Interpreting Sensitivity

The Aggregate Effects of Comovement and Liquidity Constraints

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Abstract

The standard interpretation of aggregate excess sensitivity is that it represents the economy share of non-Ricardian households. However, household level evidence suggests that excess sensitivity can also be explained by the comovement of consumption and income over the lifetime, which occurs due to retirement and changes in household size. If aggregate estimates of excess sensitivity can in part be attributed to the accumulated effect of comovements at the household level, it would significantly alter the policy implications of these estimates. The reason is that unlike under the non-Ricardian interpretation, the comovement interpretation of excess sensitivity does not imply that households would raise consumption due to temporary increases in income. This study is a first attempt to investigate whether aggregate excess sensitivity is in part determined by changes in the national age distribution. I estimate an aggregate intertemporal consumption function and investigate the degree to which excess sensitivity varies with growth in various age cohorts by means of interactions. My results indicate that there is cross-country heterogeneity in what drives aggregate excess sensitivity, and that retirement and shrinking household sizes are significant factors in some countries.

Keywords: excess sensitivity, comovement, non-Ricardian households, liquidity constraints, retirement puzzle

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1 Introduction

The textbook version of the permanent income hypothesis has long since been rejected. Contrary to what was initially proposed by scholars such as Friedman (1957) and Modigliani & Brumberg (1954, 1980), empirical evidence across several countries continues to assert that consumption is positively correlated with income. The causes of this phenomenon, commonly known as *"excess sensitivity"*, have been a topic of discussion for decades (Attanasio & Weber, 2010).

A common explanation is that a fraction of consumers are subject to *"binding liquidity constraints"*, meaning that they earn less than their permanent income and cannot borrow enough to make up the difference. Attempting to maximize utility, these agents consume their entire disposable income as well as any raise or windfall that does not cause their current income to exceed their permanent. Since this theory suggests that consumption and income are uncorrelated for "normal" households but increase at a 1:1 rate for liquidity constrained households, estimates of excess sensitivity are often interpreted as the population share of the latter (The National Institute of Economic Research, 2023).

In fact, this interpretation is explicit in several models employed by both central banks and governments to forecast and evaluate policy.[1] The reason is that excess sensitivity has significant policy implications under the liquidity constraints explanation, because it suggests that governments are able to stimulate consumption by increasing household disposable income. This justifies use of expansionary fiscal policies in the form of direct transfers to households, such as the recent U.S. stimulus checks under the "CARES" act and the Japanese counterpart, the "Special Cash Payment" (Coibion et al., 2020).

However, studies of household level data have revealed that there are other explanations for excess sensitivity, among the more popular of which are the "*retirement puzzle*" and changes in household size. These explanations are derived from the observation that consumption and income tend to move in tandem over the lifetime, increasing up until the late middle-ages and decreasing thereafter. Evidence provided by authors such as Browning & Ejrnaes (2009) suggests that the reason for comovement is that people tend to have children around the same time as their income increases and retire around the same time

[1] Examples include the Federal Reserve's "FRB/US" model (Brayton et al, 2014) and the Swedish National Institute of Economic Research's "SELMA" model (The National Institute of Economic Research, 2023).

as their children move out. Since having children is associated with added consumption, the income-age and consumption-age profiles will coincide. Naturally, the policy implications of this explanation are highly different from that of liquidity constraints, because coincidental comovement does not imply that consumption will respond to temporary increases in income. In fact, for some countries there is even evidence to suggest that consumers abide by the permanent income hypothesis when investigating data that has been adjusted to account for changes in household size (Attanasio & Weber, 2010).

Since it has been demonstrated that comovement can account for excess sensitivity at the household level, it could be that estimates at the national level are in part determined by the accumulated effect of changes in household size and retirement. The widespread use of the excess sensitivity metric, combined with its different policy implications under the comovement and liquidity constraints explanations, makes this a pertinent question for both policy and forecasting. Of course, the two explanations are not mutually exclusive, but attributing all aggregate sensitivity to liquidity constraints will overpredict the effect of temporary income changes if sensitivity is in part determined by comovement.

In this paper, I contribute to the existing literature on excess sensitivity and its underlying causes by testing how the standard aggregated model with liquidity constrained households is affected when interacted with changes in national age distributions. Using quarterly data on aggregate consumption, income and sizes of various age cohorts, I begin by reproducing the Campbell & Mankiw (1991) analysis of excess sensitivity using newer data for Costa Rica, France, Israel, Japan, Sweden, and the U.K., and investigate whether the international patterns of excess sensitivity are reflected in international changes in age distributions. I then test how the countries' respective estimates of excess sensitivity are affected by interaction with growth in various age cohorts. My results indicate that there is cross-country heterogeneity in what drives aggregate excess sensitivity, and that retirement and shrinking household sizes are significant factors in some countries.

The paper is organized as follows: section 2 reviews theoretical background on excess sensitivity and its causes, as well as presents my contribution. Section 3 presents an overview of the data. Section 4 explains and discusses estimation methodology. Section 5 presents the results and analysis, and section 6 concludes the paper.

2 Theoretical Background & Contribution

2.1 The Permanent Income/Life Cycle Model

In contemporary macroeconomics, the theoretical foundation for consumer behaviour is the "life cycle model", or "permanent income hypothesis" (Attanasio & Weber, 2010). The framework was initially developed by Friedman (1957) and Modigliani & Brumberg (1954) in an attempt to explain some empirical evidence which contradicted the previous workhorse: Keynes' fundamental psychological law. In particular, it had become increasingly clear that: (i) agents are less likely to alter consumption in response to temporary changes in income than they are in response to permanent changes, (ii) higher levels of income are correlated with lower savings rates, and (iii) positive income shocks induce higher savings rates than negative shocks (Attanasio & Weber, 2010).

The permanent income hypothesis/life cycle model was able to explain these observations by contending that consumers are forward-looking and have concave utility functions. As such, they prefer to smooth consumption over the span of their lives and thus aim to consume relative to their lifetime *average* income, or "*permanent*" income, rather than their current one. Any temporary change in income that does not alter the consumer's permanent level will hence be offset by an equal increase or decrease in savings, leaving consumption unaffected. The preferences also result in a lifetime consumption pattern under which agents borrow early in life, repay debt and save as middle-aged, and dissave when elderly (Attanasio & Weber, 2010).

The permanent income/life cycle model received widespread recognition as a theoretical framework, but the claim that consumption is unresponsive to temporary income changes has since been criticized on empirical grounds. For instance, Campbell & Mankiw (1991) were able to show that in some countries, a percentage increase in aggregate income can increase aggregate consumption by almost exactly as much. Furthermore, authors such as Carroll & Summers (1991) have provided evidence to suggest that income and consumption move in tandem over the lifetime. Much like income, consumption tends to increase up until the late middle-ages and decrease thereafter. The apparent relationship between consumption and income is commonly known as "*excess sensitivity*", and two potential explanations for it are reviewed in the following sections.

2.2 The Liquidity Constraints Explanation

A common explanation for excess sensitivity is that a fraction of consumers are unable to consume their permanent income. The reason is that they earn less than their permanent income and are subject to "*binding liquidity constraints*", meaning that they cannot borrow enough to make up the difference. Under such conditions, agents are consuming below their optimal level and will increase consumption when given the chance, thus responding to any type of increase in income (Attanasio & Weber, 2010).

Among the more influential papers in this part of the literature is Campbell & Mankiw (1991), who formulated a model of aggregate intertemporal optimization in which there are two types of agents: *"Ricardian"* households who consume their permanent income and *"non-Ricardian"* households who consume their current income.[2] Deriving a consumption function under this condition, the authors show that excess sensitivity is exactly equivalent to the share of aggregate income that accrues to non-Ricardian households. The authors subsequently estimate the function using U.S., U.K., Japanese, Swedish, French and Canadian data to show that excess sensitivity is higher for countries with stricter financial regulation. This indicates that the liquidity constraints explanation holds, since more regulated markets should decrease household access to capital and thus generate more non-Ricardian households. However, the authors were conversely unable to show that sensitivity had decreased over time in countries that had undergone deregulation (Campbell & Mankiw, 1991).

Although the Campbell & Mankiw (1991) interpretation of excess sensitivity has received widespread recognition, their partial failing to find concrete evidence of liquidity constraints is a common result in the literature. As noted in Attanasio & Weber (2010), the presence of excess sensitivity is in itself the most commonly referenced proof of such constraints. Authors such as Jappelli (1990) have attempted to show they exist by surveying U.S. loan applicants and ask if they were denied, but they may have been so due to creditors making another (more accurate) assessment of their permanent income. While such consumers should still be responsive to income changes, it can hardly be argued that they are constrained. This problem also makes it difficult to assert that cross-country

[2] Actually, Campbell & Mankiw (1991) referred to these agents as "permanent-income consumers" and "rule-of-thumb" consumers. However, in contemporary literature, "Non-Ricardian" and "Ricardian" households is the standard terminology and will hence be used throughout this paper.

differences in sensitivity are caused by differences in capital accessibility.

An approach that has been more successful in proving the liquidity constraints explanation is to use microdata to evaluate actual consumer responses to changes in income or the degree of financial regulation. A prominent example is Alessie et al. (1995), who analysed the period of financial deregulation in the U.K during the 1980's and the associated boom in consumption. Using survey data on thousands of households, the authors estimated a model of intertemporal optimization and found evidence that car purchases had risen as a result of deregulation, indicating liquidity constraints. However, a key insight of the paper was that the results *only* applied to certain age groups. In particular, the authors noted that liquidity constraints applied to the youngest individuals in their sample (ages 25-26), to a lesser extent for somewhat older individuals (ages 29-33), and not at all for those older than 33.

That liquidity constraints especially apply to young people is a common observation in the literature. It can be explained by the fact that access to credit is typically determined by criteria such as the applicants earnings and stock of assets (collateral), both of which are to the disadvantage of younger agents. Indications of this can be found in Jappelli's (1990) analysis of U.S. survey data, where both reasons were listed as causes for rejected loan applications. Other reasons included lack of credit history, type of job and time at current job, further indicating bias towards the young. More recent examples include the analysis of U.S. credit card data provided by Agarwal et al. (2007). Using distributed lag models, Agarwal et al. (2007) evaluated the response of cardholders to the 2001 tax rebate depending on individual characteristics. The results indicated that spending and debt accumulation increased as a response to the temporary increase in income, especially so for young people (below the age of 35) and those who had lower credit limits.

2.3 The Household Size & Retirement Explanations

Although the liquidity constraints explanation sufficiently accounts for the phenomenon of excess sensitivity, there is one characteristic of consumption that it does not address: the lifetime *comovement* of consumption with income. As first noted by Tobin (1967), consumption is not only volatile but also follows a certain pattern with respect to the consumer's maturity. Specifically, as shown for several countries by Carroll & Summers

(1991), both consumption and income tend to increase in the first half of life, peak during the late late middle-ages, and decrease thereafter. Virtually the only difference between these "*consumption-age*" and "*income-age*" profiles is that the latter curve is steeper than the former.

The most commonly referenced explanation for comovement of income and consumption is the coincidence of productivity increases, retirement, and changes in household size. Naturally, income tends to increase during an agent's working life due to accumulation of experience and education, and tends to decrease sharply following retirement. This evolution is intimately associated with changes in household size because people tend to have children early in life and retire around the same time as their children move out. Since having children is related to increases in consumption of items such as food, clothing, education, health care, and so on, the consumption-age profile will follow the same pattern as the income-age profile (Browning & Ejrnaes, 2009).

The most common approach to investigating the household size explanation is to use survey data on individual households. Among the more noteworthy contributions are Browning & Ejrnaes (2009), who estimate a "children response function" using data from the U.K. Family Expenditure Survey. Besides finding that having children does indeed increase consumption, the authors also show that these added expenditures increase with the age of the child. In addition, their results indicate that while having more than one child increases consumption even further, scale effects ensure that these added expenses are only a fraction of those of the first child. According to Browning & Ejrnes (2009), the combination of these findings perfectly explain the "hump-shape" of the consumption-age profile. Similar results have also been found for the U.S. using household data from the Consumer Expenditure Survey (Attanasio et al, 1999).

However, contrary to the findings of Browning & Ejrnaes (2009) and Attanasio et al. (1999), some authors have found that there is one deviation from the household size explanation that is often recurring in the data: the substantial drop in consumption following retirement. While reduced consumption during this part of life is to be expected under the household size explanation, authors such as Banks et al. (1998) show that the effects of children are often too small to account for the recorded drops. For example, Banks et al. (1998) used U.K. household data from the Family Expenditure Survey to show that predictions of the retirement consumption drop under the household size explanation underestimate the *de facto* drops by as much as 1.5 percent annually. The authors also rule out explanations such as liquidity constraints and planned early retirements. Bernheim et al. (2001) reached similar results using U.S. household level data.

The retirement drop in consumption and its incompatibility with the household size explanation has confounded scholars for decades and has even been dubbed the "retirement puzzle" (Attanasio & Weber, 2010). However, there are some potential explanations. A candidate is that retirement alters consumption patterns since consumers no longer need to use transportation from and to work, they have time to reflect and make efficient consumption choices, they do not need to dine out as much, *et cetera*. However, as pointed out in Hurd & Rohwedder (2006), these expenses are not large enough to explain the entire deviation. The authors therefore argue for complementing the altered consumption patterns with other reasons, such as *unanticipated* early retirements due to health reasons, as well as an increased ability to engage in leisurely activities other than consumption.

2.4 Contribution

In the previous subsections, I have outlined two common explanations for the empirical deviation from the life cycle model/permanent income hypothesis: (i) that a fraction of consumers are liquidity constrained and are hence unable to consume their permanent income, (ii) that income and consumption comove over the lifetime due to changes in household size and the "retirement puzzle". Although both explanations are common in the literature, research regarding changes in household size or the retirement puzzle are often confined to studies of household level data. Conversely, estimates of excess sensitivity at the national level are almost exclusively interpreted as the national share of non-Ricardian households. In particular, this interpretation is common in models used by both governments and central banks in order to evaluate policy (e.g. Brayton et al., 2014). The reason is that excess sensitivity has significant policy implications under the liquidity constraints explanation, because it implies that governments are able to stimulate consumption by increasing household income (Coibion et al., 2020). Conversely, the retirement puzzle and the household size explanation have no such implications.

My contention is simple: if retirement and changes in household size causes consumption to comove with income at the household level, then it is possible that the accumulated effect of such occurrences is apparent in the aggregate. In other words, estimates of excess sensitivity at the national level could in part be attributed to changes in the *national age distribution* and not only the share of liquidity constrained households. Specifically, we should see that: (i) the national degree of excess sensitivity is positively correlated with growth in age cohorts that are associated with expanding household sizes, and that such growth has a directly positive effect on aggregate consumption, (ii) the degree of excess sensitivity is positively correlated with growth in age cohorts that are associated with shrinking household sizes and retirement, and that such growth has a directly negative effect on aggregate consumption.

In addition, if the national degree of excess sensitivity is affected by changes in the national age distribution, then international patterns of excess sensitivity may also be reflected in international patterns in age distributions. However, this relies on the assumption that the degree to which consumption is affected by retirement and changes in household size is similar among countries. If country A experiences significantly higher growth in the number of retirees or expanding households than country B, then excess sensitivity in B could still be higher than in A if the retirement puzzle/household size explanation is more prominent in B. For example, this could potentially be the case if countries differ in their retirement schemes or in funding for child health care and schooling. However, investigation of potential causes is beyond the scope of this paper.

Finally, previous literature also suggests that changes in the national age distribution could be helpful in indicating the degree to which liquidity constraints affect excess sensitivity. The reason is that constraints have been shown to especially apply to younger agents due in part to their low incomes and lack of assets. Specifically, if liquidity constraints are affecting the degree of excess sensitivity, then we should see a positive correlation between national excess sensitivity and growth in the number of young people, and that such growth has a directly negative effect on aggregate consumption. However, this relies on the assumption that young people are especially constrained in all countries, which is not necessarily the case. For example, it might be that younger agents in certain countries are able to consume their permanent income due to access to sizeable student loans or cultural aspects such as a tendency to leave the parental home at an older age. Once again, investigation of potential causes is beyond the scope of this paper.

3 Data

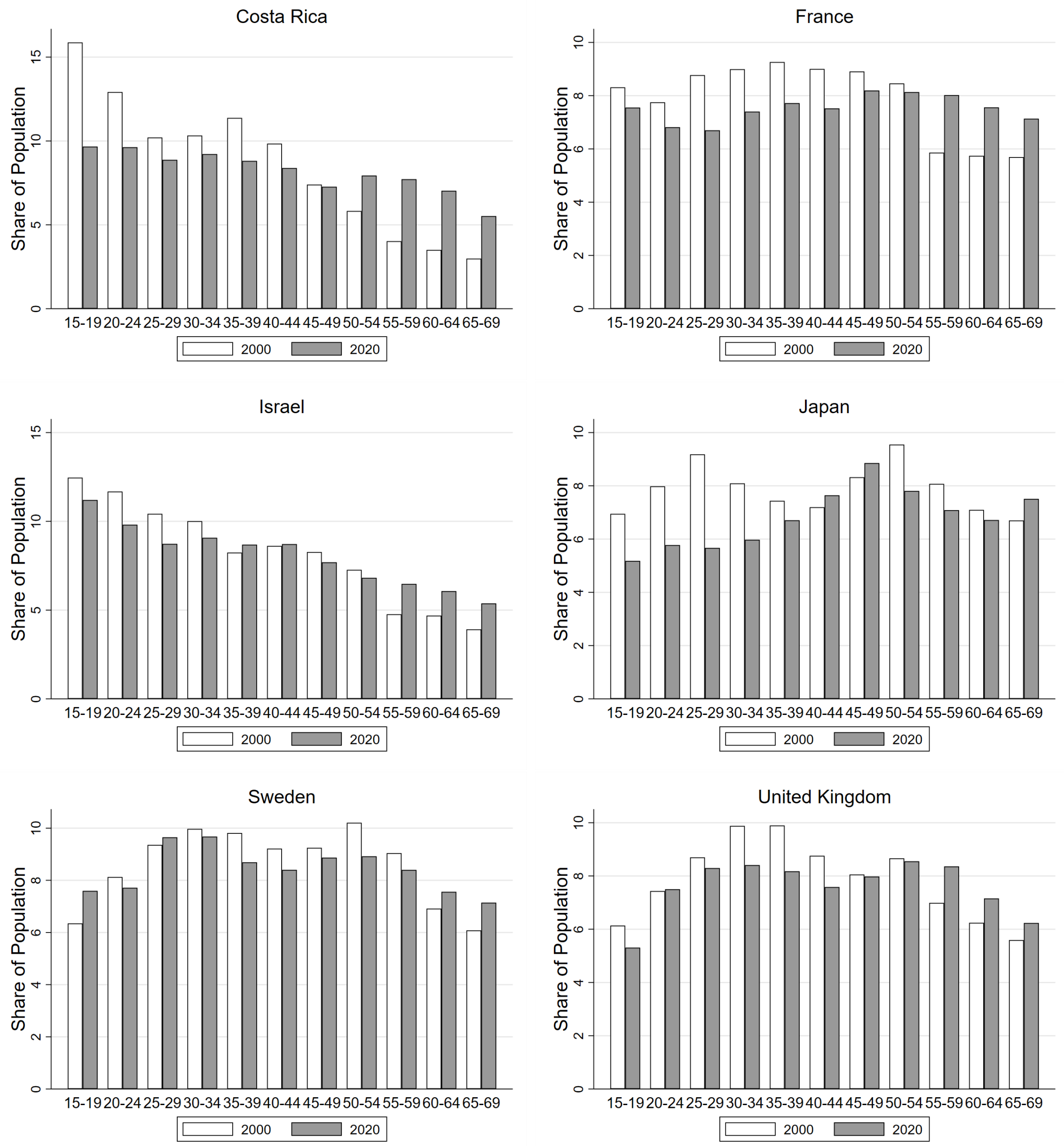
The sample used in this paper consists of quarterly aggregate data on consumption, income, and population age during the period 2000-2020. The countries that have been included are Costa Rica, France, Israel, Japan, Sweden and the United Kingdom, and these have been chosen for two reasons: (i) France, Japan, Sweden and the U.K. were also included in Campbell & Mankiw (1991). Since this paper includes a reproduction of their analysis using more recent data, choosing these countries allows for investigation into how their degrees of excess sensitivity have evolved over time. (ii) These countries are (arguably) economically comparable but differ in their age distributions, as is evident from Figure 1 below. These conditions are helpful when analysing how excess sensitivity varies with changes in age distributions.

More specifically, judging from the countries' 2020 distributions, Costa Rica and Israel have relatively young populations, Japan and France have relatively old, and Sweden and the U.K. are more normally distributed. Even more importantly, since the analysis is primarily concerned with *intra*national changes, there have been substantial movements in the age compositions of most countries. The general pattern is that all populations are aging, with the sole exception that the Swedish cohort 15-19 has increased.

As is the standard practice when analysing excess sensitivity, data on consumption is restricted to that of non-durable goods, semi-durable goods, and services (Attanasio & Weber, 2010). Consumption data for Costa Rica, France, Israel, Sweden and the U.K. have been collected from the OECD Quarterly National Accounts (2023A), and Japanese data have been collected from the Cabinet Office of Japan (2022A). All data were originally measured in national currencies at current prices and had been adjusted to account for seasonality in consumer behaviour, such as an added preference for consumption during the summer or around the holidays. Conversion of the data to per capita growth rates in constant 2015 prices has been achieved through own calculations, using data on each country's consumer price index and quarterly population data (OECD, 2023A; Statistics of Japan, 2020). Following Campbell & Mankiw (1989; 1991), the data have also been converted to logarithmic form.

As is also the standard practice, the analysis focuses on disposable income rather than actual income (Attanasio & Weber, 2010). While these should of course be highly corre-

Figure 1: Age Distributions, 2000 - 2020



Source: OECD (2023B)

lated, using disposable income makes for a clearer interpretation of the results since this is the only part of one's income that should affect the marginal propensity to consume. Due to data availability and for purposes of consistency across countries, disposable income is also measured net of consumption of fixed capital (i.e., depreciation). This has been achieved through own calculations for France, Japan and the U.K. using data from the OECD Quarterly National Accounts (2023A) and the Cabinet Office of Japan (2022B). Income data for Costa Rica and Israel have been collected from the OECD Quarterly National Accounts and data from the other countries have been collected from their respective statistics authorities (Statistics Sweden, 2023; National Institute of Statistics & Economic Studies, 2023; Office for National Statistics, 2023; Cabinet Office of Japan, 2022C). All data are seasonally adjusted and have been converted to logarithmic per capita growth rates in constant 2015 prices through own calculations, using data on each country's consumer price index and quarterly population data (OECD, 2023A; Statistics of Japan, 2020).

Due to differences in data availability, the analysis focuses on different age segments depending on which country is being considered.[3] For Israel and Costa Rica, the "young" cohort is defined as ages 15-24, and the cohort associated with shrinking household sizes and retirement (the "old" cohort) is ages 55-64.[4] While these segments are available for France and Sweden as well and could be used for greater consistency, the analysis of these two countries will instead focus on the segments 20-24 (the "young cohort"), 30-39 (cohort associated with expanding households, or the "parents" cohort), and 50-69 (the "old" cohort). The reason is that these segments correspond better to both the liquidity constraints explanation and the household size/retirement explanation. As discussed in section 2, the household size explanation suggests that income and consumption move in tandem over the life span due to people having children around the same time as their income increases and tend to retire around the same time as their children move out. The segments 30-39 and 50-69 are assumed to sufficiently capture such effects. Similarly, the liquidity constraints explanation suggests that consumption responds positively to temporary increases in disposable income because agents are unable to consume their permanent income, which empirical evidence suggests should be particularly prevalent in younger agents. Based on previous literature reviewed in section 2.2, the segment 20-24 should sufficiently capture this effect, which is at risk of being diminished by inclusion of the segment 15-19 since it is reasonable to suspect that most teenagers in these countries are not income earners and do not control their own consumption. Age data for France and Sweden have been collected from Eurostat (2023), and data for Costa Rica and Israel have been collected from the OECD Quarterly National Accounts (2023A).

[3]Japan and the U.K. are not included in this part of the analysis for reasons which are explained in section 5.2.

[4]Due to lack of data, Israel and Costa Rica do not have a cohort associated with expanding households.

4 Method

4.1 The Campbell & Mankiw Model

In order to analyse excess sensitivity at the national level, I begin by estimating the Campbell & Mankiw (1989, 1991) model of aggregate intertemporal optimization. Unlike in the standard life cycle model, the Campbell & Mankiw (1991) framework allows for two types of households. The first type, represented by a fraction "(1-λ)", are *"Ricardian"*, meaning that they abide by the permanent income hypothesis. The second type, represented by a fraction "λ", are *"non-Ricardian"* and contradict the hypothesis by consuming their current income.[5] As discussed in section 2.2, Campbell & Mankiw's (1991) assumption as to why non-Ricardian households stray from the permanent income hypothesis is that they are liquidity constrained and cannot consume their optimal amount.

Under this assumption, Campbell & Mankiw (1991) express aggregate consumption as:

$$C_t = \lambda Y_t + (1 - \lambda) YP_t \tag{1}$$

where C_t is aggregate consumption, Y_t is aggregate current income and YP_t is aggregate permanent income, all at time t. This implies that the change in consumption from time $t-1$ to t is equal to:

$$\Delta C_t = \lambda \Delta Y_t + (1 - \lambda) \Delta YP_t \tag{2}$$

And, since changes in permanent income are unforecastable, equation (2) can be expressed as:

$$\Delta C_t = \lambda \Delta Y_t + (1 - \lambda) \varepsilon_t \tag{3}$$

where ε_t is a stochastic error term.

By the interpretation of Campbell & Mankiw (1989, 1991), it is clear from equation (3) that any excess sensitivity observed from regressing changes in aggregate consumption on changes in aggregate income is equal to the economy share of non-Ricardian households, λ. However, the derivation of equation (3) builds on the notion that aggregate consumption

[5] Actually, Campbell & Mankiw (1991) interpret λ as the *share of total income* accruing to non-Ricardians, and $(1 - \lambda)$ as that which accrues to Ricardians. However, later studies that use the same framework and/or the exact estimates of Campbell & Mankiw (1991) choose to interpret λ as discussed above (see, for example, the National Institute of Economic Research (2023)).

and income are linear functions, which is not necessarily true. Following Campbell & Mankiw (1991), I instead assume that both variables are driven by log-linear processes. Under this assumption, consumer utility can be expressed as the function:

$$u(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma} \tag{4}$$

where γ is a measure of risk aversion. This yields the Euler equation:

$$1 = E_t \left[\beta R_{t+1} (\frac{C_{t+1}}{C_t})^{-\gamma} \right] \tag{5}$$

where E_t symbolizes expectations at time t and R_{t+1} is the real interest rate at time $t+1$. Converting the function to logarithmic form and simplifying yields:

$$E_{t-1}\Delta c_t = \mu^* + \frac{1}{\gamma} E_{t-1} r_t \tag{6}$$

where small letters indicate logarithmic variables. Translating equation (6) into the Campbell & Mankiw (1991) framework with two types of consumers:

$$E_{t-1}\Delta c_t = \lambda E_{t-1}\Delta y_t + (1-\lambda) \left[\mu^* + \frac{1}{\gamma} E_{t-1} r_t \right] \implies \tag{7}$$

$$\Delta c_t = \mu + \lambda \Delta y_t + (1-\lambda)\frac{1}{\gamma} r_t + \varepsilon_t \tag{8}$$

where $\mu = (1-\lambda)\mu^*$. Finally, I follow the first part of Campbell & Mankiw's (1991) study by assuming constant real interest rates, so that equation (8) simplifies to:

$$\Delta c_t = \mu + \lambda \Delta y_t + \varepsilon_t \tag{9}$$

From equation (9) it is clear that the coefficient λ can also be obtained by regressing logarithmic aggregate consumption on logarithmic aggregate income. All though this equation should fit the data better than equation (3), a downside to making this choice is that it somewhat compromises the interpretation of the results, which is now equal to the *percentage* change in consumption from a *percentage* change in income.

Nevertheless, for purposes of consistency and comparability, I follow Campbell & Mankiw (1991) and focus on estimation of equation (9). However, a problem with this approach is that changes in permanent income at time t (which are captured in the error term) are sometimes caused by changes in current income at time t. Δy_t is therefore likely to be endogenous and must somehow be instrumented. Fortunately, the model explicitly assumes that changes in permanent income (ε_t) can only be caused by changes in current income (Δy_t) or by expectations of *future* changes in current income ($E_t[\Delta y_{t+n}]$). It does not make sense for changes in permanent income at time t to be caused by changes in current income at times *prior* to t, because non-temporary changes in current income would immediately change the consumer's perception of lifetime average income. In other words, changes in permanent income (ε_t) are orthogonal to changes in current income at all times prior to t (Δy_{t-n}), meaning that Δy_t can be instrumented by Δy_{t-n} provided that they are correlated. By the same reasoning, changes in consumption at times prior to t (Δc_{t-n}) should be orthogonal to changes in permanent income at time t (ε_t). Combined with the assumption that a fraction of households are Ricardian and thus alter their consumption based on future expectations of income changes, lagged consumption changes (Δc_{t-n}) should also work as an instrument for Δy_t (Campbell & Mankiw, 1991).

Table 4.1: Forecasting Income Growth

		Lags 1-4			Lags 2-4		
Country	Sample Period	R_1^2	R_2^2	F-test	R_1^2	R_2^2	F-test
Costa Rica	2001(1)-2020(4)	-0.032	0.077	0.007	-0.020	0.043	0.012
France	2001(1)-2020(4)	0.176	0.255	0.000	0.182	0.206	0.004
Israel	2001(1)-2020(4)	0.005	0.051	0.026	-0.029	0.002	0.432
Japan	2001(1)-2020(4)	0.382	0.381	0.000	0.233	0.218	0.000
Sweden	2001(1)-2020(4)	0.193	0.328	0.000	0.089	0.118	0.000
U.K.	2001(1)-2020(4)	-0.003	0.053	0.018	0.010	0.017	0.236

Column 3 reports the adjusted R^2 from regressing Δy_t on its 1st, 2nd, 3rd, and 4th lags. Column 4 reports the same statistic from regressing y_t on the 1st, 2nd, 3rd, and 4th lags of income and consumption growth, and $c_{t-1} - y_{t-1}$. Column 5 reports the joint significance levels associated with running the same regression as in column 4. Columns 6-8 report the corresponding statistics from columns 3-5 after removing lag 1 from consumption and income growth, and lagging $c - y$ one more period.

The validity of lagged consumption growth and lagged income growth as instruments for contemporary income growth are tested in Table 4.1. Column 3 reports the adjusted R^2

from running Δy_t on its first, second, third and fourth lags. Column 4 reports the same statistic from running Δy_t on the first, second, third and fourth lags of both Δy_t and Δc_t, as well as on on $c_{t-1} - y_{t-1}$. As can be read, adding lagged consumption variables increases the fit for all countries in the sample except Japan, for which it remains the same. Column 5 reports the joint significance levels associated with running the second regression.

Similarly, column 6 reports the adjusted R^2 from running Δy_t on its second, third and fourth lags. Column 7 reports the same statistic from running Δy_t on the second, third and fourth lags of both Δy_t and Δc_t, as well as on on $c_{t-2} - y_{t-2}$. The results in columns 6-7 are highly similar to those of columns 3-4, except that the changes in fit from adding lagged consumption variables are smaller for all countries and causes a substantial drop for Japan. In addition, the adjusted R^2 associated with adding lagged consumption variables is smaller in column 7 than in column 5 for all countries. Finally, column 8 also reports that the null hypothesis of the joint significance test is rejected for both Israel and the U.K. Based on these results, I conclude that lags 1-4 are better instruments than lags 2-4 and will use the former going forward.[6]

4.2 Interpreting Excess Sensitivity

Having produced estimates of λ for each country in the sample, I will expand the analysis by testing the coefficient's interpretation. As previously discussed, the Campbell & Mankiw (1991) framework interpretation is that λ represents the economy share of non-Ricardian households. By contrast, the contention of this paper is that it might also capture the effects of the household size explanation and the retirement puzzle. As discussed in section 2.4, if λ captures such effects, then we should see that: (i) λ is positively correlated with growth in age cohorts that are associated with expanding household sizes, and such growth has a directly positive effect on aggregate consumption, (ii) λ is positively correlated with growth in age cohorts that are associated with shrinking household sizes and retirement, and such growth has a directly negative effect on aggregate consumption. Finally, if liquidity constraints are captured in λ, then we should also see that: (iii) λ is positively correlated with growth in the number of young people, and such growth has a

[6]Interestingly, that lags 1-4 outperform lags 2-4 is the opposite of what Campbell & Mankiw (1991) found.

directly negative effect on aggregate consumption.

In order to test these hypotheses, I expand on equation (9) by adding two variables:

$$\Delta c_t = \mu + \lambda \Delta y_t + \alpha_1 \Delta z_{i,t-1} + \alpha_2 \Delta(y_t * z_{i,t-1}) + \varepsilon_t \quad (10)$$

where Δz_i is the period growth in age cohort i and $\Delta(y_t * z_i)$ is an interaction term between growth in age cohort i and income growth. In order to assure that consumption has time to adjust to changes in cohort i, z_i is lagged one period in both instances.

There are three advantages to estimation of equation (10). First, the specification is highly similar to others that have been used to analyse household level effects of household sizes and retirement, such as Attanasio & Weber (1993). In other words, equation (10) is consistent with the theoretical frameworks of these explanations. Specifically, similar functions are typically derived from utility functions which allow for discount rates depending on household characteristics, such as in Banks et al. (1998). Second, the methods used to estimate equation (10) in previous literature are similar to those used to estimate λ in the first part of the analysis. In particular, income growth is often assumed to be endogenous in the household size/retirement framework as well, and is instrumented using several lags of income and consumption growth (Banks et al, 1998; Attanasio & Weber, 1993). In other words, equation (10) can be estimated using the same method as for equation (9), and the results of equation (10) can thus be attributed solely to the addition of $\Delta z_{i,t-1}$ and $\Delta(y_t * z_{i,t-1})$.

Third, and most importantly, including $\Delta z_{i,t-1}$ and $\Delta(y_t * z_{i,t-1})$ and running the regression three times (once for each relevant age cohort) sufficiently addresses hypothesis (i), (ii), and (iii). Since the variable $\Delta(y_t * z_{i,t-1})$ is an interaction term between two continuous variables, the coefficient α_2 can be interpreted as the change in slope of consumption on income from growth in age cohort i. In other words, if growth in cohort i is positively (negatively) correlated with excess sensitivity, $\Delta(y_t * z_{i,t-1})$ will enter the regression with a positive (negative) sign. Furthermore, inclusion of the interaction term implies that α_1 can be interpreted as the direct effect of $\Delta z_{i,t-1}$ on consumption growth when income growth is equal to zero, which will reveal whether growth in cohort i has a positive or negative effect on consumption, *all else equal* (Jaccard et al., 1990).

5 Results and Analysis

5.1 International Patterns of Excess Sensitivity

The results of estimating equation (9) are reported in Table 5.1. Columns 4 and 5 report the adjusted R^2 from regressing income growth and consumption growth on the instruments, respectively. Joint significance levels are reported in parentheses. As can be read, the results in column 4 and 5 are somewhat similar for most countries, which indicates that income and consumption are correlated and hence a presence of excess sensitivity. The exception is Japan, for which the null hypothesis of the joint significance test is rejected when regressing consumption growth on the instruments. This is to be expected from the results of Table 4.1, which showed that lagged consumption growth cannot forecast Japanese income growth. It thus seems that Japanese consumption is unaffected by past changes in both income and consumption, indicating a lack of excess sensitivity.

Table 5.1: Estimating equation (9)

Country	Sample Period	R_c^2	R_y^2	λ	Comparison Campbell & Mankiw (1991)
Costa Rica	2001(1)-2020(4)	0.186 (0.000)	0.077 (0.007)	0.512** (0.188)	N.A.
France	2001(1)-2020(4)	0.265 (0.000)	0.255 (0.000)	1.000** (0.318)	0.974** (0.346)
Israel	2001(1)-2020(4)	0.017 (0.000)	0.051 (0.026)	0.654** (0.166)	N.A.
Japan	2001(1)-2020(4)	0.067 (0.747)	0.381 (0.000)	0.229 (0.182)	0.017 (0.439)
Sweden	2001(1)-2020(4)	0.231 (0.000)	0.328 (0.000)	0.584** (0.105)	0.245** (0.428)
U.K.	2001(1)-2020(4)	0.139 (0.016)	0.053 (0.018)	0.285 (0.363)	0.372** (0.106)

Column 3 reports the adjusted R^2 from regressing Δc_t on the instruments of Δy_t, with results of the joint significance test reported in parentheses. Column 4 reports the same statistic from regressing y_t on its instruments, with results of the joint significance test reported in parentheses. Column 5 reports the estimates of λ, with robust standard errors reported in parentheses. ** indicates a significance level of 95%, * indicates a significance level of 90%.

The estimates of λ are reported in column 5, with robust standard errors reported within parentheses. As can be read, the estimates range from 0.285 in the U.K to 1.0 in France and are significant for all countries except Japan and the U.K. [7] Comparing the estimates of λ in column 5 to those of Campbell & Mankiw (1991) in column 6, it appears that excess sensitivity has not evolved in an internationally uniform way. The French estimate has remained stable at a very high rate (increasing slightly from 0.974 to 1.0), the Swedish estimate has more than doubled (from 0.245 to 0.584), the Japanese estimate has increased but remains insignificant (from 0.017 to 0.229), and the U.K. estimate has decreased into insignificance (from 0.372 to 0.285).

Comparing the estimates of λ to the age distributions in Figure 1, it does not appear that the international pattern of excess sensitivity is attributable to changes in age distributions over the past twenty years. If the effects of retirement and changes in household sizes are captured in λ, then we might be able to see that: (i) there is positive correlation between international sizes of λ and international sizes in the age cohort 40-59 at 2000 (indicating the extent of shrinking households and retirement between 2000-2020) (ii) there is positive correlation between international sizes of λ and international sizes in the age cohort 15-19 at 2020 (indicating the extent of expanding households between 2000-2020). Consistency with both (i) and (ii) can be found when comparing Sweden to the U.K. and Japan. However, the Israeli estimate of λ is significantly larger than that of Sweden despite Israel having a smaller 40-59 cohort at 2000, violating (i). This could be explained if household expansion is captured in λ but not the retirement puzzle (or if the former outweighs the latter), but that would not explain why the French estimate is larger than the Israeli despite France having a smaller 15-19 cohort at 2020, violating (ii).

Similarly, if the effects of liquidity constraints are captured in λ, then we might be able to see that: (iii) there is positive correlation between international sizes of λ and growth in the cohort 20-29 over the period (since young people should be especially affected). However, this is violated by Japan having an insignificant estimate of λ and the largest drop in cohort 20-29 of all countries in the sample. Similarly, Sweden and the U.K experienced similar growth in the cohort but differ substantially in estimates of λ.

[7] While an insignificant result for Japan is to be expected given the results of column 4 and Table 4.1, the U.K. result is somewhat more surprising. Judging from Table 4.1, U.K. lagged consumption growth helps to forecast income growth, and the null hypothesis of the joint significance test was not rejected when regressing consumption growth on the instruments.

As discussed in section 2.4, the lack of international patterns in degrees of excess sensitivity and changes in age distributions does not necessarily imply that none of the explanations hold. In fact, such patterns could only exist if the same explanations hold for all countries, if they affect excess sensitivity to the same degree across countries, and if they affect the same age cohorts across countries. Combined, these conditions are quite restrictive. For example, the retirement puzzle might affect all countries in the sample, but less in some due to generous pension schemes. Similarly, a country which has fewer young might still exhibit larger excess sensitivity if it is subject to more financial regulation or if liquidity constraints do not adversely affect the young. Therefore, in the next section, the analysis instead turns to *within*-country analysis of the first and second condition.

5.2 Interaction Effects of Income and Age

The results of estimating equation (10) for $i =$ "young" are reported in Table 5.2 below. Here, "young" is defined differently depending on which country is being considered due to issues of data availability (see section 3). For Costa Rica and Israel, "young" is defined as those in the age span 15-24, and for France and Sweden it is defined as those in the span 20-24. Japan and the U.K. have been excluded from this part of the analysis due to the their absence of excess sensitivity noted in section 5.1.[8] Estimates of α_1 (the coefficient of $\Delta z_{i,t-1}$) are reported in column 4, and estimates of α_2 (the coefficient of $\Delta(y_t * z_{i,t-1})$) are reported in column 5. Robust standard errors are reported within parentheses.

As can be read from columns 4 and 5, the estimates of α_1 and α_2 are significant at the conventional levels for only two countries in the sample: France and Sweden. For both countries, the interaction term enters with a positive sign, implying that excess sensitivity in these countries is positively correlated with growth in the number of young. Furthermore, the estimates of α_1 indicate that in the absence of income growth ($\Delta y_t = 0$), a unit increase in young cohort growth decreases consumption growth by circa 7.5 percent in France and 4.4 percent in Sweden. In other words, growth in the number of young not only increases excess sensitivity, but has a directly negative effect on consumption growth. As hypothesized in section 2.4, these results are consistent with the liquidity constraints explanation of excess sensitivity. Moreover, the French estimates of both α_1 and α_2 are larger than the Swedish, indicating more severe constraints for the young in France.

[8] Naturally, lack of excess sensitivity makes analysis of the interpretation of λ redundant.

Table 5.2: Estimating equation (10) with i = Young

Country	Sample Period	λ	α_1	α_2
Costa Rica	2010(4)-2020(4)	0.648**	0.002	-8.202
		(0.236)	(0.014)	(25.368)
France	2003(2)-2020(4)	1.348**	-0.078**	258.446**
		(0.321)	(0.038)	(52.168)
Israel	2001(1)-2020(4)	0.721**	-0.007	7.966
		(0.178)	(0.029)	(15.477)
Sweden	2003(2)-2020(4)	0.668**	-0.045**	40.095**
		(0.099)	(0.034)	(13.762)

Results of estimating $\Delta c_t = \mu + \lambda \Delta y_t + \alpha_1 \Delta z_{t-1} + \alpha_2 \Delta(y_t * z_{t-1}) + \varepsilon_t$, where Δz_{t-1} is the growth rate in the number of young. "Young" is defined differently depending on which country is being considered. For Costa Rica and Israel, it is the age span 15-24. For France and Sweden, it is the age span 20-24. ** indicates a significance level of 95%, * indicates a significance level of 90%.

That the estimates of α_1 and α_2 are insignificant for Israel and Costa Rica could indicate a lack of liquidity constraints in these countries, or at the very least that potential constraints do not affect the young. However, the differences in definition of the young cohort between Israel & Costa Rica and France & Sweden makes analysis more complicated. As discussed in section 3, inclusion of the span 15-19 in Israel and Costa Rica is likely to weaken the observed effects of liquidity constraints for the young cohort due to the fact that teenagers in these countries are unlikely to earn income and control their own consumption. From a theoretical perspective, interpretation of the results for cohort 20-24 is simpler than for the cohort 15-24, and so it cannot be stated with certainty that young consumers are not constrained in these two countries.

The results of estimating equation (10) for $i =$ "parents" are reported in Table 5.3 below. "Parents" is defined here as the age span 30-39. Once again, estimates of α_1 are reported in column 4 and estimates of α_2 are reported in column 5, with robust standard errors in parentheses. Besides the exclusion of Japan and the U.K (again, due to lack of excess sensitivity in these two countries), Israel and Costa Rica have also been excluded due to issues of data availability (see section 3).

As can be read from column 5, the estimates of α_2 enter with positive signs and are

Table 5.3: Estimating equation (10) with i = Parents

Country	Sample Period	λ	α_1	α_2
France	2003(2)-2020(4)	1.583**	-0.052*	986.081**
		(0.363)	(0.030)	(146.567)
Sweden	2003(2)-2020(4)	0.567**	-0.110*	55.327**
		(0.092)	(0.060)	(27.287)

Results of estimating $\Delta c_t = \mu + \lambda \Delta y_t + \alpha_1 \Delta z_{t-1} + \alpha_2 \Delta(y_t * z_{t-1}) + \varepsilon_t$, where Δz_{t-1} is the growth rate in the number of parents. "Parents" is defined here as the age span 30-39. ** indicates a significance level of 95%, * indicates a significance level of 90%.

significant at the 5 percent level for both France and Sweden. Again, this would indicate that excess sensitivity in these two countries is positively correlated with growth in ages that are associated with expanding household sizes. As hypothesized in section 2.4, this is consistent with the household size explanation. However, in direct contradiction to the hypothesis, the estimates of α_1 indicate that in the absence of income growth ($\Delta y_t = 0$), a unit increase in parent cohort growth decreases consumption growth by circa 5 percent in France and 10.4 percent in Sweden. In other words, growth in the parent cohort does increase excess sensitivity, but has a directly *negative* effect on consumption growth. This contradicts the hypothesis, which states that expanding households require added consumption and hence that cohort growth would have a directly *positive* effect on aggregate consumption.

In fact, the results of Table 5.3 resembles those of Table 5.2 and are hence more consistent with the liquidity constraints explanation. While this is somewhat unexpected for such a mature age cohort, it is not directly contradictory to findings in previous literature. As discussed in section 2.3, previous literature has found weaker evidence of constraints for consumers as old as 33-35 in some countries, though not past these ages. This could be consistent with the estimates of α_2 being significant only at the 10 percent level for both France and Sweden, as compared to the stronger 5 percent level noted for the young cohort in Table 5.2. On the other hand, the Swedish estimate of α_1 is larger in absolute terms in Table 5.3 than Table 5.2, which would suggest stricter liquidity constraints for the parent cohort than the young cohort. Similarly, the estimates of α_2 are larger in Table 5.3 than Table 5.2 for both France and Sweden, indicating that growth in the parent cohort generates more excess sensitivity than growth in the young cohort. A possible interpretation of this result is that the effects of both household expansion and constraints are captured in λ.

Finally, the results of estimating equation (10) with i = "old" are reported in Table 5.4 below. Here, "old" is defined differently depending on which country is being considered. For Costa Rica and Israel, "old" is defined as the age span 55-64, and for France and Sweden it is defined as the span 50-69. Estimates of α_1 are reported in column 4, and estimates of α_2 are reported in column 5. Robust standard errors are reported within parentheses.

Table 5.4: Estimating equation (10) with i = Old

Country	Sample Period	λ	α_1	α_2
Costa Rica	2010(4)-2020(4)	0.682**	-0.013**	15.972**
		(0.055)	(0.004)	(6.198)
France	2003(2)-2020(4)	1.529**	0.067	-84.006
		(0.527)	(0.043)	(61.552)
Israel	2001(1)-2020(4)	0.461**	-0.004	0.140
		(0.158)	(0.006)	(4.364)
Sweden	2003(2)-2020(4)	0.580**	-0.456**	150.451**
		(0.083)	(0.151)	(40.410)

Results of estimating $\Delta c_t = \mu + \lambda \Delta y_t + \alpha_1 \Delta z_{t-1} + \alpha_2 \Delta(y_t * z_{t-1}) + \varepsilon_t$, where Δz_{t-1} is the growth rate in the number of old. "Old" is defined differently depending on which country is being considered. For Costa Rica and Israel, it is the age span 55-64. For France and Sweden, it is the age span 50-69. ** indicates a significance level of 95%, * indicates a significance level of 90%.

As can be read from columns 4 and 5, the estimates of α_1 and α_2 are significant at the conventional levels for two countries in the sample: Costa Rica and Sweden. For both countries α_2 enters with a positive sign, implying that excess sensitivity in these countries is positively correlated with growth in the old cohort. Furthermore, the estimates of α_1 indicate that in the absence of income growth ($\Delta y_t = 0$), a unit increase in old cohort growth decreases consumption growth by circa 1.3 percent in Costa Rica and as much as 36.6 percent in Sweden. In other words, growth in the number of old not only increases excess sensitivity, but has a directly negative effect on consumption growth. As hypothesized in section 2.4, these results are consistent with the retirement puzzle and household size explanation of excess sensitivity.

It is worth noting that the results in Table 5.4 are attributed to the retirement puzzle and household size explanation only on the basis of theory and results of previous literature. In fact, the significantly positive estimates of α_2 and the significantly negative results of α_1 are also consistent with the results used to identify liquidity constraints in Table 5.2 and 5.3, and could therefore be interpreted as such. However, this would be highly inconsistent with previous findings from studies of individual or household level data, such as Alessie et al. (1995), Agarwal et al. (2007) or Jappelli et al (1990). The retirement puzzle and household size explanation are thus more likely to be driving the results of Table 5.4 than liquidity constraints.

A final point that can be made is that unlike the results of Table 5.2, there is no pattern in Table 5.4 between significant estimates of α_1 and α_2 and the way that "old" is defined. The Swedish estimates for the cohort 50-69 are significant but not the French, and the Costa Rican estimates for the cohort 55-64 are significant but not the Israeli. The cross-country variation in results can therefore only be attributed either to the effects of household sizes and retirement being smaller in France & Israel than in Costa Rica & Sweden, or to those effects occurring at different ages for France & Israel than for Costa Rica & Sweden.

6 Conclusion

In this study, I have analysed the interpretation of excess sensitivity at the national level. Specifically, I have challenged the common interpretation of such sensitivity as the economy share of non-Ricardian households by investigating if it also captures the effects of two common micro-level explanations: the household size explanation and the retirement puzzle. Building on previous research, I have used national growth rates in three different age cohorts as proxies for each explanation and investigated how each cohort affects excess sensitivity by means of interaction effects. I have also analysed the extent to which international patterns of excess sensitivity are reflected in international patterns of age distributions.

My results indicate that there is heterogeneity among countries with regards to what drives excess sensitivity. Specifically, it appears to be driven by liquidity constraints in France, by shrinking household sizes and retirement in Costa Rica, and by both explanations in Sweden. Furthermore, it appears that the sizes of the effects of each explanation can vary across countries. Liquidity constraints appear to be causing more excess sensitivity in France than in Sweden, and shrinking households and retirement appear to be causing more excess sensitivity in Sweden than in Costa Rica. The cross-country heterogeneity in explanations and the extent to which common explanations affect excess sensitivity can also explain why international patterns in excess sensitivity are not reflected in international patterns in age distributions.

That factors such as shrinking household sizes and retirement can affect excess sensitivity at the national level has significant practical implications. Excess sensitivity is an important metric in economic forecasting and modelling and is often used by both governments and central banks to evaluate policy alternatives. The reason is that excess sensitivity is believed to measure the extent to which consumption can be stimulated by temporarily increasing household disposable income. However, this builds on the notion that households would raise consumption if given the chance, which is not implied in the household size explanation or retirement puzzle. Therefore, the result that excess sensitivity at the national level appears to in part capture effects of these explanations implies that forecasting based on this metric may risk overpredicting consumption responses. Further research is needed to confirm or deny these findings.

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