Demographic Structure and Cyclical Volatility of Consumption

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Abstract

Does the demographic structure of a country affect the fluctuations of its aggregate consumption in business cycles? In this paper, we document that young households have more volatile consumption expenditures in business cycles than prime-aged ones. Then, we identify large effects of demographic composition on cyclical volatility of consumption using variations coming from demographic transitions for 30 countries covering 1951 to 2016. To decompose the source contributing to the age profile of consumption volatility, we build a simple RBC model with differences in credit market access and exposure to shocks by age. Calibrated to match the U.S. data, the model indicates that the lack of credit access in business cycles explains roughly 60 percent of the differences in cyclical consumption responses between young and old households, while different degrees of exposure to cyclical shocks explain the remaining 40 percent.

Keywords: Demographic structure; consumption; business cycle; aggregate volatility.
JEL codes: E21, E32, J11

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1 Introduction

The volatility of aggregate consumption over business cycles differs greatly across countries and across time. The standard deviation of detrended consumption from 1950 to 2016 is 0.8 percentage point (pp) in the U.S. and 3.6 pp in Argentina during the same period. While in the U.S., the 15-year rolling window volatility of detrended consumption exceeds 1 pp in 1970s, and decreases to 0.7 pp in mid-1990s during the Great Moderation era. Besides in absolute levels, the relative magnitude of consumption to output volatility also varies. A common finding is that emerging countries tend to also have higher *relative* volatility of consumption to output that is sometimes greater than one.

The existing literature commonly explains these facts by putting structures on aggregate variables. For instance, Aguiar and Gopinath (2007) studies how differences in the stochastic process governing productivity shocks affect consumption volatilities across countries. Garcia-Cicco et al. (2010), on the other hand, emphasizes the differences in interest rate shocks and financial frictions, which directly affect the ability of countries to smooth consumption through borrowing and lending in the international financial market.

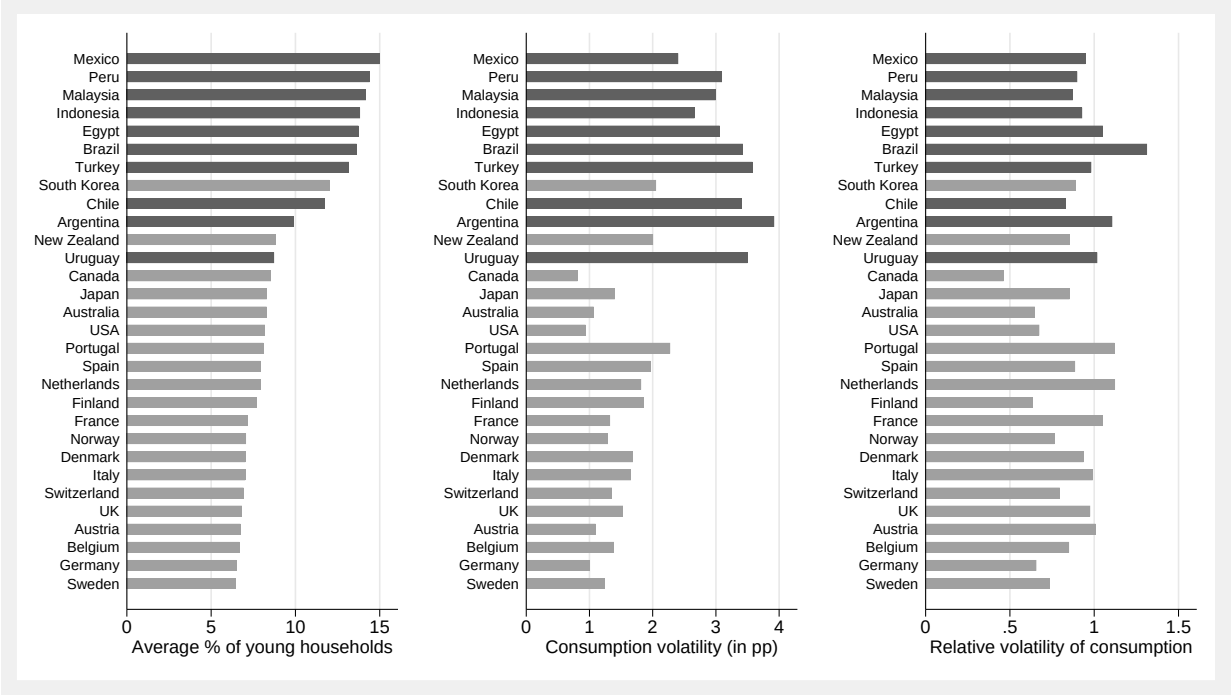
This paper investigates whether population age structure (hereafter demographic structure) affects the responses of consumption to aggregate shocks during business cycles. The question is motivated by Figure 1 which shows that countries with larger share of young households tend to have higher consumption volatility, both in absolute levels and relative to output.[1] This observation suggests that demographic structure could play a role in determining the volatilities of aggregate consumption. The simple correlation displayed here does not warrant causation, and it does not identify the underlying economic mechanism. Hence to study this issue more systematically, we proceed in three steps.

First, we show that young households have higher volatility of consumption than prime-aged ones in the United States using data from Consumer Expenditure Survey (CE) from 1988 to 2017. The standard deviation of cyclical consumption of 18-24-year-olds is more than four times that of 55-64-year-olds. The same pattern of consumption volatility by age is also found in ENIGH data from Mexico. Further inspection shows that the composition of consumption by expenditure categories is not the main explanation to this finding. Rather, I argue that the higher consumption volatilities of young households result from both the lack of access to credit market, and higher exposure to aggregate shocks in the labor market.

Second, I directly identify the magnitude of the effects of demographic composition on the

[1] See Section 3 for details on “consumption volatility" and “young households". Briefly, “consumption volatility" is measured by the standard deviation of detrended aggregate consumption; “young households" refer to those with the age of reference person below 25.

Figure 1: Consumption volatility and demographic structure, 1951-2016. Dark bars stand for emerging markets.



consumption volatility using variations of demographic structure in 30 countries from 1951 to 2016. I include country fixed effects to account for the country-specific unobservables (e.g. shock process, financial frictions, etc) studied in the previous literature. I also include year fixed effects to address global shocks affecting all countries. On average, a 1 percentage point (pp) increase of the share of households below age 25 leads to a 0.1 pp increase in consumption volatility and a 0.11 pp increase in output volatility. With a back-of-the-envelope calculation, it is demonstrated that changes in demographic composition within the U.S. could potentially account for one-third to half of the decrease in aggregate volatilities in the late 20th century. The demographic composition channel could also close a large proportion of the consumption and output volatility gap between the U.S. and Mexico. These findings are robust to (1) using lagged birth rates as instrument, and (2) including financial development and capital openness as additional controls. Moreover, an increase in the share of young households results in higher consumption volatility even conditional on output volatility. This implies that differences in demographic structure can help to explain gaps in the relative volatilities of consumption to output.

Lastly, the paper proposes a simple model to explain the observed age profile of consumption volatility and quantify the effects of two mechanisms: age-specific credit market access and heterogeneous exposure to aggregate shocks. The first channel captures that old households are better at smoothing consumption over time through borrowing and saving. The second channel

is the due to disparate nature of the labor supplied by young and old households. As argued by Jaimovich et al. (2013), when production process has capital-experience complementarity, labor earnings of old households are less vulnerable to transitory shocks. We calibrate the model to match the U.S. data. The results indicate that the credit access channel explains roughly 60 percent of the relative consumption volatility between young and old households, while the exposure channel explains the remaining 40 percent.

Literature

As mentioned above, this paper is related to the literature on differences in (relative) consumption volatilities across countries. The contribution of this paper is to incorporate heterogeneities *within* countries and study the magnitude of the resulting effects.

This paper is also related to the literature on how demographic composition shapes output volatilities within and across countries (Jaimovich and Siu (2009), Lugauer and Redmond (2012)). Jaimovich et al. (2013) is the most closely related work to ours. They argue that the age-composition effects due to demographic transition is causal to the decrease of output volatilities during the Great Moderation era. Furthermore, they prove that one needs to allow for asymmetries between young versus old labor in the production function so as to explain the age profile of both hours and wage volatilities in the data. Our paper differs from theirs by focusing on the effects of demographic structure on aggregate consumption. With a calibrated model, I disentangle the heterogeneous exposure channel due to asymmetry in earnings exposure emphasized in their paper from the credit market access channel.

Another related work is by Patterson (2018). She demonstrates that the positive correlation between marginal propensity to consume (MPC) and exposure to aggregate shocks contributes to aggregate volatility. This paper differs by focusing on age structure, and testing the composition effects across countries using panel regressions.

The rest of the paper is organized as follows. In Section 2, we document that young households have higher cyclical volatilities in consumption. In Section 3, effects of demographic composition on aggregate consumption volatilities is identified using panel regressions. In Section 4, we present the model to explain the empirical findings and decompose the two channels. The calibration strategy and model results are discussed in Section 5. Section 6 concludes.

2 Differences in Consumption Volatility by Age

2.1 Age profile of consumption volatility in the U.S.

In this section, we investigate the cyclical volatility of consumption expenditure disaggregated by age in the U.S. using statistics of Consumer Expenditure Survey (CE) published by Bureau of

Labor Statistics (BLS) from year 1988 to 2017. The number of households and median income by age of reference person is collected from the historical income tables by the Census.

We adopt the approach in Jaimovich and Siu (2009) to calculate volatility by age. For each age group, we first detrend the time series of average log real annual expenditure (in 2012 dollars) by Hodrick-Prescott filter with smoothing parameter $\lambda_{\text{HP}} = 6.25$ following the recommendation by Ravn and Uhlig (2002).[2] Then, I project the detrended series of (log) consumption onto a constant and current detrended output since we are not just interested in the high-frequency fluctuations in these series per se, but rather in how they behave in business cycles. Lastly, the age-specific cyclical volatility of consumption is defined as the percent standard deviation from trend.

The first row of Table 1 shows the percent standard deviation of the detrended age-specific series. Households with the age of reference person[3] below 25 display much higher cyclical volatility in consumption than all others with volatility of 1.46. Overall, the cyclical volatility is is decreasing in age, with the smallest value 0.32 obtained by households in the age group 55-64.

The second row displays each age group's share of total population using data from the Census. The third row reports the share of aggregate consumption attributed to each age group using population share and average consumption data. The fourth row shows the percentage of aggregate consumption volatility that each group accounts for.[4] As can be seen, although the 18-24 aged households make up only 3 percent of aggregate consumption, they account for 7 percent of aggregate consumption volatility - double the size of its consumption share. In countries where young households accounts for a larger fraction of the total population (see Figure 1), the larger share of young households could potentially have a significant impact on the overall consumption volatility assuming that the age profile of consumption volatility is similar across countries. We check this assumption in a developing country setting using data from Mexico, and later test the age-composition hypothesis directly using regressions in Section 3.

Intuitively, differences in cyclical consumption of volatility by age reflect the age profile of "pass-through" from aggregate shocks to group-specific average consumption. A natural candidate of explanation is the composition of different expenditure categories: if young households spend larger share of their expenditure on durable goods and durable goods expenditures are more volatile during business cycles, then the total expenditure by young households will be more volatile. To investigate this possibility, Table 2 shows the cyclical volatility on seven major

[2]The findings are robust to using alternative detrending methods such as first-difference.

[3]In CE tables, the first age group is actually defined as households with reference person's age between 15 to 24. An investigation into the Consumer Expenditure Survey public-use micro data reveals that the number of observations of households with reference person below age 18 is negligible. Thus, I interpret the first group as 18-24 in the following analysis, and assume that these households are making independent consumption decisions.

[4]Here, aggregate consumption volatility is defined as the weighted average of age-specific cyclical volatility, with weights reflecting consumption shares.

Table 1: Volatility of Cyclical Consumption by Age Groups, U.S.

Age group	18-24	25-34	35-44	45-54	55-64	65+
Cyclical volatility	1.46	0.63	0.83	0.61	0.32	0.55
Household %	5.43	17.78	20.27	19.08	15.61	21.85
Consumption %	3.14	17.11	23.88	23.51	16.48	15.89
Volatility %	7.20	16.96	31.16	22.64	8.27	13.77

Note: HP-filtered data from Consumer Expenditure Survey, 1988-2017.

categories of expenditure by age.[5] We can see that except for "apparel and services", 18- to 24-year-olds display highest volatility in all major categories including non-durables goods such as food and recreation. Therefore, expenditure composition could potentially matter quantitatively, but it is unlikely the only explanation to the phenomenon that young households have higher consumption volatilities than prime-aged households.

Table 2: Volatility of Expenditure on Major Categories by Age Groups, U.S.

Age group	18-24	25-34	35-44	45-54	55-64	65+
Food	1.21	0.55	0.89	1.16	0.71	0.12
Housing	1.56	0.45	0.79	0.61	0.39	0.68
Transportation	2.48	2.15	2.04	1.27	1.48	1.59
Apparel and services	0.64	0.99	0.97	2.03	1.40	0.53
Recreation	2.49	0.19	1.13	0.26	0.61	0.67
Health care	1.76	0.26	0.08	0.33	0.32	0.20
Insurance and pension	2.25	0.61	0.11	0.56	1.98	0.09

Note: HP-filtered data from Consumer Expenditure Survey, 1988-2017.

Another explanation is that household income of different age groups face different exposures to aggregate shocks. If the income of young households fluctuate more in business cycles, they are more likely to adjust their consumption if there is no perfect risk-sharing among all households. We calculate this age-specific exposure by projecting the detrended median household income from Census on detrended output, and show the regression coefficients in Table 3. As can be seen, when aggregate output decreases by 1 pp, the median household income (data from the Census) decrease by 1.23 pp for households with reference age below 25. The measure of exposure is decreasing in age, corresponding to the intuition that more senior workers have better job security and face smaller cyclical risks.

The last explanation we consider here is that households of different age have different credit market access and liquid assets on hand. In other words, even if different households have the

[5]The time series of average expenditure by categories is extracted from Consumer Expenditure Survey (CE) and is deflated using the corresponding NIPA price indexes.

Table 3: Income Exposure to Aggregate Fluctuations by Age Groups, U.S.

Age group	18-24	25-34	35-44	45-54	55-64	65+
Exposure	1.23	0.72	0.73	0.55	0.31	0.38

Note: HP-filtered data from Census, 1988-2017.

same exposure to aggregate shocks, their responses will not be the same due to different abilities of consumption smoothing over time. Empirically, there is a large literature on consumption over the life-cycle (c.f. Attanasio (1999)) arguing that borrowing constraints are empirically relevant for young households. In addition, Kaplan et al. (2014) shows that the age profile of wealthy-hand-to mouth, who hold little or no liquid wealth despite owning sizable amounts of illiquid assets, peaks around age 40. This could explain the rebound of cyclical volatility of consumption at age 35-44 in Table 1. Since it is not a simple task to directly measure the effects of borrowing constraint on consumption volatility in the data, I rely on a calibrated model to disentangle these two channels in Section 5.

2.2 Age profile of consumption volatility in Mexico

We confirm that the findings in Table 1 and 2 hold in a developing country setting by using Mexican data from *Encuesta nacional de Ingresos y Gastos de los Hogares* (ENIGH) from 1992 to 2006 extracted by Hicks (2015). Briefly speaking, ENIGH is a nationally representative survey that collects detailed information on purchases of goods and services together with household member characteristics. We use the same methodology as above to calculate consumption volatility by age group and by expenditure categories.

The first row of Table 4 indicates that the results found in the U.S. data hold in Mexico.[6] Young households in Mexico also displays significantly higher volatility of cyclical consumption than prime-aged ones. With a larger fraction of young households in the population, the 18- to 24-year-olds in Mexico account for 11 percent of aggregate consumption and account for 16 percent of aggregate consumption volatility.

Table 5 indicates that the age profile of consumption volatility for major expenditure categories in Mexico. Similar to that in the U.S., young households in Mexico display higher volatilities in non-durables, durables and also services.

To summarize, we find that cyclical responsiveness of consumption to aggregate shocks varies

[6]There are large differences in overall level of consumption volatility between U.S. and Mexico. This is mainly because the Mexican data has fewer observations and covers the entirety of 1994 Peso Crisis. These cross-country differences in average volatility levels largely reflect country-specific factors, which will be controlled for by country fixed-effects in Section 3.

Table 4: Volatility of Cyclical Consumption by Age Groups, Mexico

Age group	18-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Cyclical volatility	6.99	4.80	5.17	4.66	5.58	5.01	3.29	5.49	2.53	2.78
Household %	14.22	15.29	12.95	11.74	9.75	8.25	6.62	5.49	4.51	1.12
Consumption %	10.76	13.34	13.01	13.05	11.68	10.29	7.91	6.10	4.46	9.39
Volatility %	15.65	13.31	13.98	12.65	13.56	10.71	5.41	6.97	2.35	5.42

Note: HP-filtered data from ENIGH, 1992-2006.

Table 5: Volatility of Expenditure on Major Categories by Age Groups, Mexico

Age group	18-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Non-durables	5.73	4.00	4.49	4.29	3.98	4.26	3.05	3.80	3.04	1.52
Durables	17.80	13.08	11.33	12.36	9.97	9.47	7.86	17.00	10.65	9.01
Services	7.22	4.18	4.92	3.59	6.87	5.31	2.95	5.77	1.80	3.60

Note: HP-filtered data from ENIGH, 1992-2006.

by age in both the U.S. and Mexico despite the fact that these two countries differs greatly in institutions, financial development and demographics. Comparing Table 1 and Table 4, however, does not directly tell us the magnitude of the effects of demographic structure on aggregate consumption. In the next section, I tackle this question using panel-data methods and confirm the conjecture that age composition is a key determinant of the responsiveness of aggregate consumption to business cycle shocks.

3 Demographic Composition and Aggregate Volatility

3.1 Data and empirical specification

In this section, we present the effect of demographic composition on cyclical volatility of consumption and output using data from 30 countries covering 1951-2016. The list of countries is provided in Table 6. The sample includes both emerging and developed markets.

Table 6: List of countries

Argentina	Australia	Austria	Belgium	Brazil
Canada	Chile	Denmark	Egypt	Finland
France	Germany	Indonesia	Italy	Japan
Malaysia	Mexico	Netherlands	New Zealand	Norway
Peru	Portugal	South Korea	Spain	Sweden
Switzerland	Turkey	United Kingdom	USA	Uruguay

Our baseline measure of cyclical volatility of consumption for country i at year t is constructed as the standard deviation of filtered real aggregate consumption in country i during a 15-year rolling window centered around year t. I adopt the HP-filter with smoothing parameter of 6.25 as the benchmark and use first-difference as an alternative filter to demonstrate robustness. The finding is similar if I choose other time windows. The measure of cyclical volatility of output is constructed analogously. The data of consumption and output comes from Penn World Table 9.0 (Feenstra et al. (2015) and Zeileis (2019)). With these volatility measures, I run two separate regressions, one for dependent variable being the cyclical volatility of consumption σ_{it}^C, and the other being the cyclical volatility of output σ_{it}^Y.

The key explanatory variable is the share of young households in the economy. Young households are defined as those with the age of reference person below age 25. This definition is motivated by the fact that these households display the most volatile consumption indicated in both Table 1 and 4. Since most census only provide the number of population in 5-year age bins, the ideal measure of the share of 18- to 24-year-olds is not available. I therefore adopt an approximation by applying an age-specific population-to-household transformation ratio on the annual population data from the World Bank Development Indicators. The age-specific ratio is calculated using the U.S. data, where the aggregate number of households by age of reference person is taken from the Census. Our results are robust to alternative definitions of young households, e.g. only using the share of 20- to 24-year-olds or including 25- to 29-year-olds.

Since population composition is determined largely by fertility decisions made at least 15 years ago, this measure of demographic composition is not likely to be affected by contemporaneous business cycle shocks. One possibility, however, is the case that responses of international migration in business cycles would differ across age groups as young people could be more likely to move out of a country in recession than old people. Then, there could be reverse causality affecting the demographic composition. To address this issue, we instrument the share of young households with 20-year lagged crude birth rates. Since past fertility is almost certainly exogenous to current shocks, using lagged birth rates as instrumental variable corrects the potential bias in the OLS regression. As argued by Jaimovich et al. (2013), the bias induced by serial correlations using lagged birth rates is almost negligible under standard values of shock persistence.

The benchmark regression specification is:

$$\sigma_{it} = \alpha_i + \beta_t + \gamma \mathbf{young}_{it} + \varepsilon_{it} \tag{1}$$

I include country fixed effects α_i to capture heterogeneity across countries, such as differences in aggregate shock process emphasized in Aguiar and Gopinath (2007), or differences in financial frictions as in Garcia-Cicco et al. (2010). A full set of time dummies β_t is included to control for

time-varying factors affecting volatility that are shared across countries. With both fixed effects considered, the coefficient γ is capturing the average effect of demographic structure, as measure by $\mathbf{young}_{it}$, on consumption/output volatility within country across time.

For robustness, we also consider specifications that control for capital openness as measured by Chinn and Ito (2006) and financial development index developed by the International Monetary Fund (IMF). These variables affect the ability of households to smooth consumption over time through domestic and international financial markets. Driscoll and Kraay (1998) consistent standard errors are reported in Table 7 and 8.[7]

3.2 Regression results

Table 7 shows our main regression results. On average, a 1 percentage point (pp) increase in the fraction of young households in the population leads to a 0.101 percentage point increase in the volatility of cyclical consumption under HP-filter. The effect is significant at 1% level. The result is robust to including capital openness and financial development index as controls. It also survives the instrumental variable estimation, as well as alternative definitions of volatility using first-difference detrending.

Table 7: Young Household Share and Volatility of Cyclical Consumption

	Hodrick-Prescott				First Difference			
	OLS		IV		OLS		IV	
γ^C	0.101^{***}	0.136^{***}	0.199^{*}	0.192^{*}	0.237^{***}	0.280^{***}	0.311^{**}	0.307^{**}
	(0.027)	(0.048)	(0.121)	(0.109)	(0.050)	(0.057)	(0.140)	(0.129)
kaopen		Y		Y		Y		Y
fin.dev.		Y		Y		Y		Y
F.E.	Y	Y	Y	Y	Y	Y	Y	Y
Obs	1620	913	930	913	1620	913	930	913
Within R^2	0.125	0.314	0.136	0.172	0.158	0.213	0.145	0.165

Note: Results from OLS and IV of (1) for different specifications and two measures of consumption volatility.
* $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$.

Similarly, in Table 8 we can see that a one percentage point increase in the share of young households also results in a 0.109 percentage point increase in the volatility of output. This effect is statistically significant at 1 percent level and robust to instrumental variable estimation, alternative specifications and different ways of detrending.

[7]The number of observations differ by specification in the results due to (1) the availability of Chinn-Ito index and financial development index, and (2) the use of lagged-birth rates as instrumental variables.

Table 8: Young Household Share and Volatility of Cyclical Output

	Hodrick-Prescott				First Difference			
	OLS		IV		OLS		IV	
γ^Y	0.109^{***}	0.151^{***}	0.186^{**}	0.224^{***}	0.263^{***}	0.307^{***}	0.321^{***}	0.330^{***}
	(0.021)	(0.051)	(0.083)	(0.075)	(0.054)	(0.091)	(0.108)	(0.105)
kaopen		Y		Y		Y		Y
fin.dev.		Y		Y		Y		Y
F.E.	Y	Y	Y	Y	Y	Y	Y	Y
Obs	1620	913	930	913	1620	913	930	913
Within R^2	0.110	0.175	0.077	0.158	0.131	0.116	0.093	0.111

Note: Results from OLS and IV of (1) for different specifications and two measures of output volatility. $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$.

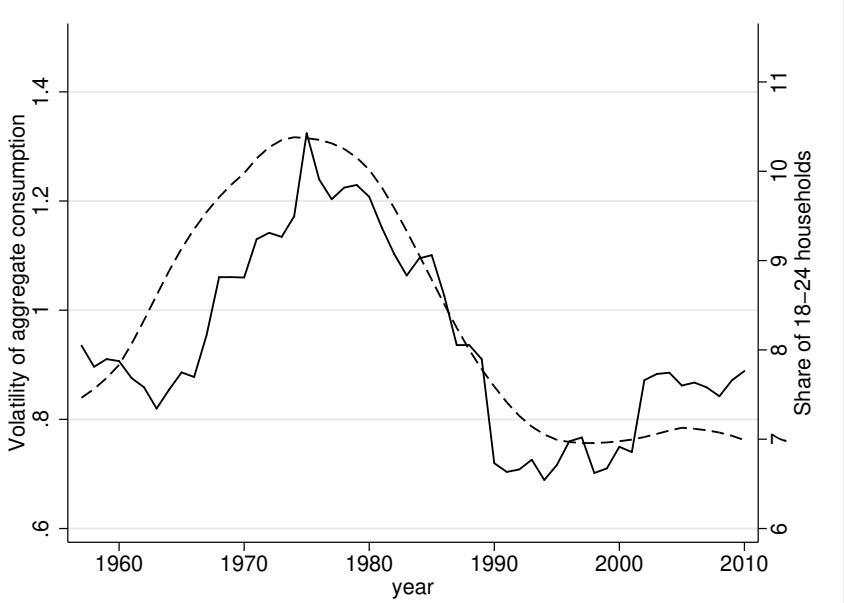
To see the economic significance of these results, we perform a back-of-the-envelope calculation to evaluate the economic significance of these estimates both within and across countries. In the United States, the percentage share of households with reference person's age between 18 to 24 years old was as high as 10.37 in 1975 due to the baby boom cohort and dips down to 6.96 in 1998. By multiplying the change in the fraction of young people with the estimated effect of demographic composition, we have

$$\frac{\widehat{\gamma}^C \times (\text{young}_{\text{U.S.,1998}} - \text{young}_{\text{U.S.,1975}})}{\sigma^C_{\text{U.S.,1998}} - \sigma^C_{\text{U.S.,1975}}} \times 100\% = 55.3\%$$

$$\frac{\widehat{\gamma}^Y \times (\text{young}_{\text{U.S.,1998}} - \text{young}_{\text{U.S.,1975}})}{\sigma^Y_{\text{U.S.,1998}} - \sigma^Y_{\text{U.S.,1975}}} \times 100\% = 34.5\%$$

where $\widehat{\gamma}^C$ and $\widehat{\gamma}^Y$ are OLS estimates with HP-filtered dependent variables taken from Table 7 and 8 respectively. This calculation shows that demographic composition could potentially explain roughly half of the decrease in consumption volatility and a third of the decrease in output volatility in the Great Moderation era. The magnitude of the latter effect is very close to the results in Jaimovich and Siu (2009). Figure 2 illustrates the time series of consumption volatility and demographic structure in the United States from 1960 to 2010.

We can also evaluate the magnitude of $\hat{\sigma}^C$ and $\hat{\sigma}^Y$ by looking at across country differences. Over the period 1957-2010, the average percentage share of young households in Mexico is 15.35 while it is 8.38 in the U.S.. The level of consumption and output volatilities are 2.43 pp and 2.49 pp respectively in Mexico; while they are 0.93 pp and 1.42 pp in the U.S.. There is no doubt that country fixed effects play an important role in explaining these differences in levels. Yet with the estimates, we can get a sense on how much of these differences in volatility could be explained by



Note: The solid line measures volatility of aggregate consumption as the 15-year rolling window percent standard deviation of detrended consumption series in the U.S.. The dashed line measures demographic composition using the fraction of households with reference person's age between 18 to 24-year-olds.

Figure 2: Demographic structure and volatility of aggregate consumption in the U.S.

demographic composition channel alone. The results below indicate that demographic structure is an important factor affecting differences in aggregate volatilities across countries.

$$\frac{\widehat{\gamma}^C \times (\overline{\text{young}}_{\text{Mexico}} - \overline{\text{young}}_{\text{U.S.}})}{\sigma^C_{\text{Mexico}} - \sigma^C_{\text{U.S.}}} \times 100\% = 46.9\%$$

$$\frac{\widehat{\gamma}^Y \times (\overline{\text{young}}_{\text{Mexico}} - \overline{\text{young}}_{\text{U.S.}})}{\sigma^Y_{\text{Mexico}} - \sigma^Y_{\text{U.S.}}} \times 100\% = 71.0\%$$

3.3 Relative consumption volatility

Lastly, I run an additional regression to investigate whether demographic composition is correlated to the volatility of aggregate consumption *conditional on* the level of output volatility. The regression specification is given by

$$\sigma^C_{it} = \tilde{\alpha}_i + \tilde{\beta}_t + \nu \sigma^Y_{it} + \gamma^R \mathbf{young}_{it} + \tilde{\varepsilon}_{it} \tag{2}$$

In specification (2), $\tilde{\alpha}_i$ and $\tilde{\beta}_t$ are country and time fixed effects; σ^C_{it} and σ^Y_{it} are the 15-year rolling window volatility of consumption and output for country i centered at year t respectively. $\mathbf{young}_{it}$ is measured as before. The goal of the regression is to see whether larger share of younger house-

holds lead to higher volatilities of aggregate consumption for a given level of output volatility. In other words, a positive γ^R means that relative volatility of consumption to output would be higher with more young households in the country. If this is the case, then demographic structure differences could help explain the excess consumption volatility puzzle, in addition to trends shocks or financial frictions studied in the literature.

The regression results are presented in Table 9. The coefficient γ^R are positive in all specifications. In OLS regressions with HP filter, the p-values are just barely above the 10% threshold. Overall, the results in Table 9 provides suggestive evidence to support the conjecture that higher share of young households leads to larger relative volatility of consumption to output as displayed in Figure 1.

Table 9: Young Household Share and Volatility of Cyclical Output

	Hodrick-Prescott				First Difference			
	OLS		IV		OLS		IV	
γ^R	0.021	0.033	0.050**	0.076***	0.052***	0.075***	0.084**	0.099***
	(0.014)	(0.022)	(0.025)	(0.024)	(0.020)	(0.029)	(0.033)	(0.033)
ν	0.733***	0.676***	0.742***	0.667***	0.704***	0.669***	0.684***	0.665***
	(0.019)	(0.026)	(0.026)	(0.026)	(0.017)	(0.023)	(0.023)	(0.023)
kaopen		Y		Y		Y		Y
fin.dev.		Y		Y		Y		Y
F.E.	Y	Y	Y	Y	Y	Y	Y	Y
Obs	1620	913	930	913	1620	913	930	913
R^2	0.841	0.889	0.876	0.889	0.876	0.919	0.915	0.919

Note: Results from OLS and IV of (2) for different specifications and measures of output volatility. $p < 10\%$, ** $p < 5\%$, *** $p < 1\%$.

4 Model

As discussed in Section 2, the age profile of consumption volatility and its aggregate impacts through composition could be explained by young people's higher exposure to aggregate shocks and less access to credit markets. In this section, we build a simple model to capture these intuitions and disentangle the two channels quantitatively. The model is an extension of Jaimovich et al. (2013) by considering separate budget constraints, so that consumption decisions are made independently across different types of households.

4.1 Household

The economy is populated by a large number of infinitely-lived households of two types - young and old. The share of young households are denoted by s_Y.[8] Households derive utility from consumption C_i and supplies one unit of labor inelastically. It is assumed that young and old households have different credit market access. While old households can borrow and save to smooth consumption over time, young households are assumed to be hand-to-mouth, using all labor earnings for consumption.

At any period t, the maximization problem for young households is given by:

$$\begin{aligned} &\mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\frac{C_Y^{1-\gamma}}{1-\gamma} \right) \\ \text{s.t.} \qquad & C_{Y\tau} = W_{Y\tau} N_{Y\tau} \quad \forall \tau \geq t \end{aligned} \tag{Y}$$

Old households' problem is:

$$\begin{aligned} &\mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\frac{C_O^{1-\gamma}}{1-\gamma} \right) \\ \text{s.t.} \qquad & C_{O\tau} + S_{\tau+1} = W_{O\tau} N_{O\tau} + (1-\delta) S_\tau + r_\tau S_\tau \quad \forall \tau \geq t \end{aligned} \tag{O}$$

In (Y) and (O), $\beta \in (0,1)$ is discount rate; capital depreciation rate is $\delta \in (0,1)$; S_τ is the savings at date τ by old households (in the form of capital); r_τ is the rental rate of capital; $W_{Y\tau}$ and $W_{O\tau}$ are the labor earnings of young and old households respectively. The parameter governing the elasticity of intertemporal substitution is γ.

While the total income of the young households $I_{Y\tau}$ is simply labor earnings, the income of the old $I_{O\tau}$ includes both labor and capital earnings.

$$I_{Y\tau} = W_{Y\tau}, \quad I_{O\tau} = W_{O\tau} + (r_\tau - \delta) S_\tau$$

4.2 Firm

The specification of the firm side follows Jaimovich et al. (2013), which argues that efficiency units supplied by young and old labor are inherently different due to capital-experience complementarity in the production function. This provides an intuitive micro-foundation for different exposures of earnings to aggregate shocks, rather than assuming it directly.

[8] As argued in Jaimovich et al. (2013), this can be viewed as a simplified framework where young members are born at rate x, young members become old at rate x, and old members die at rate x, so that the demographic composition stays constant over time.

Consider a representative firm that employs young and old labor $H_{Y\tau}, H_{O\tau}$ and rent capital K_τ to produce final goods. The production function is given by

$$Y_\tau = [\mu(A_\tau H_{Y\tau})^\sigma + (1-\mu)[\lambda K_\tau^\rho + (1-\lambda)(A_\tau H_{O\tau})^\rho]^{\sigma/\rho}]^{1/\sigma}, \qquad \sigma, \rho < 1 \tag{3}$$

where labor-augmenting technology follows an AR(1) process: $A_\tau = \exp(z_\tau)$ where $z_\tau = \phi_z z_{\tau-1} + \varepsilon_\tau$ with persistence $\phi_z \in (0,1)$. Shocks ε_τ are i.i.d. drawn from a normal distribution with zero mean and standard deviation σ_z.

Profit maximization of firms implies the following first-order conditions for factor prices:

$$W_{Y\tau} = Y_\tau^{1-\sigma}\mu A_\tau^\sigma H_{Y\tau}^{\sigma-1} \tag{4}$$

$$W_{O\tau} = Y_\tau^{1-\sigma}(1-\mu)\Omega_\tau(1-\lambda)A_\tau^\rho H_{O\tau}^{\rho-1} \tag{5}$$

$$r_\tau = Y_\tau^{1-\sigma}(1-\mu)\Omega_\tau\lambda K_\tau^{\rho-1} \tag{6}$$

where $\Omega_\tau \equiv [\lambda K_\tau^\rho + (1-\lambda)(A_\tau H_{O\tau})^\rho]^{(\sigma-\rho)/\rho}$.

If $\sigma \neq \rho$, the degree of diminishing marginal product is different between young and old labor. The elasticity of substitution between old labor and capital is given by $1/(1-\rho)$ whereas that between young labor and $H_O - K$ composite is $1/(1-\sigma)$. Jaimovich et al. (2013) defines the production function to exhibit capital-experience complementarity when $\sigma > \rho$. If this is the case, then the demand for (effective units of) old labor will tend to be less volatile than that for young labor since capital stock is inelastic in the short run.

4.3 Equilibrium

For given K_0, a *competitive equilibrium* is defined as an allocation

$$\{C_{Yt}, C_{Ot}, S_t, K_t, H_{Yt}, H_{Ot}, Y_t\}_{t=1}^\infty$$

and prices

$$\{r_t, W_{Yt}, W_{Ot}\}_{t=1}^\infty$$

such that households maximize utility, firms maximize revenue, and markets clear. Labor market clearing gives $H_{Yt} = s_Y, H_{Ot} = 1 - s_Y$ for all $t \geq 1$. Capital market clearing gives $K_\tau = s_O S_\tau$. The Walras Law implies that the final goods market also clears: $C_t + K_{t+1} = Y_t + (1-\delta)K_t$, where aggregate consumption is C_t is defined as $C_t = s_Y C_Y + (1-s_Y)C_O$.

5 Quantitative Evaluation

5.1 Calibration

We set $\beta = 0.99$ and $\delta = 0.025$ as the model is of quarterly frequency. The value of s_Y is set to match the average share of 15- to 24-year-old households. Parameter γ is set to be the standard value of 2. On the production side, parameters μ and λ are calibrated to match the average share of payment to capital and young households.

As for σ and ρ that governs the elasticity of substitution of factors, Jaimovich et al. (2013) used instrumental variable regression on the logged and first-differenced factor demand equations (4) and (5).[9] Importantly, the estimation procedure does not impose any restrictions on the household behavior, thus the credit access channel wouldn't invalidate the method. We follow their procedure with the definition of young households being those with the age of household head less than 25. We use data from the CPS and Bureau of Economics Analysis and obtain estimates $\hat{\sigma} = 0.761, \hat{\rho} = 0.217$. Since $\hat{\sigma} > \hat{\rho}$, the production function displays capital-experience complementarity as in Jaimovich et al. (2013), which generates higher volatility for both young hours and young wages. Lastly, the parameters governing the productivity process $\{\phi_z, \sigma_z\}$ are calibrated to match the cyclical volatility of output and the relative volatility of aggregate consumption to output in the U.S.. To summarize, the model parameters are displayed in Table 10.

Parameter	Value	Description
β	0.99	Discount rate
δ	0.025	Capital depreciation rate
s_Y	0.082	Share of 15- to 25-year-old households
γ	2	Elasticity of intertemporal substitution
μ	0.281	Production weight, young labor
λ	0.247	Production weight, capital
σ	0.761	Elasticity of substitution between H_Y and $K - H_O$ composite
ρ	0.217	Elasticity of substitution between K and H_O
ϕ_z	0.98	Persistence of productivity shocks
σ_z	0.0125	Standard deviation of productivity shocks

Table 10: Model Parameters

Table 11 compares the business cycle statistics for HP-filtered US data to the moments generated by our model. These non-targeted moments show the model's performance in capturing the key differences in consumption volatility and income exposure to aggregate shocks by age . The two rows in Table 11 shows the HP-filtered consumption volatility of young and old households.

[9] See section IV.A in Jaimovich et al. (2013) for detailed discussions.

As can be seen, while this moment is not targeted, these moments matches pretty well with that in Table 1. As a result, the model generates a relative volatility of 2.23 that is very close to the data. The last row shows the relative income exposure to aggregate shocks. The model is successful in generating the qualitative differences in income exposure, but falls slightly short in capturing the magnitude.

Moments	Data	Model	Source
$\sigma(C_Y)$	1.46	1.48	CE
$\sigma(C_O)$	0.65	0.66	CE
$\sigma(C_Y)/\sigma(C_O)$	2.24	2.24	CE
$\sigma(I_Y)/\sigma(I_O)$	1.89	1.46	Census

Table 11: Non-targeted Moments

5.2 Decomposition results

I decompose the relative volatility of consumption between young and old households in two channels: credit market access and heterogeneous exposure to aggregate shocks. The exercise here is to switch off the second channel by changing σ to take the same value as ρ while keeping other parameters unchanged, and see how $\sigma(C_Y)/\sigma(C_O)$ varies.

Intuitively, the production function (3) indicates that when $\sigma = \rho$, all three inputs (young labor, old labor and capital) share the same elasticity of substitution. Thus, the first-order conditions (4) and (5) would imply that the labor earnings for young and old households have exactly the same exposure to aggregate shocks z_τ. Hence, any difference in the cyclical volatility of consumption is attributed to the credit market access channel.

The result shows that when the heterogeneous exposure channel is turned off, $\frac{\sigma(C_Y)}{\sigma(C_O)}$ drops from 2.24 to 1.74. Therefore, roughly speaking, the contribution of credit market access channel to relative consumption volatility is

$$\frac{1.74-1}{2.24-1} \times 100\% = 58.87\%$$

Since the model is able to generate the relative volatility between young and old households fully, we attribute the remaining 40% to heterogeneous exposure channel ($\sigma > \rho$).

To summarize, we extend the model in Jaimovich et al. (2013) by considering independent budget constraint across heterogeneous households. The model is able to generate higher cyclical volatility of consumption for young households. The decomposition exercise shows that the model attributes roughly 60% of the difference in consumption volatility to heterogeneities in

credit market access, with the remaining 40% to heterogeneous exposure due to capital-experience complementarity in the labor market.

6 Conclusion

In this paper, we investigate the role of demographic structure in shaping the response of aggregate consumption to productivity shocks. We document that young households have higher volatility of cyclical consumption than prime-aged ones. Households with the age of reference person below 25 displays significantly higher fluctuations in cyclical consumption than those above age 25. This finding holds in all seven major categories of expenditure. We show that it also holds in a developing country setting with data from Mexico.

Using panel data from 30 countries covering 1951-2016, we identify the effect of demographic composition on cyclical volatilities. With the identification assumption that demographic composition is not affected by contemporaneous shocks after using lagged birth rates as instrument, we conclude that the share of young households has large and significant effects on aggregate fluctuations. A 1 percentage point increase in the share of young results in a 0.101 pp and 0.109 pp increase in the volatilities of consumption and output respectively. The effect could potentially account for roughly one-third to half of the changes in volatility of aggregate consumption and output in the Great Moderation era. It also explains a large proportion of volatility differences across countries. In addition, we show that larger fraction of young households is correlated with higher *relative* volatility of consumption to output. Thus, demographic composition could help to explain the excess consumption volatility puzzle studied in the literature.

Lastly, we build a simple model based on Jaimovich et al. (2013) to quantify two channels contributing to the age profile of consumption volatility: differences in credit market access and exposure to aggregate shocks. Calibrated to the U.S. data, the model does a good job in generating the relative volatility of consumption and income exposure as non-targeted moments. Decomposition results show that the credit market access channel accounts for 60 percent of the differences in cyclical consumption responses, while the heterogeneous exposure channel explains the remaining 40 percent.

To conclude, this paper focuses on the role of demographic structure in explaining the differences in cyclical consumption volatilities across countries and across time. Our results show that heterogeneities in the population *within* countries and the resulting effects from demographic composition could go a long way in explaining volatilities at the aggregate level.

References

Mark Aguiar and Gita Gopinath. Emerging market business cycles: The cycle is the trend. *Journal of political Economy*, 115(1):69–102, 2007.

Orazio P Attanasio. Consumption. *Handbook of macroeconomics*, 1:741–812, 1999.

Menzie D Chinn and Hiro Ito. What matters for financial development? capital controls, institutions, and interactions. *Journal of development economics*, 81(1):163–192, 2006.

John C Driscoll and Aart C Kraay. Consistent covariance matrix estimation with spatially dependent panel data. *Review of economics and statistics*, 80(4):549–560, 1998.

Robert C. Feenstra, Robert Inklaar, and Marcel P. Timmer. The next generation of the penn world table. *American Economic Review*, 105(10):3150–3182, 2015. URL `http://www.ggdc.net/pwt/`.

Javier Garcia-Cicco, Roberto Pancrazi, and Martin Uribe. Real business cycles in emerging countries? *American Economic Review*, 100(5):2510–31, 2010.

Daniel L Hicks. Consumption volatility, marketization, and expenditure in an emerging market economy. *American Economic Journal: Macroeconomics*, 7(2):95–123, 2015.

Nir Jaimovich and Henry E Siu. The young, the old, and the restless: Demographics and business cycle volatility. *American Economic Review*, 99(3):804–26, 2009.

Nir Jaimovich, Seth Pruitt, and Henry E Siu. The demand for youth: Explaining age differences in the volatility of hours. *American Economic Review*, 103(7):3022–44, 2013.

Greg Kaplan, Giovanni L Violante, and Justin Weidner. The wealthy hand-to-mouth. Technical report, National Bureau of Economic Research, 2014.

Steven Lugauer and Michael Redmond. The age distribution and business cycle volatility: International evidence. *Economics Letters*, 117(3):694–696, 2012.

Christina Patterson. The matching multiplier and the amplification of recessions. Technical report, mimeo, MIT, 2018.

Morten O Ravn and Harald Uhlig. On adjusting the hodrick-prescott filter for the frequency of observations. *Review of economics and statistics*, 84(2):371–376, 2002.

Achim Zeileis. *pwt9: Penn World Table (Version 9.x)*, 2019. URL `https://CRAN.R-project.org/package=pwt9`. R package version 9.1-0.

Stephen P Zeldes. Consumption and liquidity constraints: an empirical investigation. *Journal of political economy*, 97(2):305–346, 1989.