146	123	102	64
1991			6001	2420	1752	1169	832	613	464	393	347	293	244	166
1993				4619	1066	583	399	270	199	157	141	124	106	78
1995					4490	373	245	177	117	101	84	75	62	46
1998						4478	1993	1224	845	636	538	450	380	267
2000							4128	1014	667	475	398	330	256	170
2002								4406	1082	672	525	416	340	221
2004									4408	1334	995	786	631	395
2006										3811	1143	856	648	414
2008											3632	1145	806	481
2010												3330	1015	579
2012													3540	1565
2014														3697
sample size	8027	8274	8188	8089	8135	7147	8001	8011	8012	7768	7977	7951	8151	8156
% panel hhs		14.6	26.7	42.9	44.8	37.3	48.4	45.0	45.0	50.9	54.4	58.1	56.6	54.7

Table 9 shows that panel and non panel households are similar in terms of demographic and socio-economic characteristics, thus suggesting that nonrandom attrition is not a major problem in the SHIW data.

Table 9: Comparison of means and standard deviations

Variable	hhs in 2010 sample only	hhs in 2010 and 2012 samples	hhs in 2012 sample only
consumption	25299.21	26381.97	24180.87
	(16200.07)	(15376.81)	(14579.85)
durable consumption	1627.81	1233.78	952.76
	(5086.05)	(4300.55)	(3596.78)
non-durable consumption	23671.40	25148.18	23228.106
	(14515.29)	(14069.37)	(13409.34)
disposable income	33146.58	31788.48	29289.21
	(25129.62)	(22629.14)	(22604.65)
gender of head of hh	1.46	1.45	1.46
	(0.5)	(0.5)	(0.5)
age of head of hh	55.10	53.09	55.81
	(17.18)	(15.37)	(17.21)
education of head of hh	3.25	3.43	3.19
	(1.07)	(1.04)	(1.07)
family size	2.49	2.60	2.43
	(1.28)	(1.32)	(1.31)
geographic area	1.81	1.85	1.80
	(0.85)	(0.88)	(0.87)
observations	2315	1015	3540

B.2 HBS

HBS sampling scheme is organized in two-stages: firstly, municipalities are selected among two groups according to the size of population; chief towns of provinces are fully included and selected to take part to the survey every month, while the remaining are grouped in strata according to some economic and geographic characteristics and are extracted every 3 months; second, households are randomly selected within the stratum from the registry office records. As a result, the survey unit is the legal family recorded by the registry office. Sample size is around 28,000 households from 480 municipalities and weights allowing for a recalibration of population in each stratum and for the distribution by household size within region are also provided for.

Data are recorded by means of two complementary methods: a diary (Libretto degli Acquisti) where the household keeps track of expenditures made and of quantities of internally produced goods consumed in the previous 7 days (Taccuino degli Autoconsumi); a proper interview for the remaining purchases done in the previous month and for durables bought in the previous 3 months. It has to be remarked that expenditure is provided on a monthly basis, so commodities recorded on a wider recording period are made monthly in the survey by dividing the amount for the number of months they are recorded for.

B.3 Sample selection

I use the SHIW waves 1989 to 2014 and HBS waves 2003 to 2012. Sample selection in both data sets satisfies the following criteria. Given that the model focuses on households' economic choices during working age, only households whose head is aged 30-59 are kept in the sample. Most young people still live with their parents around age 20 in Italy. Moreover, there is a well known (Jappelli and Pistaferri (2000)) head of household bias in SHIW data at early ages due to a strong positive correlation between wealth and young household headship.

As the model does not allow for singles and family transitions, such as marriage, divorce and widowhood, single households or households whose head reports changing marital status at a given wave are dropped from all waves in which they are observed. In SHIW, this means dropping about 20% of observations in the original sample of households in the selected age range (15% of the dropped observations are singles). Hence, the final SHIW dataset is an unbalanced panel of around 43,000 household-year observations, where about 25% of households are observed for at least five subsequent waves (i.e. ten years).

All monetary values are CPI adjusted (base year 2014). Variables for durables stock and flow, non-durable consumption and financial assets are all trimmed at the 95th percentile of the age specific distribution in order to mitigate the impact of misreporting. The variable for financial assets includes bank and postal accounts, government bonds and stocks net of consumption debt, but, for consistency with the model, it excludes housing and mortgages. In order to be fully consistent with the choice of modelling financial assets as completely liquid, the data measure for net financial assets is adjusted for down payment (observed or imputed) for non home owners.

The variable for individual's net earnings is defined as the sum of compensation of employees and net income from self-employment and entrepreneurial income. It excludes pensions and income from property and assets, but includes government transfers. It is trimmed at the 1st and 98th percentiles of the education specific distribution.

B.4 Consumption equivalence scale

I use the non-durable consumption equivalence scale provided by ISTAT.

members in hh	1	2	3	4	5	6	7 or more
coefficient	0.60	1	1.33	1.63	1.90	2.16	2.40

C Estimation

C.1 First step: earning process

Under the assumption of non constant variance, the variance-covariance matrix of y consists of the following theoretical moments[12]:

$$var(y_{i,t}) = var(z_{i,t}) + var(\varepsilon_{i,t}) = \rho^{2t}\sigma^2_{z_0} + (1-\rho^{2t})\frac{\sigma^2_u}{1-\rho^2} + \sigma^2_\varepsilon \tag{22}$$

$$cov(y_{i,t}, y_{i,t-j}) = cov(z_{i,t}, z_{i,t-j}) = \rho^j var(z_{i,t-j}) \qquad if \qquad j > 0 \tag{23}$$

The identification strategy for the parameters of interest is the following: ρ is identified from the slope of the covariance at lags greater than zero:

$$\frac{cov(y_{i,t}, y_{i,t-4})}{cov(y_{i,t-2}, y_{i,t-4})} = \frac{\rho^4 var(z_{i,t-4})}{\rho^2 var(z_{i,t-4})}$$

σ^2_ε is identified from difference between variance and covariance at first lag, once ρ has been identified:

$$var(y_{i,t-2}) - \frac{1}{\rho^2}cov(y_{i,t}, y_{i,t-2}) = var(z_{i,t-2}) + \sigma^2_\varepsilon - \frac{1}{\rho^2}\rho^2 var(z_{i,t-2})$$

$\sigma^2_{z_0}$ is identified residually from variance at age zero, once ρ and σ^2_ε have been identified:

$$var(y_{i,0}) - \sigma^2_\varepsilon$$

Lastly, σ^2_u is identified from difference between variance and covariance at second lag, once all other parameters have been identified :

$$var(y_{i,t-2}) - cov(y_{i,t}, y_{i,t-4}) - \sigma^2_\varepsilon = \rho^4 var(z_{i,t-4}) + \sigma^2_u + \sigma^2_\varepsilon - \rho^4 var(z_{i,t-4}) - \sigma^2_\varepsilon$$

Full identification is achieved with two lags of the current age $(t, t-2, t-4)$, therefore the same household must be interviewed for at least three subsequent waves of SHIW in order to be included in the earning process' estimation sample.

The predicted residuals from the regressions in (19) are consistent estimators of y, hence to construct the empirical counterparts of the theoretical moments, the corresponding empirical moments are computed on the predicted residuals so to build the empirical variance-covariance matrix. Let $\mathbf{f}(\psi)$ be the vector of the unique moments of the symmetric theoretical variance-covariance matrix, which are functions of the parameters $\psi = \{\rho, \sigma^2_u, \sigma^2_\epsilon, \sigma^2_{z_0}\}$ to be estimated,

[12]Given that SHIW is conducted every other year, I do not observe household earnings at every age, but only at age $t, t+2, t+4...$ and have to adjust the model accordingly.

and $\mathbf{m}$ be the vector of the corresponding empirical moments. The estimators of the parameters in ψ are found by minimizing the weighted (diagonal weighting matrix) distance between theoretical and empirical moments:

$$\hat{\psi} = \arg\min_{\psi}[\mathbf{m} - \mathbf{f}(\psi)]'\mathbf{\Omega}[\mathbf{m} - \mathbf{f}(\psi)] \tag{24}$$

Results of estimation are reported in Table 5 and are in line with those found in the existing literature. Two additional remarks are in order.

First, my estimates are obtained on the sub sample of households in which at least one of the spouses is working, either as an employee or as a self employed. This means that I am selecting the households that participate into the labour market that could be systematically different from those that are left out of the sample due to having zero wages and this can of course result into selection bias of the estimated parameters that I am not correcting for. However, the work requirement sample selection that I apply results into dropping only around 16% of all household observations in the age range 25-59, hence applying the sample selection correction should not affect my results substantially.

Second, in principle the term $\varepsilon_{i,t}$ might be thought of as a mix between transitory shock and measurement error, however, as already mentioned before, I assume that all estimated transitory shocks to wages represent measurement error. In SHIW the fundamental cause of measurement error for income data is under reporting of earnings. It has been shown (Biancotti et al. (2008)) that income and wealth are voluntarily underestimated by the respondents more severely in the south and when the head of the household is self employed, poorly educated or older. If under reporting is not systematic the tendency to under report can be a relevant cause of additional variance of the measurement error.

C.2 Second step

C.2.1 Method of simulated moments estimation

The Method of Simulated Moments (MSM) estimation technique, first introduced by McFadden (1989), consists in finding the parameters that minimize the weighted distance between moments computed in the data and the analogous moments computed on the simulated panel produced by the life-cycle model by means of an iterative procedure. More precisely, the vector of estimates of the parameters of interest, $\hat{\Theta}$, is the solution to the following minimization problem:

$$\hat{\Theta} = \arg\min_{\Theta}\left\{\sum_{k=1}^{K}\left[(m_k^d - m_k^s(\Theta))^2/Var(m_k^d)\right]\right\} = \arg\min_{\Theta}\left\{g(\Theta)'Wg(\Theta)\right\} \tag{25}$$

where, m_k^d denotes the k^{th} data moment computed over N observations in the sample, $m_k^s(\Theta)$ represents the k^{th} simulated moment computed over S simulations obtained under a specific set of parameters values Θ and $g(\Theta)$ is the Kx1 vector collecting all distances between empirical and simulated targeted moments. These squared distances are weighted by the diagonal matrix W whose entries on the main diagonal are the inverse of the empirical variances. I do not use the asymptotically optimal weighting matrix because of its small sample properties, as suggested by Altonji and Segal (1996). The simulations are initialized to the empirical, education-specific joint distributions of the three state variables (earnings, financial assets, durables) at age 30-31. The aim is to embed in the model the initial heterogeneity among households, within and across education levels, that is observed in the data at the start of working life, also taking into account the strong correlations that exist among the three state variabes.

The MSM estimation is performed by iterating back and forth between the solution of the life-cycle model and the minimization of the MSM objective function in (25). Starting from a given set of initial values of the parameters to be estimated, the solution of the dynamic programming problem is found and the corresponding optimal policy functions are obtained. Then, using these decision rules, the life-cycle choices of a large number of simulated agents are produced so to get a simulated panel. Targeted moments are computed in the data sample and in the simulated panel and the MSM objective function is constructed and minimized with respect to the estimating parameters. The values of the parameters that solve the minimization problem are returned. If the value of the associated minimized objective function is the minimum the routine terminates, otherwise the routine starts over again using the current values of the parameters as initial values for the next iteration [13].

Given the non-convexities in the durable choice, the MSM objective function may not be a smooth function of the model parameters everywhere in their domain. Therefore, I use the derivative-free Nelder-Mead optimisation routine [14].

C.2.2 Identification

The proof of the identification of the parameters for durables depreciation δ and irreversibility π goes as follows. Starting from the durables law of motion: $d_t = (1-\delta)d_{t-1} + x_t$.

For net sellers, $\tilde{d} = \pi d$ and $\tilde{x} = \pi x$ are observed in data and the durables law of motion can be rewritten in terms of observables:

$$\pi d_t = (1-\delta)\pi d_{t-1} + \pi x_t \rightarrow \tilde{d}_t = (1-\delta)\tilde{d}_{t-1} + \tilde{x}_t$$

$$1-\delta = \frac{\tilde{d}_t - \tilde{x}_t}{\tilde{d}_{t-1}}$$

[13]The code for solution, simulation and estimation of the model is written in Fortran90. The solution part of the code is parallelized on 8 processors using OpenMP libraries.

[14]Implemented in Fortran using routine from NAG library. I experimented starting the algorithm from various initial values to ensure that the minimum found is global.

hence, δ is identified in the sub sample of households who are net sellers between two subsequent waves.

For net buyers, $\tilde{d} = \pi d$ and $\tilde{x} = (1 + \tau^d)x$ are observed and the transformed durables law of motion in terms of observables is:

$$\begin{aligned}(1 + \tau^d)\pi d_t = (1 - \delta)(1 + \tau^d)\pi d_{t-1} + (1 + \tau^d)\pi x_t \rightarrow \\ (1 + \tau^d)\tilde{d}_t = (1 - \delta)(1 + \tau^d)\tilde{d}_{t-1} + \pi\tilde{x}_t\end{aligned}$$

$$1 - \delta = \frac{\tilde{d}_t - \frac{\pi}{1+\tau^d}\tilde{x}_t}{\tilde{d}_{t-1}}$$

$$\pi = (1 + \tau^d)\frac{\tilde{d}_t - (1 - \delta)\tilde{d}_{t-1}}{\tilde{x}_t}$$

once δ has been identified, also π is identified in the sub sample of households who are net buyers between two subsequent waves.

The moments that I target in estimation are tractable approximations of the above theoretical relationships:

$$\frac{1}{N_s T}\sum_{i=1}^{N_s}\sum_{t=1}^{T}\left[\frac{\tilde{D}_{i,t} - \tilde{X}_{i,t}}{\tilde{D}_{i,t-1}}\right] \qquad \text{and} \qquad \frac{1}{N_b T}\sum_{i=1}^{N_b}\sum_{t=1}^{T}\left[\frac{\tilde{D}_{i,t} - \tilde{X}_{i,t}}{\tilde{D}_{i,t-1}}\right]$$

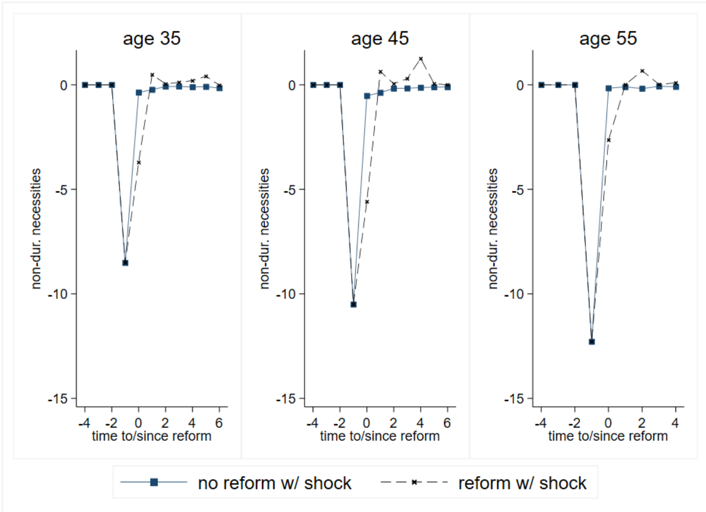
computed separately over the sub samples of net sellers (N_s) and net buyers (N_b).

D Additional Results from Tax Experiments

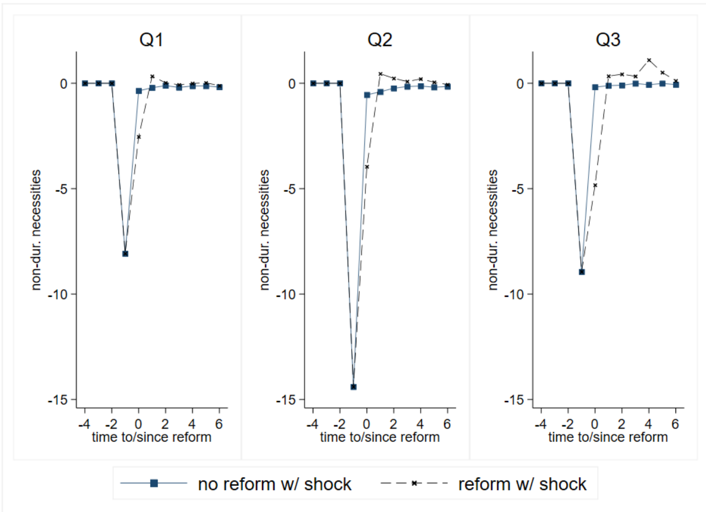
D.1 Temporary VAT cut on non-durable luxuries

Figure 12: Effects of reform on non-durable necessities

(a) by age



(b) by total income terciles



(c) by total wealth terciles

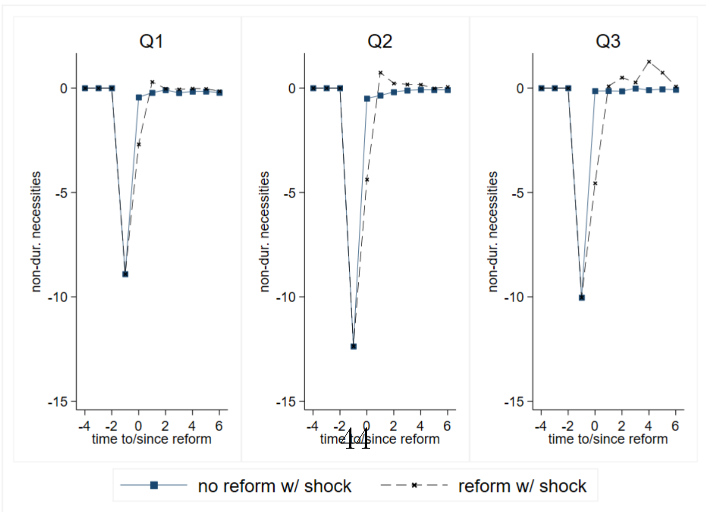
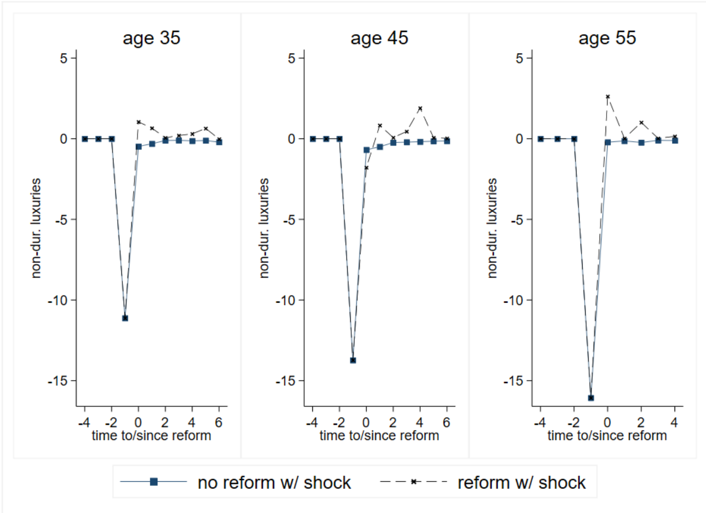
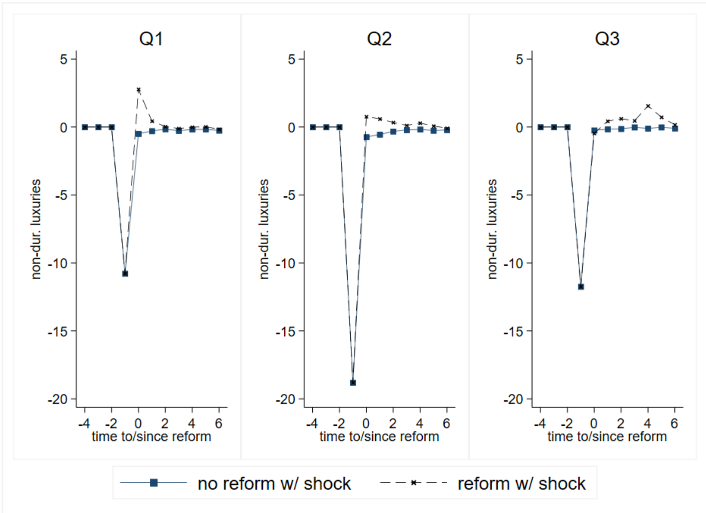


Figure 13: Effects of reform on non-durable luxuries

(a) by age



(b) by total income terciles



(c) by total wealth terciles

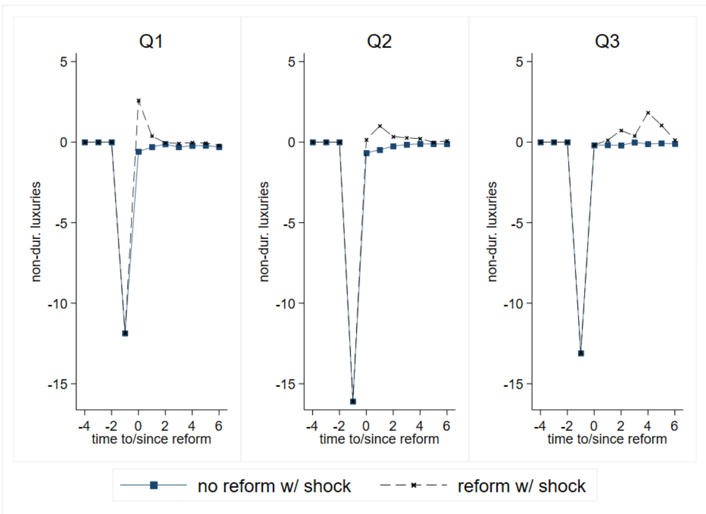
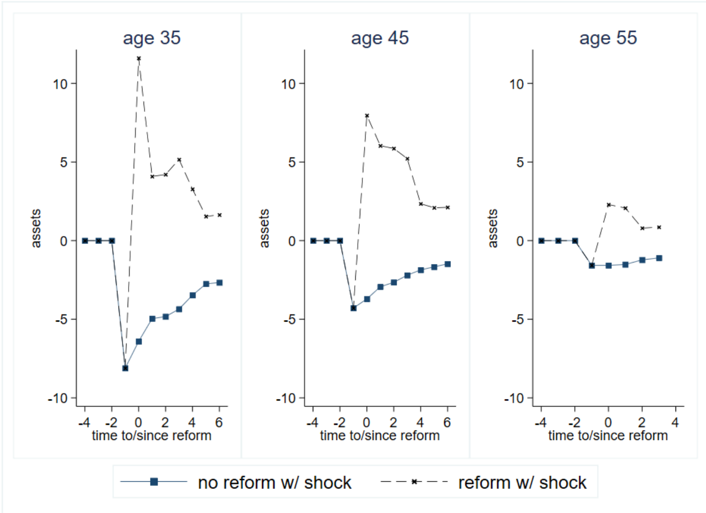
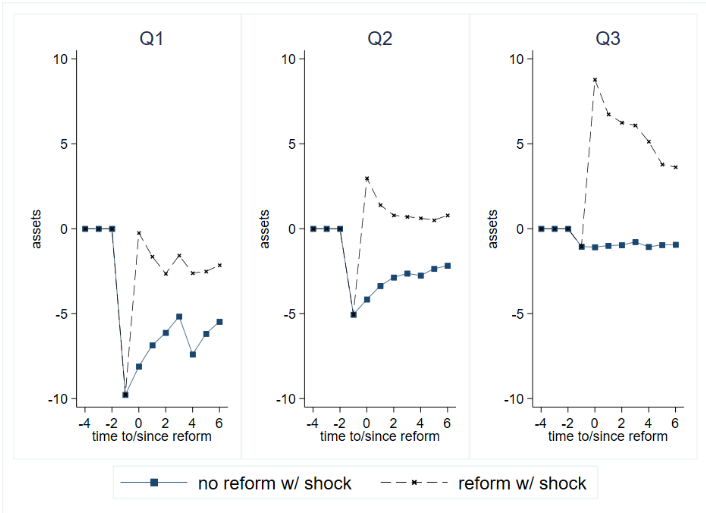


Figure 14: Effects of reform on savings

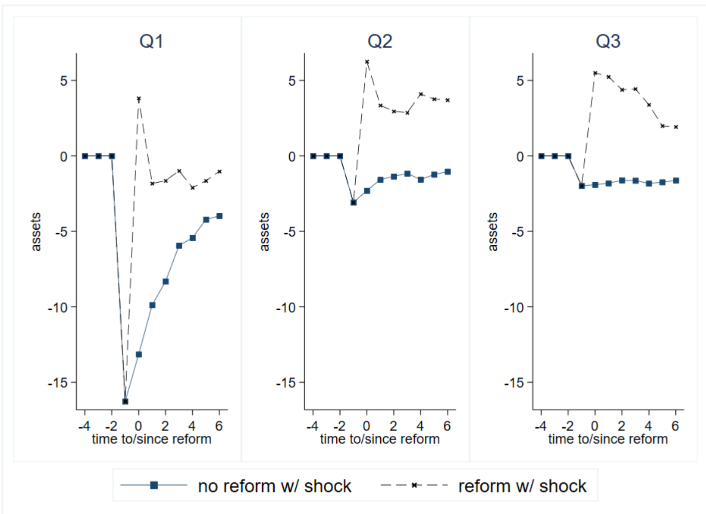
(a) by age



(b) by total income terciles



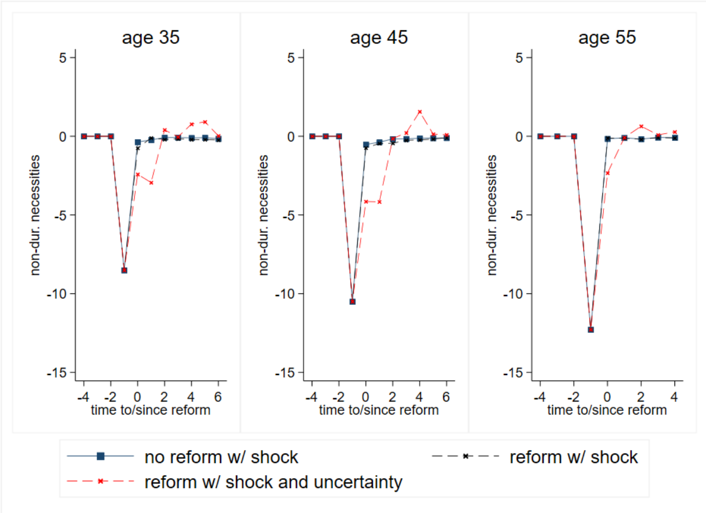
(c) by total wealth terciles



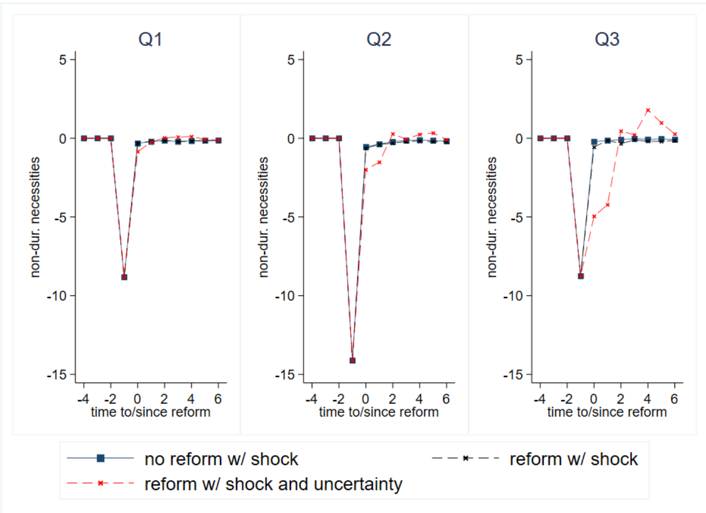
D.2 Temporary VAT cut on durables

Figure 15: Effects of reform on non-durable necessities

(a) by age



(b) by total income terciles



(c) by total wealth terciles

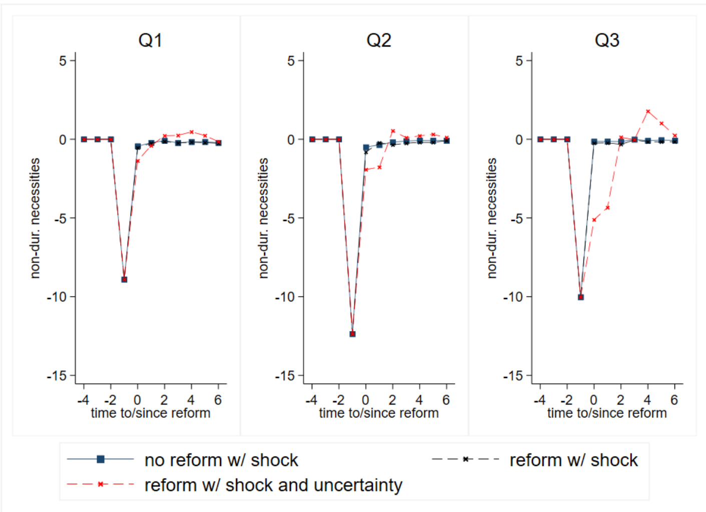
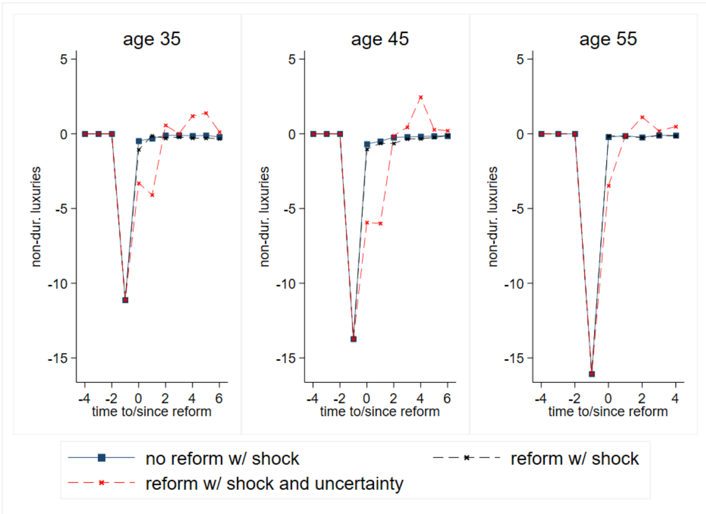
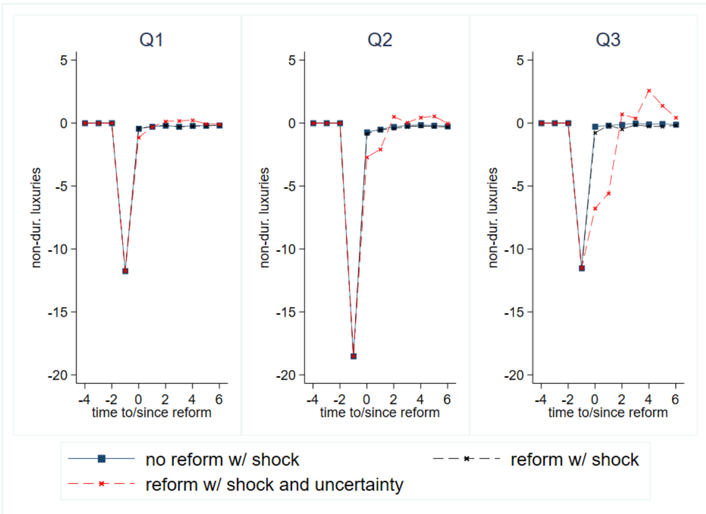


Figure 16: Effects of reform on non-durable luxuries

(a) by age



(b) by total income terciles



(c) by total wealth terciles