Living Arrangements and Labor Market Volatility of Young Workers*

Sebastian Dyrda
University of Toronto

Greg Kaplan
University of Chicago and NBER

José-Víctor Ríos-Rull
University of Pennsylvania,
CAERP, CEPR, and NBER

May 1, 2019

Abstract

We provide new evidence on the cyclical behavior of the household size and labor market outcomes of young people conditional on their living arrangements in the United States from 1979 to 2015. Household size is countercyclical, which is mostly driven by young people moving into or delaying departure from the parental home. We document that young people living with the old work and earn less, and their hours and wages are more volatile relative to their peers living alone. We argue that living arrangements induce larger disparities in the labor market outcomes than age does. Motivated by these observations we provide a joint theory of household formation and labor market engagement including the business cycle. We lay down a theory where young individuals decide where to live depending on their relative wage rate, disutility of living with old and implicit transfers received from the old. We show differences in volatilities across age groups can be accounted for by incorporating household formation channel in to the real business cycle model, while restricting the labor elasticity of the old to be within the range measured by microeconomists. We use our model to infer the implied labor supply elasticities of the young and conclude young living together with the old have it 63.8 percent times larger. Through the lens of the model we measure the size of the implicit transfers concluding they account for at least 50.2 percent of the market consumption of the young living with the old. The inclusion of people living in unstable households yields an implied aggregate, or macro, Frisch elasticity that is at least around 62.7 percent larger than the assumed micro elasticity.

Keywords: Business cycles; Household formation; Aggregate risk

JEL Classification: E32, J22

*An earlier version of this paper circulated under the title "Business Cycles and Household Formation: The Micro versus the Macro Labor Elasticity". We thank seminar attendants at the ICREA–MOVE Conference on Family Economics and those at the EFACR small group of the NBER's Summer Institute. We thank Matthias Kredler for discussions. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

1 Introduction

In macroeconomics the household and the agents have traditionally been taken as the same entity.[1] This is especially true in business cycle research.[2] In this paper we document how household composition varies over the cycle: household size is countercyclical with the bulk of the variation accounted for by young people moving in and out of multiperson households. Moreover, during recessions young people move into larger households and reduce their hours worked. We then proceed to construct a business cycle model where agents both adjust their household size and the hours that they work. We use this model to generate aggregate variations in total hours that is far larger than the variation of hours in response to shocks that would result from representative agent models with the same preferences. In this sense we provide for a novel, (and arguably, unique) channel through which the macro-labor elasticity is larger than the micro labor elasticity.

Once we document the main cyclical facts about household composition and about hours and wages of both the group of stable people that we call old from now on (they maintain their household characteristics over the cycle) and the rest or of people that we consider unstable, and that we call young, we construct a business cycle model with two types of agents, old and young. The old are agents that are essentially the same as the representative agent in standard models. Its preferences and characteristics (essentially, their Frisch labor elasticity[3]) are obtained from micro studies. The young agents are hand to mouth and can choose where to live: alone or within the old household. The preferences of the young are set so that the shocks in the model account for the same fraction of the volatility of the young than that of the old, ensuring that in our study we do not generate aggregate volatility by making the young bear a disproportionate share. Jaimovich, Pruitt, and Siu (2012) have argued persuasively (and we corroborate it here) that not only the ours of the young are more volatile than those of the old,[4] but also the wages of the young are much more volatile. This feature requires the departure from the standard RBC model that uses Cobb-Douglas technology in capital and efficiency units of labor that are assumed to be perfect substitutes. For wages of the young and the old to have different behavior, the labor inputs of the young and the old have to be imperfect substitutes. Consequently we implement a CES production function following the work of Jaimovich et al. (2012).

[1] In labor there is a lot of work that treats them separate.

[2] Cubeddu and Ríos-Rull (2003) uses a growth model treating family composition as shocks, while Aiyagari, Greenwood, and Güner (2000) Greenwood and Guner (2009), Greenwood, Güner, and Knowles (2003), and Regalia, Ríos-Rull, and Short (2013) study the evolution of family arrangements. None of this work deals with business cycles.

[3] Ríos-Rull, Schorfheide, Fuentes-Albero, Kryshko, and Santaeulalia-Llopis (2009) among others argue that this is the only parameter that matters for business cycles research in the absence of frictions.

[4] Clark and Summers (1981) first noted that labor volatility is high for young workers, and Kydland (1984), Ríos-Rull (1992), Ríos-Rull (1993), Ríos-Rull (1996), and Gomme, Rogerson, Rupert, and Wright (2005) confirmed it.

Macroeconomists often argue that the Frisch elasticity of labor supply is larger than what microeconomists have measured (see Chetty, Guren, Manoli, and Weber (2011a) and Ljungqvist and Sargent (2011) for recent discussions). While microeconomists' arguments are based on measurements of this elasticity using data on the labor supply choices of actual people, the rationale for macroeconomists preferring a larger elasticity is less clear. Macroeconomists' arguments are implicitly based on the desire to account for aggregate movements in hours worked through movements in prices. A more explicit, or empirical, argument for preferring a larger elasticity is based on criticisms about the way that microeconomists have performed their measurements. These criticisms insist that the micro measurements miss margins that are relevant for the behavior of an aggregate economy. Some of these criticisms (movements in the extensive margin, existence of more volatile secondary earners in the family, explicit consideration of lifetime labor supply) have been accounted for by microeconomists in recent work and have contributed to increase the microeconomic assessment of the labor elasticity. However, the gap between the two views remains large. Macroeconomists (e.g., Prescott (2006)) sometimes insist that the elasticity of the stand-in household can be larger than that of any real household.

The measurement of the aggregate, or macro, elasticity that we provide is consistent with micro estimates, yet yields a much higher value. The rationale is that because of the nature of available micro data, micro estimates of the Frisch elasticity tend to be based on the behavior of people who live in what we call *stable* households: people whose living arrangements do not change much over time. In practice, this usually translates into a focus on married people or people above a certain age. However, the labor force consists of many other types of people who live in less stable households. Such people, including the young and the single, frequently change whom they live with: sometimes alone, sometimes with a partner, often with their parents. These movements are in part a response to changes in individual and aggregate labor market conditions.

The first contribution of our paper is to provide new evidence on aggregate business cycle movements in the living arrangements and labor outcomes of these less stable individuals. Using quarterly data from the Current Population Survey (CPS), we document large cyclical fluctuations in the average size of US households. During economic expansions households shrink, while during recessions households expand. To quantify the overall importance of these movements, we construct a new series for aggregate hours per household and compare it to traditional measures of hours per person. We find that hours per person are around 15% more volatile than hours per household, with the difference due to the variation in household size. A substantial fraction of this variation is due to the part of the population that we term *unstable*: people whose household structure is most likely to vary over the business cycle. We identify groups of people that move in and out of households frequently, and use these to partition the population into those that live in stable households and those that do not. Our analysis considers three such groups: people under 30; people that have never been married; and people that are both under 30 and have never been married. In addition to having a large volatility in household size, we show that these people work more hours when living alone than when living with other more stable people, and have a higher volatility of hours worked no matter what type of households they live in. Also, when living alone they earn more and have smaller volatility of wages relative to their peers living with the stable individuals.[5]

For at least two reasons, it is important to recognize that living arrangements change with the business cycle, and to incorporate these movements into macro models. First, despite labor market inputs being measured at the level of the individual, consumption is almost always measured at the level of a household. This reflects the fact that for the majority of the population, spending decisions are made in the context of shared living arrangements, which in turn reflects the presence of economies of scale within households. Thus, for any analysis of the welfare costs of business cycles (and the welfare implications of policies that affect the cycle), the distinction between individuals and households is potentially important. This is true because, as we document, the relationship between persons and households itself features significant business cycle variation. Yet, there are almost no quantitative business cycle models that make this distinction. Second, a growing literature has recognized that the labor supply decisions of individuals also reflect the opportunities and preferences of the people they live with.[6] Hence, changes in living arrangements can be important for labor market variables even at the individual level.

Our second contribution in this paper is to explicitly incorporate the behavior of individuals with flexible living arrangements into the quantitative business cycle model. To do this, we build a RBC model with stable and unstable people (which we also refer to as old and young, respectively), where the unstable optimally choose whether to move and live with a stable person or to live alone. We restrict stable people to have a labor elasticity within the range measured by microeconomists. We discipline our quantitative model with the set of the first and the second moments related to the labor supply and living arrangements of both stable and unstable people. We evaluate the appropriateness of our theory by it's ability to replicate key business cycle moments such as: relative volatility of hours of the young to the old, relative volatility of wages of the young to the old or measures of the cyclical changes in the household size; documented in the empirical section. We argue our model performs well *vis-à-vis* the data. We then proceed to use it as a measurement device to infer the Marshallian elasticities of labor supply, which in our environment drive (rather than Frisch elasticities) the response of both groups of young individuals to the aggregate fluctuations. We conclude young living together with the old have it 63.8% larger. Furthermore, we use the model to learn about and quantify in various ways the magnitude of the implicit transfers, unmeasured in the data, that young receive while living with stable people. These transfers account for at least 33% of the consumption of the old with whom they live. Next, we quantify the contribution of our joint theory of living arrangements and labor market outcomes (we refer to it as supply channel) over the existing theory (we refer to it as demand channel), highlighting the role of the capital-

[5] We define an unstable person to be living alone if they do not live in the household of a corresponding stable person. For example, this means that a young person living with other young people as roommates is considered as living alone.

[6] See for instance Guler, Guvenen, and Violante (2012)

experience complementarity in production (Jaimovich et al. (2012)), in shaping the differences in volatilities of hours and wages across age groups. Finally, we examine the volatility of total hours in the model and recover the implicit labor elasticity that a standard representative agent model with only stable people would need, in order to replicate this volatility of hours worked. We find that the required Frisch elasticity of the stand-in household is over 62.7% higher than the micro estimates.

The most important feature of our calibration procedure is that we not only target the relevant first moments of the economy, but we also target the hours volatility of the unstable living alone, the hours volatility of the unstable living in stable households, and the volatility of the fraction of unstable people living alone, *all relative to the volatility of the hours worked by stable households*. It is crucial to understand the importance of targeting these volatilities relative to the hours volatility of the stable group, rather than targeting their absolute magnitudes. The reason is that we do not want to allow total factor productivity (TFP) shocks, the unique, and rather conventional, source of fluctuations in our economy, to account for any more of the variance of hours of the unstable than they do for the hours of the stable. In our calibrated model, the fraction of the variance of total hours accounted for by TFP shocks is equal for (i) hours worked by stable households, (ii) hours worked by unstable people living alone, (iii) hours worked by unstable people living together with stable people, and (iv) the fraction of unstable people living in stable households. By calibrating the model in this way, we ensure that the volatility of total hours is not larger than in standard representative agent models, purely because of a large volatility of hours of the unstable.

In our model, there are three reasons why the volatility of hours worked is higher than in a representative agent economy with the same Frisch elasticity for stable people. First, as in the data, unstable individuals have a higher volatility of hours than stable individuals, regardless of whether they live in stable or unstable households. Second, the existence of a second group of workers with higher hours volatility generates movements in the relative prices of capital and labor in equilibrium - wages are less volatile and rates of return are more volatile. These price movements induce stable individuals to have a higher volatility of hours than what they would have in the representative agent world because their hours respond more to increases in interest rates than to reductions in wages. Third, during expansions, the unstable tend to move out of stable people's households into their own households (or together with other unstable people, which we consider as living alone). Since they work more hours when living alone, this increases aggregate hours volatility.

Related Literature

Clark and Summers (1981) first noted that labor volatility is high for young workers. Kydland (1984), Ríos-Rull (1992), Ríos-Rull (1993), Ríos-Rull (1996), and Gomme et al. (2005) also documented differences in labor volatility by age or skill groups. They posed models with age or skill variation to explore the business cycle implications of these economies and the possible source of the variation in volatility. More recently, Jaimovich and Siu (2009) exploited the higher volatility of the young to argue that the Great Moderation (the reduction in economic volatility between 1984 and 2007) was due in part (between one-fifth and one-third) to demographic change that reduced the share of young people in the G7 economies. These papers, and, to our knowledge, all existing studies of the business cycle, assume that household size is constant.[7]

Jaimovich et al. (2012) explore the role of imperfect substitution in production between young and old workers to account for the higher volatility of the young. They astutely argue that the relative volatility of wages between young and old workers points to an explanation based on differences in technology rather than preferences. In our paper, the focus is not on explaining the labor market volatility of young workers, but on the interaction between their living arrangements and hours fluctuations. Yet, the evidence on the relative movements of wages for the two groups point to (under competition) a technology where both types of labor are not perfect substitutes. We find that the strategy followed by that paper, where the young have lower Frisch elasticity than the old is not a good one to understand the relative behavior of both types of labor.[8] In our paper the strategy of targeting the same fraction of the volatility of the young both living alone and living with others, and of the coresidence accounted by the model than that accounted of the volatility of hours of the old, yields higher labor elasticity for the young, and a much higher macro elasticity (the elasticity of a representative agent model needed to replicate the movements in aggregate hours generated by our model).

Kaplan (2012) also studies the relationship between the labor market and the tendency for the young to move in with the old in response to labor market outcomes. He estimates a dynamic game between youths and their parents to understand the structural microeconomic relationship between changes in living arrangements and labor supply. In this paper we model this interaction in a much simpler way, in order to be able to build a model that is amenable to equilibrium business cycle analysis with aggregate technology shocks.

More papers to include here: Aguiar, Bils, Charles, and Hurst (2017), Erosa, Fuster, and Kambourov (2016), Doepke and Tertilt (2016) - **TO BE COMPLETED**

The paper proceeds as follows. Section 2 documents business cycle properties of household composition and labor market variables. Section 3 describes a model with two types of agents, old and young, with the latter moving in and out of the formers' households. Section 4 discusses how we calibrate the model, giving special attention to the issue of the relative variances of hours of the old and the young. Our findings for the baseline economy are discussed in Section 5. Section 6 describes the properties of the economies with alternative calibration targets in what is a robustness check of the findings of the baseline economy. Section 8 studies a representative agent representation of our model economies that provide

[7] There are, of course, many papers about household formation, outside of a business cycle context.

[8] Jaimovich et al. (2012) choose a Frisch elasticity for the old to match a large volatility of hours in response to productivity shocks. When they do that, to replicate the relative volatility of wages in the data a lower Frisch for the young is needed.

what we call the macro elasticity. Section 9 concludes.

2 Living Arrangements and Labor Market Variables over the Business Cycle

In this section, we show that living arrangements are varied and volatile. Living arrangements are varied in the sense that there is substantial cross-sectional heterogeneity in household structure, both in terms of household size and the relationship between the individuals in a given households. Living arrangements are volatile in the sense that the set of people that make up a household changes over time, in a way that is correlated with business cycles.

The extent of this variability and volatility differs across sub-groups of individuals. For certain sub-groups, such as prime-age married couples, living arrangements are relatively homogenous and constant over time; hence we refer to these individuals as stable. For certain other sub-groups, such as younger unmarried individuals, living arrangements are particularly heterogeneous and cyclical; hence we refer to these individuals as unstable. We show that unstable individuals are also the group whose labor market outcomes (employment, hours and wages) vary most over the business cycle, and that the labor market outcomes of unstable individuals differ depending on their living arrangements. These findings suggest that the household structure within which any individual lives is an important factor in understanding their hours, employment and wages.

Much, but not all, of the variability and volatility in living arrangements can be attributed to parental coresidence for young people, or more generally, unstable individuals moving in and out of the homes of stable individuals. In this section we also explicitly document facts about the cyclicality of this form of coresidence alongside household composition more generally. These facts about coresidence will be used later as calibration targets for our structural model.

2.1 Data

We use data from the Basic Monthly Surveys from the Current Population Survey (CPS) to measure hours, employment and living arrangements. The CPS is an ideal data set for measuring aggregate movements in household composition at business cycle frequencies because it contains data on hours and employment of all individuals in a given household. Our monthly data covers a large cross section of individuals from 1979 to 2010, which we use to construct de-seasonalized quarterly series from 1979:Q1 to 2010:Q3. For data on wages and earnings we use the Annual Social and Economic Supplement to the CPS, commonly known as the March CPS. Since earnings data are not available in the monthly surveys, we are restricted to computing wage and earnings statistics at an annual frequency.

We define a household in the same way that the CPS defines a household: as the set of all persons occupying a dwelling unit. A dwelling unit is defined as "a room or group of rooms intended for occupation as separate living quarters and having either a separate entrance or complete cooking facilities for the exclusive use of occupants". From a theoretical point of view, we think of the defining feature of a household as being the possibility for a set of people to benefit from economies of scale in consumption. The empirical definition in the CPS coincides closely with this view.

Despite its large size and high frequency, the main drawback of the CPS is that it is cross-sectional data. This means that we cannot discuss a notion of who moves in with whom when household composition changes. We can only observe the other people that an individual is living with, not the physical structure that he or she is living in. To know who physically does the moving, we would need panel data. But large enough panel data with the required information on living arrangements and labor market outcomes are not availbe for the United States.

Measuring household composition is essentially an exercise in counting numbers of people and numbers of households that satisfy various criteria. Yet despite this apparent simplicity, some complications arise. First, there have been significant low-frequency secular trends in the age and demographic structure of the population over the period that our data cover. In particular, the aging of the baby boomer generation has led to a systematic change in household composition and average household size because of life cycle effects in living arrangements. To remove the systematic changes induced by this and other changes in the demographic structure of the population, we use a Hodrick-Prescott (HP) filter to de-trend our data[9].

Second, since the CPS is a nonrandom sample of dwellings rather than a random sample of individuals, care must be taken when measuring changes in household size. For each sampled dwelling, information is gathered about all the people who currently reside there. This generates a nonrandom sample of individuals. One of these individuals is then labeled in the data as the household head. In order to calculate statistics that are representative of the US population as a whole, the Census Bureau constructs weights based on observable features of individuals (non-interview status, age, sex, race, and Hispanic origin). Households can then be counted by constructing weighted counts of household heads, while individuals can be counted by constructing weighted counts of all household members. The weights are constructed using data from the decennial census and are updated between census dates using population projections. This updating of census weights can sometimes lead to discrete jumps in the relative counts of people of different types. Since there are systematic differences in the average household structure of individuals with different characteristics, such changes in the weights may lead to discrete changes in our estimates of household structure. The most consequential of these changes occurred with the updating of the weights in January 1991. To deal with the updating in the CPS weights, we allow for a structural break by filtering the

[9] We have experimented with other ways of de-trending the data. Most of our results are not affected by this choice. When the choice of de-trending matters, and only then, we report statistics using alternative methods.

data separately before and after 1990.

2.2 Household composition: variation in the cross-section

In the first column of Table 1, we illustrate the distinction between an individual and a household by reporting statistics on the distribution of household size for the population of adults aged 18 and over. On average, adults in the United States live in households with 1.26 other people. Thus, although it may seem a trivial point, we note that the distinction between an individual and a household is a real one. Moreover, this average household size masks substantial heterogeneity across individuals in the number of other people with whom they live. Column 1 of Table 1 reports a breakdown of this distribution: 16% of adults live alone, 56% live with one other person, 17% live with two other people and 10% live with three or more other people. We will demonstrate that this variation in living arrangements is intimately related to labor market outcomes in both the cross section and over the business cycle. There is more cross-sectional heterogeneity in living arrangements for some sub-groups than for others. The remaining columns of Table 1 report the distribution of household size for individuals of different ages and marital status. Young people (who we define as those aged 18 to 30) and individuals who have never been married live with more people on average than older people (aged 31 and over) and married individuals. Within these groups there is also a greater diversity of living arrangements. For example, 18 to 30 year-olds live in households with 1.56 other people on average, with a standard deviation of 0.53%, compared with 31 to 65 year-olds, who live in households with 1.22 other people on average, with a standard deviation of 0.28%.

Table 1: Variation and volatility in household composition

	Age				Marital status	
	18+	18-30	31-65	65+	never married	married
av hh size	2.26	2.56	2.22	1.88	2.59	2.23
frac alone	0.16	0.12	0.15	0.32	0.23	0.15
frac 1 other	0.56	0.48	0.60	0.55	0.28	0.60
frac 2 other	0.17	0.22	0.17	0.10	0.27	0.17
frac 3 or more other	0.10	0.18	0.08	0.04	0.22	0.08
st dev hh size	0.32%	0.53%	0.28%	0.32%	0.58%	0.28%
corr with total hours 18+	-0.272	-0.264	-0.289	-0.024	-0.227	-0.279

These statistics suggest that drawing a distinction between an individual and the household in which he or she lives is more important for some demographic groups than others. The evidence that follows will demonstrate a clear pattern in who these individuals are: the same groups of people that exhibit the most diversity in living arrangements in the cross section are also those with the most volatile living arrangements over the business cycle and the most volatile labor market outcomes (hours, employment and wages) over the business cycle. Anticipating these findings, we will use the label stable to refer to groups of individuals with homogenous and relatively constant living arrangements (and labor market outcomes), and the label unstable to refer to groups of individuals with diverse and volatile living arrangements (and labor market outcomes).

We propose three definitions of the stable/unstable distinction that partition the set of individuals aged 18 to 65 in different ways. These definitions, which are shown in Table 2, reflect how we will calibrate our model in Section 4. Definition 1 is based purely on age. According to definition 1, unstable individuals are those aged 18 to 30, and stable individuals are those aged 31 to 65. Since this is our baseline definition, we will frequently refer to the unstable as young and the stable as old. Definition 2 is based purely on marital status. According to definition 2, unstable individuals are those aged 18 to 65 who have never been married, and stable individuals are all other individuals aged 18 to 65. Definition 3 is the intersection of these two definitions: according to definition 3, unstable individuals are those aged 18 to 30 who have never been married, and stable individuals are all other individuals aged 18 to 65.

Table 2 reports the fraction of unstable individuals amongst all adults aged 18 to 65 according to the three definitions: 32%, 26% and 19% respectively. Much of the relevant cross-sectional variation in the living arrangements of the unstable is reflected by whether they live in a household that contains a stable individual (not living with a stable individual may entail either living alone or living with other unstable individuals). Table 2 shows that the fraction of unstable individuals who live with a stable individual is 50%, 52% and 67% for the three definitions, respectively. Thus the cross-sectional diversity in living arrangements for unstable individuals is captured by only an indicator for living in the home of a stable individual. With a slight abuse of language, we will use the adjective together to describe an unstable person who lives with a stable person, the adjective apart to describe one who does not, and the label coresidence to describe the state in which an unstable person lives with a stable one[10].

2.3 Cyclical volatility of household composition

Living arrangements are not only varied, but they are also cyclically volatile, particularly for unstable individuals. We demonstrate this first for average household size in the total adult population, and then for coresidence of the unstable.

Figure 1a plots the raw time series for average household size and average hours worked per person aged 18 and over[11]. The plots show a clear negative correlation between the two

[10]It should be clear that our language is not precise. We have also documented facts for coresidence rates per se. Ref last draft, ref Kaplan. It turns out that the stable-unstable divide both captures the relevant heterogeneity and is consistent with our model. Thus, while there are many dimensions of living arrangements, our point is that this simple statistic will capture almost all the relevant dimensions of living arrangements.

[11]For consistency with the statistics in Table 1, average household size is computed as the average across individuals of the number of people in the household that they live in. Computing average household size as

Table 2: Variation and volatility in household composition

	defn 1	defn 2	defn 3
frac unstable	0.32	0.26	0.19
frac unstable live old	0.50	0.52	0.67
st dev live together	0.83%	0.80%	0.66%
corr with hours 18-65	-0.477	-0.325	-0.372
corroleogram			
-3	-0.175	0.020	-0.076
-2	-0.294	-0.111	-0.185
-1	-0.414	-0.256	-0.330
0	-0.477	-0.325	-0.372
1	-0.522	-0.375	-0.436
2	-0.470	-0.395	-0.421
3	-0.408	-0.406	-0.381

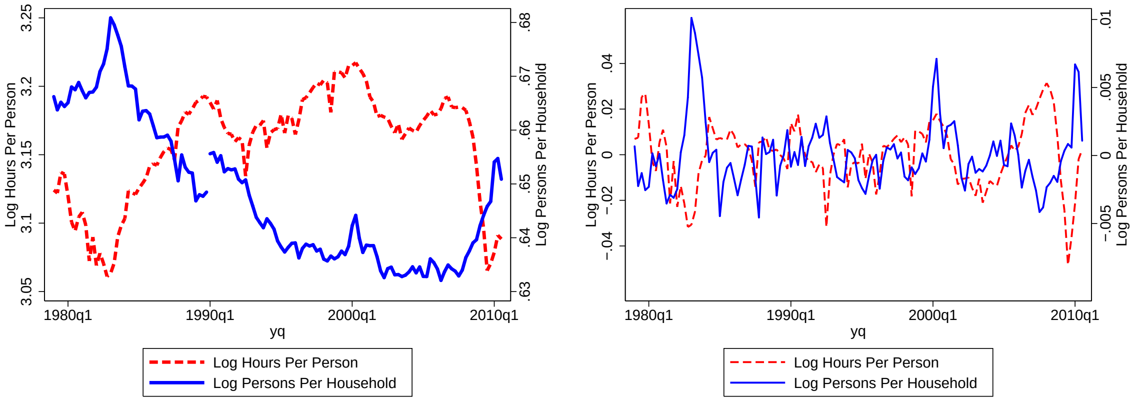
series: overall this correlation is -0.84. The correlation between the two series is exacerbated at business cycle frequencies. There is a sharp increase in household size in the 1981 and 2008 recessions, and a smaller increase in the milder recessions of 1990 and 2001. Figure 1b plots the corresponding HP-filtered series. The plot shows a significant negative correlation (-0.27) that is also exacerbated during the two large recessions. To put the size of these changes in household size in perspective, during the most recent recession, the seasonally adjusted number of persons per household aged 18 and over increased from 1.883 in 2007:Q3 to 1.925 in 2010:Q4. This 2.2% rise in persons per household corresponds to roughly 2.5 million households taking in an extra person during this recession[12].

The cyclical volatility of household size is more pronounced for unstable individuals. The bottom two rows of Table 1 report the standard deviation of HP-filtered log household size and its correlation with average hours worked, for the entire adult population and for sub-groups defined by age and marital status. The differences in volatility are large: for example, the time-series variance of HP-filtered log household size is over three times larger for individuals aged 18 to 30 than it is for individuals aged 31 to 65.

Table 2 shows that the coresidence rate (i.e. the fraction of unstable people living with a stable person) is volatile and counter-cyclical for each of the three definitions. For the baseline definition based on age, the standard deviation of the HP-filtered log coresidence rate for young people is 0.83%. Its correlation with average hours worked of 18 to 65 year-olds is

the total number of households divided by the total number of people aged 18 and over yields very similar results.

[12] Calculation based on assumption of 116,783,000 households in 2008 from census table HH1, available at http://www.census.gov/population/www/socdemo/hh-fam.html



(a) Raw time series

(b) HP-filtered series

Figure 1: Persons per household, hours per person

Notes: All people 18 years and over. Households with no people aged 18 years and over included. Quarterly data, 1979:Q1-2010:Q3, authors' calculations from Basic Monthly CPS. Deseasonalized. HP-filtered before and after 1990 separately with parameter 1600.

-0.477.

The bottom panel of Table 2 illustrates the business cycle dynamics of living arrangements by reporting elements of the cross-correlogram between the cyclical components of coresidence and hours worked. Two features of these joint dynamics motivate some of the modeling choices we make in Section 3. First, note that the negative correlation is very long lived. Second, note that hours worked slightly lags the fraction of the young living with the old.

2.4 Household composition and the labor market

It is well established that younger and single individuals have more volatile hours and employment than older and married individuals (Kydland (1984), Ríos-Rull (1996), Gomme et al. (2005), Jaimovich and Siu (2009)). Jaimovich et al. (2012) show that in addition, the wages of younger individuals are more volatile than the wages of older individuals. It also well known that average wages and hours are both lower for younger individuals.

All of these features of the data are inherited by our three definitions of stable and unstable people. Table 3 reports average hours and wages, and the variance of HP-filtered log wages and log hours for the unstable (young), all expressed relative to the corresponding statistics for the stable (old). The differences are large. For example, according to the first definition, hours volatility is 2.74 times larger and wage volatility is 2.08 times larger for the young than the old.

This simple fact, that the young have more volatile hours and wages than the old, is the focus of Jaimovich et al. (2012). They show that by augmenting a representative agent business cycle model with young people who are imperfect substitutes to old people in production, they can generate both larger hours volatility and larger wage volatility for the young, and thus higher overall hours volatility than in a models that excludes young people[13]. However, this existing literature has overlooked an important aspect of the differences in labor market volatility between young and old people: young people themselves exhibit very different labor market volatility depending on who they live with.

Table 3 demonstrates the importance of distinguishing young people by their living arrangements by reporting analogous labor market statistics separately for the unstable living apart from stable individuals and the unstable living together with a stable individual. These statistics show that young people who live apart from old people have average hours and wages and hours volatility that is much more similar to old people than the young people who live together with the old people. Most importantly, for the young together HP-filtered log hours is over 4 times more volatile than for the old, while it is only 1.78 times more volatile than the old for the young living apart. Similarly average hours of the young together are 0.75 of average hours of the old, while average hours of the young apart are actually higher than average hours of the old. Thus the observed labor market differences between unstable and stable individuals which have been the focus of the existing literature are actually less about whether people are young and single, but more about whether or not they live inside the homes of old or married peoples.

This distinction is important because whereas it is relatively simple to observe in panel data sets (such as the PSID) the labor market outcomes of young and single people when they are living apart from stable people, it is much more difficult to observe their labor market outcomes when they are living inside the homes of stable people. As a result, almost all existing empirical studies that measure labor elasticities, do not include the unstable living together as part of their sample. Yet this is exactly the group who differ the most from the old. Thus we believe that in order to augment a representative agent business cycle model to capture the high hours volatility of the young, it is crucial to model their living arrangements, in particular their coresidence with the old.

There are two channels through which allowing for variation in living arrangements among the unstable group helps to replicate their high hours volatility. Both channels are important empirically and both will be active in our model. The first channel arises because hours volatility of the unstable together as a group is larger than hours volatility of the unstable apart as a group. For definition 1, Table 3 shows this difference to be a factor of 2.26. Thus

[13] Jaimovich et al. (2012) are unable to generate big enough differences in volatility between the young and the old to simultaneously match the relative wage volatility and the relative hours volatility in the data. Moreover, all of their quantitative findings require an infinite Frisch elasticity of labor supply for the old and a very large Frisch elasticity for the young. Our approach, which exploits Marhallian elasticities rather than Frisch elasticities for the young (motivated by the evidence on living arrangements in this section) allows us to match all the relative volatilies with a Frisch elasticity for the old that is consistent with the empirical evidence.

Table 3: Household composition and the labor market

		defn 1	defn2	defn3
Av Hours	All stable	0.91	0.89	0.84
	Stable, apart	1.06	1.03	1.06
	Stable, together	0.75	0.75	0.73
Av Wages	All stable	0.57	0.62	0.51
	Stable, apart	0.72	0.82	0.72
	Stable, together	0.43	0.43	0.40
Var log hours	All stable	2.74	2.69	3.36
	Stable, apart	1.78	1.77	1.84
	Stable, together	4.01	4.22	4.63
Var log wages	All stable	2.08	1.48	2.22
	Stable, apart	2.21	1.63	2.23
	Stable, together	2.57	1.99	2.70
fraction due to mov. in x		11%	6%	10%

even if living arrangements were constant over the business cycle, the mere fact that there is cross-sectional variation in living arrangements (captured by the inclusion of the young together) yields an increase in overall hours volatility of the unstable. In our model this additional volatility will arise because of shared consumption inside the homes of the unstable. Since young people have very little liquid wealth available to smooth consumption, their hours fluctuations are governed by income rather than substitution effects and it is their Marshallian, rather than Frisch elasticity, that matters for the size of their hours volatility. Living inside the homes of stable people increases their consumption and hence their Marshallian labor elasticity.

The second channel through which living arrangements matter for hours volatility is that, as we demonstrated in Tables 1 and 2, the fraction of unstable people who live inside the home of a stable person is itself volatile. Thus even if the hours volatility of the unstable apart and the unstable together were the same, the fact that the average hours of the young apart is 1.41 times higher than the average hours of the young together, means that total hours of the unstable would be vary mechanically as the fraction of unstable in each group varies. In the bottom row of Table 3 we provide a statistic that measures the size of this channel by computing the volatility of a counterfactual series for hours that is constructed by holding the coresidence rate fixed at its steady-state values, i.e.

$$M = 1 - \frac{Var\left(\log\left[x_{SS}h^{yT} + (1 - x_{SS})\,h^{yA}\right]\right)}{Var\left(\log\left[xh^{yT} + (1 - x)\,h^{yA}\right]\right)} \tag{1}$$
$$= 1 - \frac{Var\left(\log\left[x_{SS}h^{yT} + (1 - x_{SS})\,h^{yA}\right]\right)}{Var\left(\log h^{y}\right)}.$$

The difference between the volatility of this counterfactual series and the volatility of total hours of the unstable measures the contribution of volatility in living arrangements to hours volatility. For definition 1, the contribution is 11%. In Section XX, we will return to this statistic as a calibration target for our model.

2.5 A useful decomposition: hours per household vs hours per person

We conclude the section by conducting a decomposition that is useful for measuring the contribution of cyclical movements in household size to the cyclical volatility of hours and employment more broadly. Let hours be denoted by H, the number of employed individuals by E, the number of households by F, and the total number of individuals by N. Then we can decompose total hours per person as

$$\frac{H}{N} = \frac{H}{F} \times \frac{F}{N}.$$

This decomposition expresses hours per person (the traditional measure of aggregate hours) as the product of hours per household and households per person. Similarly, we can decompose total employment per person as

$$\frac{E}{N} = \frac{E}{F} \times \frac{F}{N}.$$

Taking logs and variances yields

$$V\left(\log\frac{H}{N}\right) = V\left(\log\frac{H}{F}\right) + V\left(\log\frac{F}{N}\right) + 2COV\left(\log\frac{H}{F}, \log\frac{F}{N}\right).$$

Table 4 reports the result of this decomposition for employment and hours, using HP-filtered data at annual and quarterly frequencies. The results suggest that between 13% and 19% of fluctuations in per person labor market variables over the business cycle are offset at the household level by endogenous changes in household structure. Table 4 also reports analogous calculations when the data are de-trended using a linear trend rather than an HP-filter. De-trending the data in this way yields an even larger contribution of movements in the number of persons per household. Since the difference between the two methods of de-trending is the effect of medium-frequency secular changes due to episodes such as the productivity slowdown during the 1990's, these results imply that the mechanisms we are highlighting in this paper may be important for understanding labor movements over longer frequencies in addition to business cycles.

Table 4: Decomposition of hours and employment per person

	Quarterly Data		Annual Data	
	HP-filter (%)	Linear trend (%)	HP-filter (%)	Linear trend (%)
Hours: $V\left(\log \frac{H}{N}\right)$				
Households per person + covariance	15.2	25.5	13.7	21.7
Employment: $V\left(\log \frac{E}{N}\right)$				
Households per person + covariance	16.4	39.5	19.0	28.9

3 Model

Demographics Our model is populated by two types of agents. We label one type as *stable*, as a stand-in for old, independent, or married; and the other type as *unstable*, as a stand-in for young, dependent, or unmarried. For consistency with our baseline calibration, we will refer to the two types as old and young in our description of the model. The fundamental difference between the two types of agents is that the old always live in their own stable households, whereas the young live in unstable households in the sense that they sometimes join other people to form multiperson households and sometimes they do not.

Old agents in our model, like the agents in standard models, have preferences over consumption and leisure in the current and all future periods and, consequently, make savings and work decisions. In addition, the old are associated to some young agents whose company they enjoy, in a separable and unmodeled way, but over whom they have no altruistic feelings. In this fashion, if a young agent chooses to join the old household, she is welcomed in, and she shares part of the consumption of the old due to the presence of economies of scale within the household. The arrival of the young occurs after the old have chosen how much to work and save. We explicitly model the fact that the old and the young have different amounts of efficiency units of labor by making the productivity of the young idiosyncratic random variable and that the young and the old have different preferences over pairs of consumption and leisure within the period. Further, for convenience, we assume that the young are extremely impatient.

Preference over living arrangements of the young agents depends of three elements: (i) idiosyncratic productivity (ii) amount of extra consumption due to economies of scale (iii) preference of living alone, which we model as a random variable varying from period to period. In some circumstances (low wages, low preference for living alone), young agents will choose to join an old household. In an ironic abuse of language, we assume that both the young and the old never age.[14] We build this structure on top of a standard growth model that is suitable for quantitative macroeconomic analysis.

Timing The timing of the events within the period is the following. First, all the shocks: aggregate technology shock z, idiosyncratic productivity shock ε and disutility from living with the old η are realized. Then old make their labor and consumption choices. Next, young choose where to live and further how much to work. Finally production and consumption take place at the end of the period.

The old There is a measure μ of old agents that live in stable households of size γ agents per household. Consequently, there are $\frac{\mu}{\gamma}$ of these households. All old members of the household have identical preferences and consequently have perfect agreement making their decisions

[14]It is easy, but tedious, to show that this model is isomorphic to another model where agents do age and the young inherit the assets of the old.

unanimous. Old-agent households can be invaded by a young agent, but only after having made their choice of consumption and hours worked. [15] Consequently, old agents take into account the probability of being invaded by a young agent but the history of the young living at home is irrelevant. Let x denote the probability that (or fraction of) young agents that choose to join an old household. Given the relative sizes of the population groups, the per-period utility function of an old agent has to take into account the household size both in the event of being invaded by a young person or not, and is given by

$$u(c^o, h^o, x) = \left[1 - \frac{x(1-\mu)\gamma}{\mu}\right] \left[\frac{1}{1-\sigma^o}\left(\frac{c^o}{\zeta^o}\right)^{1-\sigma^o} - \psi^o \frac{(h^o)^{1+\frac{1}{\nu^o}}}{1+\frac{1}{\nu^o}}\right] + \frac{x(1-\mu)\gamma}{\mu}\left[\frac{1}{1-\sigma^o}\left(\frac{c^o}{\zeta^o+\zeta^y}\right)^{1-\sigma^o} - \psi^o \frac{(h^o)^{1+\frac{1}{\nu^o}}}{1+\frac{1}{\nu^o}}\right], \quad (2)$$

where the first term alludes to the household being composed of only old agents and the second term to being invaded by a young agent. Here ζ^{oo} indicates the economies of scale among the old: if c^o is spent by a household of size γ, then $\frac{c^o}{\zeta^{oo}}$ is enjoyed on a per capita basis. Similarly, parameters $\{\psi^o, \nu^o\}$ take into account the disutility on a per capita basis of having household members work a total amount of h^o hours per period. Notice that given the functional form, ν^o is the Frisch elasticity of labor. The additional parameter ζ^y reflects the strain imposed by the young. Notice that there is no pooling of resources when the young invades the old household. This is another trivial extension without any quantitative implications. The old discount the future at rate β and face the following period budget constraint

$$c^o + a' = w^o \;\; h^o + (1+r)\, a, \quad (3)$$

where a are the assets held by the household, w and r are factor prices, and where we have normalized the efficiency units of labor of the old to 1.

The young There is a measure $1-\mu$ of young agents. These agents have preferences over consumption, leisure, and the type of household they live in, but are completely impatient (hand-to-mouth). Every period they draw an i.i.d. idiosyncratic shocks, $\varepsilon \sim F_\varepsilon$, labor productivity and $\eta \sim F_\eta$, to the disutility of sharing a household with an old agent. They can change their residence status after observing all relevant information within the period: the realization of ε, η, and the aggregate state of the economy that determines prices and allows them to forecast the relevant decisions of the old.

[15] Alternatively, we could have assumed insurance markets among the old. With separable utility, this would simply imply that those that are invaded by a young receive a transfer from those that are not invaded, without affecting hours worked. In any case all households would hold the same assets the following period keeping the model simple. We think that this is a trivial simplification.

If the agent chooses to live alone alone, denoted A, its utility is

$$u^i\left(c^{yA}, h^{yA}\right) = \frac{\left(c^{yA}\right)^{(1-\sigma^y)}}{1-\sigma^y} - \psi^y \frac{\left(h^{yA}\right)^{1+\frac{1}{\nu^y}}}{1+\frac{1}{\nu^y}} \tag{4}$$

Notice that while the utility of the old displays log consumption, the young agents have a different curvature. Since the young do not care about the future, log utility would result in constant hours, and a different shape of the utility function is required so that hours of the young vary over the cycle.

When a young agent chooses lives together with an old household, denoted T, its utility is given by

$$u^i\left(c^{yT}, h^{yT}, \eta\right) = \frac{\left(c^{yT} + \ g\left(c^o\right)\right)^{(1-\sigma^y)}}{1-\sigma^y} - \psi^y \frac{\left(h^{yT}\right)^{1+\frac{1}{\nu^y}}}{1+\frac{1}{\nu^y}} - \ \eta. \tag{5}$$

Here ζ reflects the economies of scale in the old household, or, in effect, how much free riding the young get from the old. Note that these economies of scale are the fraction of the consumption of the old.

The young living alone choose $\{c^{yA}, h^{yA}\}$ while the young living together choose $\{c^{yT}, h^{yT}\}$. Both choices satisfy the budget constraint of the young:

$$c^{yj} = \varepsilon^y \ w^y \ h^{yj}, \quad j \in \{A, T\}, \tag{6}$$

where ϵ is the idiosyncratic efficiency units of the young and w^y is the wage of the young.

Production This structure is integrated onto a standard growth model. Following Jaimovich et al. (2012), there is a CES aggregate production function with capital-experience complementarity

$$F(z, K, N^y, N^o) = \left[\mu_F\left(zN^y\right)^\sigma + \left(1-\mu_F\right)\left(\lambda_F K^\rho + \left(1-\lambda_F\right)\left(zN^o\right)^\rho\right)^{\sigma/\rho}\right]^{1/\sigma} \tag{7}$$

where N^y and N^o are labor inputs of young and old respectively. and the resource constraint for the economy is

$$C + \left[K' - (1-\delta K)\right] = Y, \tag{8}$$

where C is aggregate consumption, K is aggregate capital, Y is output, N is the aggregate labor input (not total hours worked), and z is an AR(1) productivity shock.

Aggregation Despite the fact that our model features multiple types of agents and households, aggregation in this environment is relatively simple. There are three types of choices:

those made by the old, by the young alone, and by the young together (recall that the old cannot make their choices contingent on whether a young agent is present). There are three types of households: old households without young agents (a measure $\frac{\mu}{\gamma} - x(1-\mu)$), old households with young agents (a measure $x(1-\mu)$ of those), and young agents alone (with measure $(1-x)(1-\mu)$).[16] To determine the aggregates, we describe first the indifference condition

$$\eta^*(\varepsilon) = \frac{\left(c^{yT} + \zeta c^o\right)^{1-\sigma^y}}{1-\sigma^y} - \varphi^y \frac{\left(h^{yT}\right)^{1+\frac{1}{\nu^y}}}{1+\frac{1}{\nu^y}} - \left[\frac{\left(c^{yA}\right)^{1-\sigma^y}}{1-\sigma^y} - \varphi^y \frac{\left(h^{yA}\right)^{1+\frac{1}{\nu^y}}}{1+\frac{1}{\nu^y}}\right] \tag{9}$$

i.e. it provides a threshold $\eta^*(\varepsilon)$ for each ε in the space of disutility shock realizations above which agent chooses to live alone at his residence and below which agent chooses to move into the old household. Equipped with this threshold we define the aggregates in our economy. The fraction of the young individuals living with the old households is given by

$$x = \int_0^\infty \int_{-\infty}^{\eta^*(\varepsilon)} dF_\eta \, dF_\varepsilon \tag{10}$$

Aggregate labor inputs of young alone and young together are

$$N^{yA} = \int_0^\infty \int_{\eta^*(\varepsilon)}^\infty \varepsilon h^{yA}(\varepsilon) \, dF_\eta dF_\varepsilon, \quad N^{yT} = \int_0^\infty \int_{-\infty}^{\eta^*(\varepsilon)} \varepsilon h^{yT}(\varepsilon) \; dF_\eta dF_\varepsilon. \tag{11}$$

Analogously, the total hours worked by young alone and young together are

$$H^{yA} = \int_0^\infty \int_{\eta^*(\varepsilon)}^\infty h^{yA}(\varepsilon) \, dF_\eta dF_\varepsilon, \quad H^{yT} = \int_0^\infty \int_{-\infty}^{\eta^*(\varepsilon)} h^{yT}(\varepsilon) \, dF_\eta dF_\varepsilon. \tag{12}$$

Total consumptions of the young alone and young together are

$$C^{yA} = \int_0^\infty \int_{\eta^*(\varepsilon)}^\infty w^y \varepsilon h^{yA}(\varepsilon) \, dF_\eta dF_\varepsilon, \quad C^{yT} = \int_0^\infty \int_{-\infty}^{\eta_T^*(\varepsilon)} w^y \varepsilon h^{yT}(\varepsilon) \; dF_\eta dF_\varepsilon. \tag{13}$$

Moreover, the aggregate earnings of young alone and young together

$$W^{yA} = \int_0^\infty \int_{\eta^*(\varepsilon)}^\infty w^y \varepsilon(\varepsilon) \, dF_\eta dF_\varepsilon, \quad W^{yT} = \int_0^\infty \int_{-\infty}^{\eta^*(\varepsilon)} w^y \varepsilon(\varepsilon) \; dF_\eta dF_\varepsilon. \tag{14}$$

[16] The relative sizes of the young and the old as well as the nature of the processes for η and ε guarantee that there are not more young agents moving in with the old than the number of old households.

Using the aggregates for the young agents we have that the aggregate values for consumption (C), labor input (N), and hours (H), are given by

$$C = \frac{\mu}{\gamma}c^o + (1-\mu) \quad [C^{yT} + C^{yA}], \tag{15}$$

$$N^o = \frac{\mu}{\gamma}h^o \tag{16}$$

$$N^y = (1-\mu)[N^{yT} + N^{yA}] \tag{17}$$

$$N = N^o + N^y, \tag{18}$$

$$H = \frac{\mu}{\gamma}h^o + (1-\mu) \quad [H^{yT} + H^{yA}], \tag{19}$$

Capital is owned by the old, so wealth is equal to total capital: $K = a\,\frac{\mu}{\gamma}$.

Equilibrium Our model is simple enough such that the objects required to define an equilibrium are the same as in a standard representative agent model. The aggregate state of the economy is $s = \{z, K\}$, since these are sufficient statistics for wealth and prices.

Definition 1. *A recursive equilibrium is a set of functions for capital, $K'(s)$; consumption $\{C^{yA}(s), C^{yT}(s), c^o(s)\}$; hours worked $\{H^{yA}(s), H^{yT}(s), H^o(s)\}$; the threshold $\eta^*(\varepsilon)$; the fraction of young that move in with the old $x(s)$; and competitive factor prices $\{r(s), w(s)\}$, such that*

1. *The young maximize given the choice of the old. This includes the choices of consumption, hours worked when together, hours worked when alone, and household type.*

2. *The fraction of the young moving in with the old satisfies (10), and the marginal young are indifferent, i.e., $\eta^*(\varepsilon)$ satisfies (9) for each ε.*

3. *The old maximize given the expected choices of the young, and when imposing the representative agent condition, their choices yield $\{K'(s), c^o(s), h^o(s)\}$.*

4 Calibration

The goal of this paper is to provide a quantitative theory of living arrangements and labor market engagement over the business cycle. We discipline our theory, laid down in the previous section, using the set of first and second macroeconomic moments which are relevant from the standpoint of the labor market outcomes of individuals with different living arrangements.

Table 5: Technological Parameters and Targets

	Parameter Description	Target variable	Target value	Model value	Parameter value
		Parameters set without solving the model			
ρ	CES elasticity	Micro estimates JPS	-	-	.201
σ	CES elasticity	Micro estimates JPS	-	-	.662
		Parameters that require solving the model			
δ	Depreciation rate	I/Y	.26	.26	.035
μ_F	Weight of young	K/Y	7.5	7.4	.044
λ_F	Weight of capital	Share of olds' income in total	.50	.51	.256
λ_ε^1	Shape par of gamma dist	w^{yA}/w^o	.72	.66	15.4
λ_ε^2	Scale par of gamma dist	w^{yT}/w^o	.42	.46	2.68
ρ_z	AR(1) prod shocks	Autocorr AR(1) RA Solow Res*	.94	.94	.934
σ_z	St Dev productivity shocks	Var Solow Res*	3.19	3.19	.010

* Unfiltered series.

In particular we target, among others: mean hours worked of old, young alone and young together; relative wages (to the ones of the old) of young alone and young together; fraction of young individuals living with the old; relative (to the old) variances of hours of young alone and together; relative (to the hours of the old) variance of the fraction of young living with the old and finally correlation between fraction of young living together and average hours.

We chose to match relative second moments for a particular reason. An alternative to proceed would be to choose parameters so that the model generates the same volatility of hours of the young people, and the same volatility of household size, as in the data. We think that such a procedure would give a misleading answer because it would implicitly assume that *all* movements in these variables are due to TFP shocks, whereas only a small fraction of the volatility of hours of the old are due to TFP shocks. Instead we choose parameters so that shocks to TFP account for the same fraction of the variances of all types of hours worked and the variance of household size. Calibrating the model in this way requires that we target both first and second moments simultaneously. This means that the solution to the full stochastic model is required for calibration, rather than just its steady-state statistics.

4.1 Baseline calibration

Technology Table 5 shows the parameters and the targets that we use. The first set of parameters are those that can be set directly without solving the model. The second set of parameters require solving the whole model, where the system of equations includes second moments of the time series. We pose a nested CES technology with both young and old labor, where the labor input of the old is complementary with the capital stock and the old labor-capital composite is imperfect substitute for the labor input of the young. The technology shock z augments both labor inputs of the young and the old. For the σ and ρ, the parameters governing the elasticities of substitution[17], we rely on the estimates by Jaimovich et al. (2012). We impose that the idiosyncratic productivity ε is drawn from the Gamma distribution parameterized with the shape parameter, λ_ε^1, and scale parameter λ_ε^2. We discipline these parameters by targeting the relative (to the old) mean wages of the young alone and young together respectively, defined using equations (14) and (14) by:

$$\bar{w}^{yT} = \frac{W^{yT}}{x}, \quad \bar{w}^{yA} = \frac{W^{yA}}{1-x}. \tag{20}$$

As stated above, hours of the young (i) command a lower wage (are less efficient than) hours of the old and (ii) are more volatile than hours of the old. These two facts imply that aggregate hours (the unweighted sum of all hours) are more volatile than the labor input (hours weighted by their efficiency). Contrary to the standard RBC model with Cobb-Douglas technology, in our model the Solow residual — defined as $SR_t = \log Y_t - \alpha \log K_t - (1-\alpha)\log H_t$ — is not the same as the TFP shock. Consequently, the parameters that govern the stochastic process for TFP must be determined simultaneously with the other model parameters. This ensures that a univariate representation of the Solow residual from our model displays an autocorrelation of 0.94 and a standard deviation for the innovation of 3.19 which is what we take that the U.S. data displays. The implied coefficients for the productivity shock in the baseline calibration are an autocorrelation of 0.94 and a standard deviation of innovations of 0.01.

Demographics In our baseline calibration we identify the unstable young as those aged below 30, and the stable old as those aged 30 to 65. Unless stated otherwise, the calibration and findings that we report in the main text refer to this definition. The fraction of old agents is 0.684, which is the average fraction of people aged 18 to 65 that are 30 and above, over the sample period in our CPS data. Most of these people are married, generating an average household size of 1.8.

Preferences of the old Table 6 displays the targets for the preferences of the old, under the baseline definition described above. The discount factor is 4% and is standard. Recall that the utility function of the old posed in equation (2) was separable between consumption

[17] The elasticity of substitution between labor input of the old and capital stock is given by $(1-\rho)^{-1}$, whereas the elasticity of substitution between labor input of the young and the old labor=capital composite is $(1-\sigma)^{-1}$. Whenever $\sigma > \rho$ the technology exhibits the complementarity between labor input of the old and capital stock.

Table 6: Parameters of preferences of the old

Parameter	Description	Target variable	Target value	Model value	Parameter value
	Parameters that can be set without solving the model				
μ	Fraction of old	Measurement	-	-	.684
γ	Old household size	Measurement	-	-	1.80
ζ^{oo}	Ec of scale for old	OECD	-	-	1.70
ζ^{o}	Additional Ec of scale	OECD	-	-	.50
ν^{o}	Frisch elast. of old	Measurement	-	-	.72
β	Discount rate	Interest rate	.04	.04	.99
	Parameters that require solving the model				
ψ^{o}	Weight of hours of old	Hours in Old Hholds	.50	.50	4.54

and hours, with log utility for consumption and a constant Frisch elasticity for labor. Because of the presence of log utility, equilibrium allocations are not affected by the actual parameter values for economies of scale among the old. We report the OECD values for completeness.

For the Frisch elasticity of the old, we use a value that attempts to take into account both the extensive margin and the typical existence of a couple in an old household. Our baseline value of 0.72 is computed based on Heathcote, Storesletten, and Violante (2010). This number is very close to the value obtained by Chetty et al. (2011a) of 0.82 in their meta-analysis of estimates for the Frisch elasticity using micro data. We also note that with one possible exception (the 1987 Iceland zero tax year studied by Bianchi, Gudmundsson, and Zoega (2001)), none of the studies analyzed by Chetty et al. (2011a) or Chetty, Guren, Manoli, and Weber (2011b) are based on data that include the type of unstable marginal workers that we are emphasizing in this paper. We also perform a sensitivity analysis on the assumed Frisch elasticity of the old using values in $\{0.5, 1.0, 2.0\}$. For the disutility of work, we target a value of .503 for mean hours worked, since this is the fraction of one adult's time endowment that is worked by the 1.8 adults in an old household.

Preferences of the young Table 7 displays the targets of the parameters concerning the young agents in the baseline economy. We target the following first moment statistics of the young: (i) hours worked if alone, (ii) hours worked if living with the old, and (iii) fraction of the young that live with the old. Note, we target the average hours of young alone and together, given by

$$\bar{h}^{yT} = \frac{H^{yT}}{x}, \quad \bar{h}^{yA} = \frac{H^{yA}}{1-x} \tag{21}$$

where H^{yT} and H^{yA} are defined by set of equations 12 respectively.

We also target the following second moment statistics: (i) variance of hours worked if alone, (ii) variance of hours worked if living with the old, and (iii) variance of the fraction of the young that live with the old (iv) correlation between hours worked and fraction of young living with the old. We target the first three of these moments *relative to the variance of hours of the old*. By targeting the variance of the fraction of the young that live with the old we make sure our model does not feature more movement along the coresidence margin than is implied by the data. It is important to reiterate the fact that we target relative variances. On of our goals is to measure the contribution of productivity shocks to the variance of hours. Our calibration strategy implies that the contribution of productivity shocks is the *same* for all of the components that contribute to move total hours: the hours of the old, the hours of the young living alone, the hours of the young living with the old, and the fraction of the young living with the old.

Table 7 also displays the six parameters involved in the calibration: three standard parameters of the utility function (risk aversion, weight on hours, labor elasticity); two parameters governing the distribution of distaste for living with the old; one parameter for the economies of scale when living with the old.[18] We use them to pin down seven targets.

The degree of risk aversion is particularly important. With log utility and no patience, hours are constant, irrespective of the wage rate. When risk aversion is greater than unity, hours move countercyclically, since the income effect of wage changes dominates the substitution effect. This means that in our calibrated economy, the risk aversion of the young is less than 1.

It is crucial that we allow the idiosyncratic shocks for the distaste of living with the old η to be drawn from a flexible two-parameter distribution. We choose a Normal distribution. If there were only one parameter, it would be pinned down by the mean fraction of the young living with the old. However, what matters for our question is the slope of the cumulative distribution function (CDF) at this value, since this is what determines the mass of young agents that are induced to change their living arrangements in response to small changes in the wage rate.

[18] With the functional form that we have chosen all parameters affect all choices and, as a result, the calibration of the preference parameters of the young requires, that we solve for the stochastic equilibrium even though some of the targets are first moments.

Table 7: Parameters of preferences of the young

Parameter	Description	Target variable	Target value	Model value	Parameter value
		Parameters that require solving the model			
ψ^y	Weight of hours of Young	Hours of young together	.21	.19	5.20
σ^y	Risk Aversion of young	Hours of young alone	.30	.32	.341
λ^1	Mean of η	% of young with old	50.2	50.4	.463
ν^y	Labor elasticity of young	$Var(h^{yT})/Var(h^o)$	4.01	3.84	.931
λ^2	Std of η	$Var(x)/Var(h^o)$	.46	.46	.215
ζ	Ec of scale of Young	$Var(h^{yA})/Var(h^o)$	1.78	1.82	.331
-	-	$Corr(x,h)$	.48	.48	-

5 Findings of the Baseline Economy

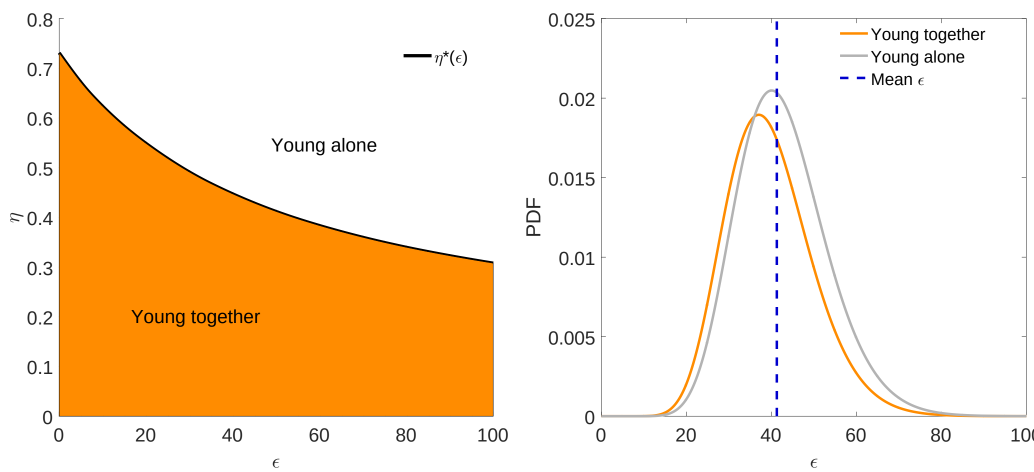
In this section we discuss the main findings for our baseline calibration. We begin with discussing the steady state properties of the model and highlighting the mechanism of self-selection into living arrangements of young individuals. Then we move to document performance of the model in terms of replicating key time series moments of the labor market variables and living arrangements variables. We argue our model performs very well versus the data in these two key dimensions. Next, we use our model as a measurement device to learn about the implied labor elasticities of young individuals, the magnitude of the implicit transfers, to disentangle the labor supply from the labor demand channel and finally to quantify our propagation mechanism in terms of aggregate hours volatility.

5.1 Model performance

Steady state properties Young individuals in the model are heterogenous with respect to living arrangements, hours worked and wages. Thus there is a cross-sectional distribution of labor market variables conditional on the living arrangements in the model. Young individuals self-select themselves into those living alone and together after observing the realization of the two idiosyncratic shocks: (i) productivity shock (ii) disutility of living with the old shock. The key equilibrium condition for this choice is equation (9), which defines threshold in the domain of the η shock relevant for changing the living arrangements at the beginning of the period. This threshold is illustrated in the left panel of Figure 2.

Young individual who enters the period moves into the old if only, for every productivity shock ε, the disutility shock falls below the $\eta^*(\varepsilon)$. For any realization above this threshold young individual chooses to live alone. The independence of the shocks over time induces that previous living arrangement of the young individual is irrelevant for the choice in the current period. The threshold is downward sloping and as a result young individuals living with the old are on average less productive (with mean ε of 17.1) and have lower disutility from living in larger households, whereas young individuals living alone are on average more productive (with mean ε of 24.2) and have higher disutility of living with the old. The distribution of productivities, conditional on living arrangements, is illustrated in the right panel of Figure 2. The distribution of distribution of wages of the young in the model is isomorphic to the distribution of productivities[19], therefore young living alone have on average higher wages relative to their peers living in larger households.

Figure 2: Partitions of young workers (left panel) and productivity densities (left panel)



Time series properties Table 8 presents the performance of our baseline economy *vis-à-vis* the time series data. The first three rows present the relative, to the old individuals, standard deviations of hours of all young, young alone and young together respectively. By construction, we replicate relative standard deviations of hours of young alone and young together, since we target them. The key finding is though that we replicate almost perfectly the relative standard deviation of hours of all young individuals relative to the old accounting for 103% of the data, in a stark contrast to the benchmark economy in Jaimovich et al. (2012). One might think it is a mechanical result since the group of the young people in our model consists only of young alone and young together. To illustrate it is not the case inspect the

[19] The wage rate is simply the product of the w^y and ε.

log-linearized formula for the relative variance of hours of young and old individuals

$$\frac{Var\left(\widehat{h}_y\right)}{Var\left(\widehat{h}_o\right)} = \left(\frac{\overline{x}\overline{h}_{yT}}{\overline{h}_y}\right)^2 \left(\frac{Var\left(\widehat{x}\right)}{Var\left(\widehat{h}_o\right)} + \frac{Var\left(\widehat{h}_{yT}\right)}{Var\left(\widehat{h}_o\right)} + \frac{2Cov\left(\widehat{x},\widehat{h}_{yT}\right)}{Var\left(\widehat{h}_o\right)}\right) + \tag{22}$$

$$+ \left(\frac{\overline{x}\overline{h}_{yA}}{\overline{h}_y}\right)^2 \left(\frac{Var\left(\widehat{1-x}\right)}{Var\left(\widehat{h}_o\right)} + \frac{Var\left(\widehat{h}_{yA}\right)}{Var\left(\widehat{h}_o\right)} + \frac{2Cov\left(\widehat{1-x},\widehat{h}_{yA}\right)}{Var\left(\widehat{h}_o\right)}\right)$$

$$+ 2\left(\frac{\overline{x}\overline{h}_{yT}}{\overline{h}_y}\right)\left(\frac{\overline{x}\overline{h}_{yA}}{\overline{h}_y}\right)\frac{Cov\left(\left(\widehat{x}+\widehat{h}_{yT}\right),\left(\widehat{1-x}+\widehat{h}_{yA}\right)\right)}{Var\left(\widehat{h}_o\right)}$$

where variables with bar denote steady state levels and variables with hat denote the log deviations from the steady state. Our calibration procedure pins down the steady state relationships showing up in equation 22 and three relative variances: $Var\left(\widehat{h}_{yT}\right)/Var\left(\widehat{h}_o\right)$, $Var\left(\widehat{h}_{yA}\right)/Var\left(\widehat{h}_o\right)$ and $Var\left(\widehat{x}\right)/Var\left(\widehat{h}_o\right)$. The covariances terms are not pinned down by the calibration procedure and could potentially induce a large disparity between the model and the data for this moment[20].

The second set of results illustrates the performance of the model with respect to the relative volatilities of wages. We do not target any of these moments. The model accounts for 88.9% of the relative variance of wages between young and old individuals. Within the young group the model accounts for 87.9% percent and 74.3% for young alone and young together respectively. Our model falls short in replicating higher volatility of wages of young together relative to the young alone. In the third set of moments we illustrate the model performance with regards to the fluctuations in living arrangements and total hours. We compute the model counterpart of the decomposition introduced in Section 2.5. Decomposition quantifies the contribution of cyclical movements in household size to the cyclical volatility of hours. Our baseline model generates a contribution of 13.4% accounting for 88.2% of the data. The model generates a slightly lower contribution than the data, suggesting, perhaps, that for cyclical purposes, our definition of the young is too narrow, i.e., there is an insufficient role for variation in family size in the baseline model economy. In Section 2.4 we provide also an alternative measure to the relative variance of x in order to measure contribution of volatility in living arrangements to hours volatility of young individuals. For the definition of the young used in the baseline model this measure indicates the contribution is 11% in the data. The model is able to generate 8.4% accounting for 76.3 percent of the data. We view these numbers as a success of

[20] We also target the $corr(x, h)$. The presence of the implicit transfers makes hours worked of young alone and young together imperfectly correlated, even though there is only one aggregate shock in the model. Hence, imposing this target does not explicitly pin down the covariances terms in the formula 22.

Table 8: Model performance in replicating key moments

Moments	Data	Baseline Economy	% of the data accounted for
Relative hours			
$\sigma\left(h^{y}\right)/\sigma\left(h^{o}\right)$	1.65	1.65	100.0
$\sigma\left(h^{yA}\right)/\sigma\left(h^{o}\right)^{*}$	1.33	1.35	101.5
$\sigma\left(h^{yT}\right)/\sigma\left(h^{o}\right)^{*}$	2.00	1.96	98.0
Relative wages			
$\sigma\left(w^{y}\right)/\sigma\left(w^{o}\right)$	1.44	1.28	88.9
$\sigma\left(w^{yA}\right)/\sigma\left(w^{o}\right)$	1.49	1.31	87.9
$\sigma\left(w^{yT}\right)/\sigma\left(w^{o}\right)$	1.60	1.19	74.3
Other moments			
Contr F/N	15.2%	13.4%	88.2
M - moment	11.0%	8.4%	76.3
$\sigma\left(x\right)$	0.67	0.25	37.3
$\sigma(h)$	1.42	0.44	31.0

*Calibrated moments

our model, in particular given it's simplicity and only one source of the aggregate uncertainty. In Section 6 we discuss the alternative calibrations of our model which directly target these two statistics and we argue the properties of these models are very similar to the ones from our baseline economy. Finally, the last two rows report standard deviations of aggregate hours and fraction of young individuals living with the old in the model. The well known fact is an inability of the representative agent real business cycle model to account for the cyclical volatility of aggregate hours. Our model shares this feature and it accounts only for 31% of the data. However, as we argue in Section 5.6 the presence of young agents together combined with the varying living arrangements of young individuals provides additional propagation mechanism on the top of the standard intertemporal considerations in the RBC model. A by-product of this feature of the model and our calibration strategy, which targets relative rather than absolute variance of x, is that in our baseline economy model the standard deviation of the fraction of young individuals living with the old is 0.25, accounting for 37.3% of the data. Thus, one should read this result as the measure of the contribution of the productivity shocks to the movements in living arrangements. Given that in our model productivity shocks do not induce the volatility of hours in line with the data, it is not surprising that they do not generate variances in x in line with the data.

5.2 A tale of two elasticities

Steady state elasticities In the empirical section we have documented that living arrangements induce larger differences in the first and second moments of hours and wages than age does. Our joint theory of living arrangements and labor market outcomes over the business cycle has sharp predictions for the differences in variance of hours worked across both age and living arrangements dimensions, as documented in the previous section. We argue that the implicit transfers from the old to the young together are the key ingredient to capture the regularities we observe in the data. To illustrate this, notice that labor supply of young individual living alone, who received ε labor productivity shock, in our economy is:

$$h^{yA} = \left(\frac{(w^y \varepsilon)^{1-\sigma^y}}{\psi} \right)^{\frac{\nu^y}{1+\sigma^y \nu^y}}$$

It turns out though that Marshalian elasticity of labor supply for such individual is independent on the realization of any idiosyncratic shocks and is given by[21]

$$\eta_{w^y}^{h^{yA}} = \frac{(1-\sigma^y)\,\nu^y}{1+\sigma^y \nu^y}. \tag{23}$$

At the same time labor supply of young individual living with the old, who received ε labor productivity shock, does not exhibit closed form solution, due to the presence of the implicit transfers ζc^o. However, one can derive the following formula for the Marshallian elasticity of labor supply:

$$\eta_{w^y}^{h^{yT}}(\varepsilon) = \frac{\nu^y (1-\sigma^y)}{1+\sigma^y \nu^y} \frac{\left[1 + \left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1-\sigma^y}\right)\right]}{\left[1 + \left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1+\sigma^y \nu^y}\right)\right]} = \eta_{w^y}^{h^{yA}} \frac{\left[1 + \left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1-\sigma^y}\right)\right]}{\left[1 + \left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1+\sigma^y \nu^y}\right)\right]} \tag{24}$$

In the absence of the intertemporal concerns these two Marshallian elasticities, rather than Frisch ones, control the response of the hours of young alone and young together to the aggregate fluctuations. Our theory predicts that hours of young together respond stronger than hours of young alone over the business cycle as long as $\zeta > 0$ (i.e. implicit transfers are strictly positive), whereas our calibration quantifies that difference. Observe first that, if only $\sigma^y < 1$, which we argued is the case, for any $\zeta > 0$ we have

$$\eta_{w^y}^{h^{yA}} < \eta_{w^y}^{h^{yT}}(\varepsilon) = \eta_{w^y}^{h^{yA}} \frac{\left[1 + \left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1-\sigma^y}\right)\right]}{\left[1 + \left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1+\sigma^y \nu^y}\right)\right]} \quad \forall \varepsilon$$

[21] See Appendix B for the details of derivation.

thus the presence of the positive implicit transfers induces that labor supply elasticity of young together is *strictly* larger relative to the young alone. Moreover, observe that elasticity of young together $\eta_{w^y}^{h^{yT}}(\varepsilon)$ is an increasing function of the fraction of the consumption of the old the young together receive, ζ. The larger are the transfers the more strongly hours of the young together respond to changes in the wage rate and also the larger is the gap relative to the young alone. Also, observe that as $\zeta \to 0$ then $\eta_{w^y}^{h^{yT}}(\varepsilon) \to \eta_{w^y}^{h^{yA}}$ and $\eta_{w^y}^{h^{yT}}(\varepsilon) = \eta_{w^y}^{h^{yA}}$ for $\zeta = 0$, i.e. as transfers disappear the two elasticities and hence the response to the aggregate fluctuations become identical. Our theory of living arrangements builds upon the idea of economies of scale in the old household, which implies free riding consumption for young together, and predicts that precisely this force accounts for the differences in the variance of hours worked over the business cycle across different living arrangements of the young. The calibration strategy we follow allows us to match exactly the relative variances of hours and hence we can back out the difference in the elasticities driven by economies of scale. The implied values of the elasticity of the young alone and the mean elasticity of young together in the baseline economy are presented in Table 9.

Table 9: Labor supply elasticities for old, young alone and young together

Elasticity		Baseline model value
Frisch elasticity of the old	ν	0.72
Marshallian elasticity of young alone	$\eta_{w^y}^{h^{yA}}$	0.47
Mean Marshallian elasticity of young together	$\bar{\eta}_{w^y}^{h^{yT}}$	0.77

These numbers contrasts sharply with results by Jaimovich et al. (2012), who require Frisch elasticity of the young to be 25 to match relative variances of the hours of young and old or Frisch of 7 to match the relative variance of wages of these two groups. In both exercises they keep the Frisch elasticity of the old *infinite*[22]. All three numbers violate starkly any estimates from the microeconometric literature - see Chetty et al. (2011a),Chetty et al. (2011b), Keane (2010). Our model matches endogenously, without targeting, the relative variance of hours and wages of young and old closely. At the same time we tie our hands by respecting the micro measurement of the Frisch elasticity of the stable, old households and set it to 0.72. Our theory, disciplined by the data, implies Marshalian elasticities of the young to be 0.47 for young alone and 0.77 for young together.

5.3 Business cycle elasticities

TO BE COMPLETED

[22] See Table 5 in the Jaimovich et al. (2012) paper.

5.4 The magnitude of the implicit transfers: learning from macro moments

The analysis of the elasticities of labor supply from the previous paragraph highlights the crucial role of the implicit transfers, ζc^o, young individuals receive when living with the old for the transmission of the aggregate productivity shock. These transfers are not directly observable and hence are not reported in the CPS data we use. However, we look at the magnitude of them through the lens of our model. By doing so we aim to learn from our quantitative exercise how large the implicit transfers are, conditional on the fact that we discipline our model with the macroeconomic moments from time series related to the hours of young alone, together and living arrangements. In what follows we introduce five measures of the transfers.

1. Fraction of the consumption of the old: ζ. This measure comes directly from how we model the transfers, which enter into the utility of young individual living together with the old household.

2. Fraction of the market consumption of the young together: $\frac{\zeta c^o}{c^{yT}}$. This measure allows for a direct comparison of market and non-market consumption of the young together.

3. Fraction of the market consumption of the young alone: $\frac{\zeta c^o}{c^{yA}}$. This measure allows for a direct comparison with market consumption of the young alone.

4. Additional average hours worked young together would have to spend on the market to achieve the same utility as with the implicit transfers. Define the measure as follows

$$\Delta_h = \left(\frac{\hat{h}^{yT} - \bar{h}^{yT}}{\bar{h}^{yT}} \right)$$

   where $\bar{h}^{yT}$ is the mean hours of the young together, as defined in 21, in the baseline calibration, and $\hat{h}^{yT}$ is the hours required to keep the utility unchanged absent transfers (see Appendix C.1 for derivation).

5. Additional productivity young together would have to have on the market to obtain the same utility as with the implicit transfers

$$\Delta_\varepsilon = \left(\frac{\hat{\varepsilon} - \bar{\varepsilon}}{\bar{\varepsilon}} \right)$$

   where $\hat{\varepsilon}$ is the mean productivity of the young together in the baseline calibration, and $\hat{\epsilon}$ is the mean productivity required to keep the utility unchanged absent transfers (see Appendix C.2 for derivation).

Table 10: Measures of the implicit transfers (%)

	Measures of implicit transfers (%)				
	ζ	$\frac{\zeta c^o}{c^{yT}}$	$\frac{\zeta c^o}{c^{yA}}$	Δ_h	Δ_ε
Baseline model	33.0	163.2	78.2	40.6	393.9

In terms of all five measures implicit transfers induced by our model are sizeable, ranging from 33% when measured as a fraction of the consumption of the old, up to 393.9% when measured in terms of additional productivity required to make young individual indifferent. Very large additional productivity required to account for the implicit transfers is a result of the fact that there is a significant fraction of the young individuals living within the old household, who work very little. While computing the measure we keep hours worked fixed so that this fraction contributes disproportionally to the average, additional productivity required to compensate for the implicit transfers.

5.5 Demand vs. supply channel

Jaimovich et al. (2012) argue that the joint behavior of age-specific hours and wages over the business cycle provides evidence to determine whether labor supply (preferences) or labor demand (technology) channel shapes differences in volatilities across age groups. They cleverly show that with production technology where labor input of the young and the old are perfect substitutes one can not generate larger volatilities of hours and wages of the young at the same time. Then, they argue that capital-experience complementarity allows to generate relative volatilities of hours and wages across age groups which are quantitatively similar to these observed in the data, while the keeping the preferences of the young and old identical. We denote this mechanism as a *demand channel*. This result hinges though on two assumptions which are not innocuous. First, they assume infinite Frisch elasticity of labor supply for both young and old agents in the economy. Second, they impose perfect risk sharing between young and old agents, by introducing a notion of family with separable preferences between young and old and joint budget constraint, which implies that consumptions are equalized between these two groups. We depart from these two assumptions in our analysis and support our argument with the empirical findings.

As we document in the empirical section a large fraction of the difference in relative hours volatility between young and old is due to the presence of the young together, which exhibit more then 4 times larger variance of hours than the old. In fact, we argue that young alone are more like old, both in terms of the first and the second moments of hours worked. Also, a significant portion of the wage differences between young and old is driven by the presence of the young living together, who earn 40 percent less relative to their peers living alone.

Thus, our main takeaway from the empirical section is that living arrangements generate larger differences in labor market outcomes between individuals than age. Given this finding, we take we take a stand that where people live does not matter for their productivity in the labor market. Hence, young alone and young together are perfect substitutes in production. With identical preferences if only the demand channel is present these two groups would have identical volatilities of hours and wages, in a stark contrast with the data. Therefore, we argue that demand channel is only a part of the story behind observed differences in volatilities across age groups and that one needs a theory of living arrangements that would speak quantitatively to the empirical regularities we have documented. We denote a theory of living arrangement proposed in this paper as a *supply channel.* By incorporating capital-experience complementarity in production and theory of living arrangements in our model, we can disentangle the demand from the supply channel and evaluate the contribution of each of them quantitatively. To do so we consider four economies:

1. Economy 1 is a standard RBC model with two types of agents (young and old) with identical preferences[23], capital-experience complementarity in production given by 7 and perfect risk sharing. We impose the finite Frisch elasticity of 0.72 for both groups.
2. Economy 2 is Economy 1 with *imperfect* risk sharing modeled by making young agents hand to mouth and introducing curvature in their utility from consumption.
3. Economy 3 is our baseline economy but with the Cobb-Douglas production technology, rather than capital-experience complementarity one.
4. Economy 4 is our baseline economy.

Table 11 summarizes the results for the four considered economies. Importantly, we make sure that the Solow residual in all economies has the same autocorrelation and variance, so that the magnitude of the aggregate shock is comparable across them. The third column illustrates the performance of Economy 1, with just the demand channel present, versus the data. While this model can get quantitatively close to the data on relative variances in hours and wages of the young it is unable to speak to the data on heterogeneity across young individuals, which largely shapes the observed differences in volatilities across age groups. Also, it misses the ratio of wages of the young to the old. The implied standard deviation of the aggregate hours is 0.36, which is 18.8% less than in our baseline economy. In Economy 2 we shut down the perfect risk sharing channel by making young individuals hand to mouth. If we keep the utility from consumption to be log hours would not move at all over the cycle, therefore we introduce the curvature parameter in the utility from consumption. By varying the curvature from the log to the $\sigma^y = 1$ one can generate relative volatility of hours of the young between zero and 2.17, as we illustrate in Table 16. In Table 11 we choose to discipline the curvature by targeting directly the relative volatility of hours worked of the young. The model yields similar results as

[23] The preferences are given by $\log(c) - \psi \frac{h^{1+1/\nu}}{1+1/\nu}$, where ν is the Frisch elasticity of labor supply.

Economy 1 with respect to relative volatility of wages, but dismisses entirely by construction the sources of differences in volatilities and the first moments, i.e. heterogeneity within the young with respect to the living arrangements. Also the standard deviation of the aggregate hours is almost identical with Economy 1. Economy 3 is constructed by shutting down the demand channel in our baseline economy and replacing capital-experience complementarity in technology with standard Cobb-Douglas technology. Hence, this version of the model contains our entire theory of living arrangements and labor market outcomes, i.e. supply channel. It speaks to the data on heterogeneity within the young group and can replicate the differences in the first moments of wages and hours, which Economies 1 and 2 could not. Also, it performs better in terms of replicating relative standard deviations of hours of the young and speaks data to the differences across young with different living arrangements. We corroborate the result by Jaimovich et al. (2012), that economy with perfect substitution between young and old is not able to generate differences in wage volatilities across age groups and hence all wages are equally volatile in this model. Finally, the model generates standard deviation of the aggregate hours of 0.57% which is 29% larger relative to the baseline economy. Thus, if anything, the demand channel dampens the response of the aggregate hours rather than amplifies it in our baseline model, when the Frisch elasticity of the old is disciplined by the microeconomic measurement.

5.6 The cyclical volatility of hours worked

Table 12 displays our main findings with respect to the cyclicality of hours worked. The first column shows the relevant second moments of the data, starting with the cyclical volatility of total hours. The remaining moments are the variances of hours of the young, the old, the young living alone, and the young living with the old, as well as the variance of the fraction living alone. As discussed in Section 2, the old have a lower volatility than the young, and the volatility of the young is far higher when they live inside an old household than when they live alone.

The second and third columns report the volatility of hours in a standard representative agent real business cycle model with a Frisch elasticity of .72, and the ratio of the model variances to the data. The volatility of hours in the standard model is very small .104 or just 5.1% of that in the data, but 6.8% of the variance of hours of the old in the data.

The final two columns report the analogous findings for the baseline economy. Recall that our calibration strategy imposed that productivity shocks should account for the same fraction of the total variance of all components of hours worked, which turns out to be 8.8%[24]. Looking at the variance of the old, we see that it is larger than that of the representative agent in the standard model (0.104 versus 0.134) despite the fact that the Frisch elasticity is the same: the existence of the young as well as variable living arrangements make prices move differently in

[24] The discrepancy from this fraction in case of the $var(h^{yA})$ and $var(h^{yT})$ comes from the fact that we do not match the targets exactly, as shown in the Table 7.

Table 11: Labor demand vs labor supply channel

Moments	Data	Economy 1: RBC + imperf. subst.+ perf. risk sharing	Economy 2: RBC + imperf. subst.+ no risk sharing	Economy 3: RBC + living arrangements	Baseline Economy
Means					
h^y/h^o	0.91	0.91*	0.91*	0.90	0.91
h^{yA}/h^o	1.06	-	-	1.10*	1.15*
h^{yT}/h^o	0.75	-	-	0.70*	0.68*
w^y/w^o	0.57	0.79	0.90	0.56	0.56
w^{yA}/w^o	0.72	-	-	0.68*	0.66*
w^{yT}/w^o	0.43	-	-	0.44*	0.46*
Second moments					
$\sigma(h^y)/\sigma(h^o)$	1.66	1.53	1.66*	1.63	1.65
$\sigma\left(h^{yA}\right)/\sigma(h^o)$	1.33	-	-	1.30*	1.35*
$\sigma\left(h^{yT}\right)/\sigma(h^o)$	2.00	-	-	1.98*	1.96*
$\sigma(x)/\sigma(h^o)$	0.68	-	-	0.66*	0.68*
$\sigma(w^y)/\sigma(w^o)$	1.44	1.27	1.22	1.00	1.28
$\sigma\left(w^{yA}\right)/\sigma(w^o)$	1.49	-	-	1.00	1.31
$\sigma\left(w^{yT}\right)/\sigma(w^o)$	1.60	-	-	1.00	1.19
$\sigma(h)$	1.43	0.36	0.35	0.57	0.44
$autcorr(SR)$	0.94	0.94	0.94	0.94*	0.94*
$var(SR)$	3.19	3.19	3.19	3.19*	3.19*

*Targeted moments

our economy than in the RBC model inducing the old to have more volatile hours.

Our calibration strategy is to target exactly the same volatility relative to the data of the hours of young when alone, the hours of the young when living with their parents, and the fraction of the young living alone than the volatility relative to the data of the hours worked by the old. Consequently, the additional volatility of total hours accounted for by the model comes from the covariance terms which are driven by the fact that the fraction of the young living at home is countercyclical. Hence, it is fundamental for the quantitative exercise we conduct to match the correlation between aggregate hours and the fraction of the young living with the old. This

Table 12: Second Moments of the Data, Standard Representative Agent and Baseline Economy

	Data	Representative Agent		Baseline	
		Value	% Accounted for	Value	% Accounted for
$var(h)$	2.03	.104	5.1%	.190	9.4%
$var(h^y)$	4.16			.364	8.8%
$var(h^o)$	1.52	.104	6.8%	.134	8.8%
$var(h^{yA})$	2.70			.245	9.0%
$var(h^{yT})$	6.10			.515	8.5%
$var(x)$	0.70			.062	8.8%
$var(SR)$	3.19	3.19	100%	3.19	100%
$autcor(SR)$	.94	.94	100%	.94	100%

countercyclicality increases the fraction accounted of the total variance of hours accounted for by the willingness of households to respond to movements in prices induced by productivity shocks to 0.190 or by 83% of the amount accounted for by a standard representative agent model with *the same* Frisch elasticity of labor.

6 Robustness

We now consider various other model economies with different calibration strategies. Our goal here is to make sure that the main results of the paper are invariant with respect to the definition of the young that we use, as well as with respect to the alternative choices for disciplining the volatility of living arrangements.

6.1 Alternative definitions of the young

In our baseline economy we identify the unstable young, somewhat arbitrarily, with individuals between 18 and 30 years old. We also consider three alternative definitions of the young. The first two of these definitions are based on equally arbitrary notions of who is young/unstable: (i) individuals who have never been married, and (ii) individuals who both have never been married and are between 18 and 30 years old. The third alternative definition of the unstable young is constructed not by choosing a particular demographic group, but by imposing that the implied movements in households per person relative to the variance of total hours of the old are the same in the model economy as in the data. The size of the young/unstable that achieves this target is higher than in the baseline economy: 35.6% compared with 31.6%.

When the unstable young are defined by explicitly targeting a particular demographic group, it is possible to obtain direct measures of the volatility of hours of the young, both living together and living alone, of hours of the old, and of the fraction of the young living with the old, from the data. This is not the case for the third alternative definition of the young, since the members of the group are defined only implicitly. Given that we do not have direct measures of the variances of the relevant variables, we cannot use them as targets for calibration. Instead, we have used the relative variance targets from the baseline calibration when calibrating the economy with the implicit definition of the young.

The findings are reported in Table 13. Unsurprisingly, the volatility of hours is slightly smaller for the narrow definitions of the young. Interestingly, for the narrowest definition (never-married individuals under 30) we see that the variance of the hours of the young is the largest of all the groups (recall that we target the relative variance of the hours of that particular group), but the size of the group is too small for this to have a large impact on the volatility of total hours worked. Overall, our basic findings are not affected by defining the young as different explicit demographic groups: we find a 66.3 (58.7) increase in total hours volatility when the young are defined as never-married individuals (never-married individuals under 30), compared with an increase of 82.7% in our baseline calibration, where the young are defined as individuals under 30.

Table 13: Second Moments of Main Variables for Alternative Calibrations

	$var(h)$	$var(h^o)$	$var\ (h^y)$	$var(x)$	(%) Contr of HH per pers + cov	$cor(x,h)$
Representative agent model	.104	.104	-	-	-	-
Baseline economy	.190	.134	.364	.062	13.4%	.480
<u>Alternative definitions of young</u>						
Never married	.173	.131	.351	.053	7.4%	-.325
Never married, 18-30	.165	.129	.428	.035	7.4%	-.374
Implicit definition	.201	.136	.375	.062	15.0%	-.491
<u>Alternative calibrations</u>						
Targeting M-moment	.193	.134	.377	.193	16.6%	-.465
Targeting absolute $var(x)$	.203	.134	.419	.697	22.2%	-.476

The implicit definition of the young is chosen so that the size of the young generates a contribution of the variance of households per person to total hours volatility that is the same as in the data.

The economy with an implicit definition of the young, calibrated so that the contribution of changes in households per person to the variance of aggregate hours is the same in the data (15.2%), generates quite a larger volatility of hours, 0.20. One might argue that the correct value for the fraction of young agents is somewhere between the values in the baseline economy and this economy.

6.2 Alternative target for the cyclicality of household size

In our baseline calibration we target $Var(x)/Var(h^o)$, implicitly assuming that the fraction of the observed cyclical variation in hours of old workers that is driven by TFP shocks is the same as the fraction of cyclical variation in the proportion of the young living with the old that is driven by TFP shocks. We now target directly the empirical counterpart of the counterfactual experiment that we are interested in: shutting down the margin of movements in x over the business cycle. To do this we use the moment M defined in Section 2.4 in equation 1. M compares the volatility of hours of the young with the volatility of a counterfactual series for hours that holds x fixed at its steady-state value. It thus provides a direct measurement of how much movement there is in x over the business cycle: the target value is 0.11. In this calibration we substitute only one calibration target, yet all nine parameters in Table 7 change, as well as the two parameters that determine the productivity shock process. This economy yields a variance of hours (0.193) slightly higher than in the Baseline (0.190), despite having a total contribution of the movements of households per person to total hours (16.6%) that is larger than in the baseline (13.4%) and indeed that in the data (15.2%).

An alternative approach to targeting relative (to the variance of hours of the old) variance of the fraction of young individuals living with the old is to target it's absolute variance. In our model this would implicitly imply that all the movements in living arrangements are driven by the TFP shocks. Hence, one could ask how much different the main statistics of the model would be if we follow this approach. The last row in Table 13 illustrates the results. Indeed, the model would generate larger variance of the aggregate hours (0.203 vs. 0.190 in the baseline) but the difference it is not substantial. The variance of the hours of the old remains unchanged, whereas the variance of the hours of young increases by roughly 15%. Variance of x by construction is in line with the data and almost ten times larger relative to the baseline, but the effect on covariances dampens it's impact on the variance of the aggregate hours. In this economy the contribution of the movements in the household size to the hours per person is 22.5%, overshooting the data (15.1%) and exceeding the baseline model (13.4%). Thus, we view this exercise as the validation of our calibration strategy. If we allow TFP shocks to drive all the movements in the living arrangements it would not change substantially the variance of the aggregate hours and we would be much worse off relative to the data in terms of the contribution of the changes in household size to the volatility of the hours per person over the cycle.

7 The Great Recession through the lens of the model

We ask two questions here:

1. Given dynamics for hours of old, were hours and living arrangements of young in line with expectations based on previous recessions?
2. Which channel demand or supply contributed more to the young vs. old disparity of labor market outcome?

TO BE COMPLETED

8 Implications for the calibration of representative agent models

Part of the aim of this paper is to show that the macro labor elasticity is indeed different from its micro counterpart, even while remaining scrupulously respectful of the measurements of the micro elasticity that are based on direct empirical evidence. Consequently, we now ask the question of how much higher is the macro elasticity when we are explicit about both the existence of young people and the existence of movements in household size. To answer this question, we calibrate a standard representative agent business cycle model by choosing the Frisch elasticity so that the representative agent model generates the same volatility of total hours as the model economies that we study in this paper.

Table 14 reports these findings. For our baseline definition of the young, we find that the implied macro Frisch elasticity is 1.17. Since the elasticity of the old in our baseline economy was 0.72, our findings suggest an increase in the Frisch elasticity of 62.7% which we find quite sizable.

Table 14 also provides the implied macro elasticity of the alternative calibration strategies discussed in Section 6. The value of these other macro elasticities moves in a consistent manner to the models' predictions for the total volatility of hours.

Alternative assumptions for micro Frisch elasticity A concern that we have is whether the increase in the Frisch elasticity when moving from a representative agent economy to an economy with unstable agents is affected by the level of the actual micro Frisch elasticity.[25] The reason for this concern is the non-linearity of the underlying model. To explore this issue, we replicated the analysis above for an economy where all the targets are the same as

[25] Chetty et al. (2011a) and Chetty et al. (2011b) conduct a meta analysis of micro estimates of the Frisch elasticity. Of all the studies they examine, only one could be argued to include the type of individuals with unstable living arrangements that we focus on in this paper: this is the study of Iceland's temporary tax holiday by Bianchi et al. (2001). The remaining studies should be interpreted as estimates of the Frisch elasticity for stable or old individuals.

Table 14: Macro elasticity comparable to a micro elasticity of 0.72

Economy	Implied Frisch in RA RBC	Proportional Increase
Baseline economy	1.17	62.7%
Alternative definitions of young		
Never married	1.09	51.4%
Never married, 18-30	1.05	45.8%
Implicit definition	1.22	69.7%
Alternative calibrations		
Targeting M-moment	1.18	64.5%
Targeting absolute $var(x)$	1.23	71.2%

The implicit definition of the young is chosen so that the size of the young generates a contribution of the variance of households per person to total hours volatility that is the same as in the data.

in the baseline, except for the Frisch elasticity of the stable old agents. We consider values of $\{.5,1.0,2.0\}$. Table 15 reports the representative agent counterpart of our economies with young agents. Interestingly, we find that the level matters, exacerbating the role of the young in shaping the macro elasticity: for all the alternative values of the Frisch elasticity in the multiple agent economies that we tried, the implied Frisch elasticity of its representative agent counterpart is proportionally higher than in the Baseline, with the effect being stronly nonlinear as we increase the Frish in our baseline model.

Table 15: Macro elasticity for alternative micro elasticities

Frisch elasticity for the stable:	$var(h)$	% Acc. for	Implied Frisch in RA RBC	Proportional Increase
$\nu = 0.72$ (Baseline)	.190	9.4%	1.17	62.7%
$\nu = 0.5$	.105	5.2%	0.76	52.0%
$\nu = 1.0$	.302	14.9%	1.72	72.0%
$\nu = 2$	.725	35.7%	4.75	137.5%

Notes: Results are based on baseline definition of the unstable: individuals aged 18 to 30.

9 Conclusions

In this paper we have first documented of countercyclical movements in household size over the business cycles. We found that these cyclical movements are large: changes in the average number of households per person account for 15% of the cyclical variation in hours worked per person. A large part of these changes in household composition is due to young, or unstable, individuals moving in and out of the homes of older, stable individuals.

We then posed a model with both stable and unstable individuals where household composition is chosen optimally by the unstable agents in the model. Our model is embedded in a growth model that is suitable for business cycle analysis and that incorporates the imperfect substitubility in production of the labor of the young and the old documented by Jaimovich et al. (2012). We used the model to reassess the importance of TFP shocks for hours volatility.

Our findings for the volatility of hours can be summarized as follows. Although TFP shocks in a baseline representative agent economy account for a very small fraction of the observed volatility of hours, this fraction increases by 114% when (i) the existence of young people, some of whom live with the old, is taken into account; and (ii) it is recognized that they move in and out of older households in a cyclical manner. A decomposition of the increase in hours volatility yields that about one half due to the existence of young, unstable agents with a high labor elasticity, while the rest is due to the fact that the young live sometimes with other, older people. The cyclical movements of the fraction of the young living with older agents by itself is responsible for 7% of that increase.

We then calculated what size of a Frisch elasticity would a representative agent model need to have to display the same volatility of total hours than our model (with old agents having a Frisch elasticity of labor of 0.72), and we found that its implied value is 1.24, an increase of 72% over the Frisch elasticity that would be obtained from measuring individual, stable, households. Moreover, we also found that this 72% is the minimum increase that results from economies where the old display a wide range of Frisch elasticities (from .5 to 2.0). All our findings are very robust to details of the calibration.

We conclude that macroeconomists now have a powerful argument to claim that the macro labor elasticity is larger than that yielded by micro studies that are based on young agents having both a more volatile behavior of wages and a variable (both across time and in the cross section) household structure.

References

Aguiar, M., M. Bils, K. K. Charles, and E. Hurst (2017): "Leisure Luxuries and the Labor Supply of Young Men," Working Paper 23552, National Bureau of Economic Research.

Aiyagari, S. R., J. Greenwood, and N. Güner (2000): "On the State of the Union," 108, 213–244.

Bianchi, M., B. R. Gudmundsson, and G. Zoega (2001): "Iceland's Natural Experiment in Supply-Side Economics," *American Economic Review*, 91, 1564–1579.

Chetty, R., A. Guren, D. S. Manoli, and A. Weber (2011a): "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins," in *American Economic Review: Paper and Proceedings*, vol. 101(3), 471–475.

——— (2011b): "Does Indivisible Labor Explain the Difference Between Micro and Macro Elasticities? A Meta-Analysis of Extensive Margin Elasticities," *NBER Working Papers*, 16729.

Clark, K. B. and L. H. Summers (1981): "Demographic Differences in Cyclical Employment Variation," *Journal of Human Resources*, 16, 61–79.

Cubeddu, L. M. and J.-V. Ríos-Rull (2003): "Families as Shocks," 1, 671–682, (Papers and Proceedings of the Seventeenth Annual Congress of the European Economic Association, Venice, 21-24 August 2002).

Doepke, M. and M. Tertilt (2016): *Families in Macroeconomics*, Elsevier, vol. 2 of *Handbook of Macroeconomics*, chap. 0, 1789–1891.

Erosa, A., L. Fuster, and G. Kambourov (2016): "Towards a Micro-Founded Theory of Aggregate Labour Supply," *Review of Economic Studies*, 83, 1001–1039.

Gomme, P., R. Rogerson, P. Rupert, and R. Wright (2005): "The Business Cycle and the Life Cycle," in *NBER Macroeconomics Annual 2004*, ed. by M. Gertler and K. Rogoff, MIT Press, vol. 19, 415–592.

Greenwood, J. and N. Guner (2009): "Marriage and divorce since World War II: analyzing the role of technological progress on the formation of households," in *NBER Macroeconomics Annual 2005*, University of Chicago Press.

Greenwood, J., N. Güner, and J. A. Knowles (2003): "More on Marriage, Fertility and the Distribution of Income," 44, 827–862.

Guler, B., F. Guvenen, and G. L. Violante (2012): "Joint-search theory: New opportunities and new frictions," *Journal of Monetary Economics*, 59, 352–369.

Heathcote, J. H., K. Storesletten, and G. L. Violante (2010): "The Macroeconomic Implications of Rising Wage Inequality in the United States," 118, 681–722.

Jaimovich, N., S. Pruitt, and H. E. Siu (2012): "The Demand for Youth: Implications for the Hours Volatility Puzzle," Forthcoming, *American Economic Review*.

Jaimovich, N. and H. E. Siu (2009): "The Young, the Old, and the Restless: Demographics and Business Cycle Volatility," *American Economic Review*, 99, 804–826.

Kaplan, G. (2012): "Moving Back Home: Insurance against Labor Market Risk," *Journal of Political Economy*, 120, 446 – 512.

Keane, M. P. (2010): "Labor Supply and Taxes: A Survey," Working Paper No. 160, School of Finance and Economics, University of Technology Sidney.

Kydland, F. E. (1984): "Labor-Force Heterogeneity and the Business Cycle," *Carnegie-Rochester Conference Series on Public Policy*, 21, 173–209.

Ljungqvist, L. and T. Sargent (2011): "A Labor Supply Elasticity Accord?" *American Economic Review*, 101, 487–491.

Prescott, E. C. (2006): "Nobel Lecture: the Transformation of Macroeconomic Policy and Research," 114, 203–235.

Regalia, F., J.-V. Ríos-Rull, and J. Short (2013): "What Accounts for the Increase in Single Households and for the Properties of Fertility?" Mimeo, University of Minnesota. First version, 1998.

Ríos-Rull, J.-V. (1992): "Business Cycle Behavior of Life-Cycle Economies with Incomplete Markets," *Cuadernos Economicos de ICE*, 51, 173–96.

——— (1993): "Working in the Market, Working at Home and the Acquisition of Skills: A General-Equilibrium Approach," *American Economic Review*, 83, 893–907.

——— (1996): "Life Cycle Economies and Aggregate Fluctuations," 63, 465–490.

Ríos-Rull, J.-V., F. Schorfheide, C. Fuentes-Albero, M. Kryshko, and R. Santaeulalia-Llopis (2009): "Methods versus substance: measuring the effects of technology shocks on hours," National Bureau of Economic Research Cambridge, Mass., USA.

Appendix

A Numerical procedure

The model is computed using standard perturbation techniques. The only non-standard feature of the solution is computation of the integrals (10) - (14). To do so we use Gauss-Laguerre quadrature for approximating the value of integrals of the following kind:

$$\int_0^{+\infty} e^{-x} f(x)\, dx.$$

In this case

$$\int_0^{+\infty} e^{-x} f(x)\, dx \approx \sum_{i=1}^{n} \omega_i^{GL} f(\zeta_i^{GL})$$

where ζ_i^{GL} is the i-th root of Laguerre polynomial $L_n(x)$ and the weight ω_i^{GL} is given by

$$\omega_i^{GL} = \frac{\zeta_i^{GL}}{(n+1)^2 [L_{n+1}(\zeta_i^{GL})]^2}.$$

To illustrate our application, start with the equation 10 defining x and let

$$g(\varepsilon) \quad = \quad F_\eta\left(\eta^*(\varepsilon); \lambda_\eta^1, \lambda_\eta^2\right)$$

where λ_η^1 and λ_η^1 are the parameters of the normal distribution. Hence:

$$\begin{aligned} x &= \int_0^\infty \int_{-\infty}^{\eta^*(\varepsilon)} dF_\eta\, dF_\varepsilon = \int_0^\infty F_\eta\left(\eta^*(\varepsilon)\right)\, dF_\varepsilon \\ &= \int_0^\infty g(\varepsilon)\ f_\varepsilon\left(\varepsilon; \lambda_\varepsilon^1, \lambda_\varepsilon^2\right)\, d\varepsilon \end{aligned}$$

where f_ε is density of Gamma distribution with parameters $\lambda_\varepsilon^1, \lambda_\varepsilon^2$ given by

$$f_\varepsilon\left(\varepsilon; \lambda_\varepsilon^1, \lambda_\varepsilon^2\right) = \frac{1}{\Gamma\left(\lambda_\varepsilon^2\right)\left(\lambda_\varepsilon^1\right)^{\lambda_\varepsilon^2}} \varepsilon^{\lambda_\varepsilon^2 - 1} \exp\left(-\frac{\varepsilon}{\lambda_\varepsilon^1}\right) \quad \text{for} \quad \varepsilon > 0,\ \lambda_\varepsilon^1, \lambda_\varepsilon^2 > 0$$

where $\Gamma\left(\lambda_{\varepsilon}^{2}\right)$ is a Gamma function. Let

$$y = \frac{\varepsilon}{\lambda_{\varepsilon}^{1}}$$

which defines a mapping $\phi : \left[\phi^{-1}\left(0\right), \phi^{-1}\left(\infty\right)\right] \rightarrow \left(0, \infty\right)$ given by $\varepsilon = \phi\left(y\right) = \lambda_{\varepsilon}^{1} y$ with $\phi'\left(y\right) = \lambda_{\varepsilon}^{1}$. Thus, the density becomes

$$f\left(\phi\left(y\right); \lambda_{\varepsilon}^{1}, \lambda_{\varepsilon}^{2}\right) = \frac{1}{\Gamma\left(\lambda_{\varepsilon}^{2}\right)\left(\lambda_{\varepsilon}^{1}\right)^{\lambda_{\varepsilon}^{2}}}\left(\lambda_{\varepsilon}^{1} y\right)^{\lambda_{\varepsilon}^{2}-1}\exp\left(-y\right)$$

and therefore integrating by substitution we get

$$\begin{aligned}
x &= \int_{0}^{\infty} g\left(\varepsilon\right)\; f_{\varepsilon}\left(\varepsilon\right)\; d\varepsilon \\
&= \int_{\phi^{-1}(0)}^{\phi^{-1}(\infty)} g\left(\phi\left(y\right)\right)\; f_{\varepsilon}\left(\phi\left(y\right)\right)\; \phi'\left(y\right)\; dy \\
&= \int_{0}^{\infty} g\left(\lambda_{\varepsilon}^{1} y\right)\; \frac{\left(\lambda_{\varepsilon}^{1} y\right)^{\lambda_{\varepsilon}^{2}-1}}{\Gamma\left(\lambda_{\varepsilon}^{2}\right)\left(\lambda_{\varepsilon}^{1}\right)^{\lambda_{\varepsilon}^{2}-1}}\exp\left(-y\right)\; dy \\
&= \int_{0}^{\infty} g\left(\lambda_{\varepsilon}^{1} y\right)\; \frac{y^{\lambda_{\varepsilon}^{2}-1}}{\Gamma\left(\lambda_{\varepsilon}^{2}\right)}\exp\left(-y\right)\; dy
\end{aligned}$$

let

$$\varphi\left(y\right) = g\left(\lambda_{\varepsilon}^{1} y\right)\frac{y^{\lambda_{\varepsilon}^{2}-1}}{\Gamma\left(\lambda_{\varepsilon}^{2}\right)} = F_{\eta}\left(\eta^{*}\left(\lambda_{\varepsilon}^{1} y\right); \lambda_{\eta}^{1}, \lambda_{\eta}^{2}\right)\frac{y^{\lambda_{\varepsilon}^{2}-1}}{\Gamma\left(\lambda_{\varepsilon}^{2}\right)}$$

hence using the Gauss-Laguerre quadrature the x can be numerically approximated as follows

$$\begin{aligned}
x &= \int_{0}^{\infty} g\left(\lambda_{\varepsilon}^{1} y\right)\; \frac{y^{\lambda_{\varepsilon}^{2}-1}}{\Gamma\left(\lambda_{\varepsilon}^{2}\right)}\exp\left(-y\right)\; dy \\
&= \int_{0}^{\infty} \varphi\left(y\right)\exp\left(-y\right)\; dy \\
&= \sum_{i=1}^{n} \omega_{i}^{GL}\varphi\left(\zeta_{i}^{GL}\right)\; .
\end{aligned}$$

We proceed analogously with the rest of the integrals (11) - (14).

B Labor supply elasticities

Start with the labor supply of young alone, which is independent on the living arrangement at the beginning of a period, given by

$$h^{yA} = \left(\frac{(w^y \varepsilon)^{1-\sigma^y}}{\psi^y}\right)^{\left(\frac{\nu^y}{1+\sigma^y \nu^y}\right)}. \tag{25}$$

Taking derivative of (25) with respect to wage w^y yields

$$\begin{aligned}
\frac{dh^{yA}}{dw^y} &= \left(\frac{\nu^y}{1+\sigma^y\nu^y}\right)\left(\frac{(w^y)^{1-\sigma^y}\varepsilon^{1-\sigma^y}}{\psi^y}\right)^{\left(\frac{\nu^y}{1+\sigma^y\nu^y}-1\right)}(1-\sigma^y)\left(\frac{(w^y)^{-\sigma^y}\varepsilon^{1-\sigma^y}}{\psi^y}\right) \\
&= \left(\frac{(1-\sigma^y)\nu^y}{1+\sigma^y\nu^y}\right)\left(\frac{\varepsilon^{1-\sigma^y}}{\psi^y}\right)^{\left(\frac{\nu^y-1-\sigma^y\nu^y}{1+\sigma^y\nu^y}+1\right)}(w^y)^{-\sigma^y}\left((w^y)^{1-\sigma^y}\right)^{\left(\frac{\nu^y-1-\sigma^y\nu^y}{1+\sigma^y\nu^y}\right)}.
\end{aligned}$$

By the fact that

$$\begin{aligned}
\left(\frac{\nu^y-1-\sigma^y\nu^y}{1+\sigma^y\nu^y}+1\right) &= \frac{\nu^y}{1+\sigma^y\nu^y} \\
(1-\sigma^y)\left(\frac{\nu^y-1-\sigma^y\nu^y}{1+\sigma^y\nu^y}\right) &= \frac{\nu^y-1-2\sigma^y\nu^y}{1+\sigma^y\nu^y}
\end{aligned}$$

we get

$$\frac{dh^{yA}}{dw^y} = \left(\frac{(1-\sigma^y)\nu^y}{1+\sigma^y\nu^y}\right)\left(\frac{\varepsilon^{1-\sigma^y}}{\psi^y}\right)^{\left(\frac{\nu^y}{1+\sigma^y\nu^y}\right)}(w^y)^{\frac{\nu^y-1-2\sigma^y\nu^y}{1+\sigma^y\nu^y}}.$$

Hence the uncompensated, Marshallian elasticity of labor supply for young alone is

$$\begin{aligned}
\eta^{h^{yA}}_{w^y} &= \left(\frac{w^y}{h^{yA}}\right)\frac{dh^{yA}}{dw^y} \\
&= \frac{1}{h^{yA}}\left(\frac{(1-\sigma^y)\nu^y}{1+\sigma^y\nu^y}\right)\left(\frac{\varepsilon^{1-\sigma^y}}{\psi^y}\right)^{\left(\frac{\nu^y}{1+\sigma^y\nu^y}\right)}(w^y)^{\frac{\nu^y-1-2\sigma^y\nu^y+1+\sigma^y\nu^y}{1+\sigma^y\nu^y}} \\
&= \left(\frac{(1-\sigma^y)\nu^y}{1+\sigma^y\nu^y}\right)\left((w^y)^{1-\sigma^y}\right)^{-\left(\frac{\nu^y}{1+\sigma^y\nu^y}\right)}(w^y)^{\frac{\nu^y-\sigma^y\nu^y}{1+\sigma^y\nu^y}}.
\end{aligned}$$

Notice that

$$-\frac{(1-\sigma^y)\,\nu^y}{1+\sigma^y\nu^y}+\frac{\nu^y-\sigma^y\nu^y}{1+\sigma^y\nu^y}=0$$

implying

$$\eta_{w^y}^{h^{yA}}=\frac{(1-\sigma^y)\,\nu^y}{1+\sigma^y\nu^y} \tag{26}$$

which is the formula 23 in the main body of the paper. The labor supply of the young together is implicitly defined by the following first order condition

$$\left(w^y h^{yT}\varepsilon+\zeta c^o\right)^{-\sigma^y} w^y\varepsilon-(\psi^y)\left(h^{yT}\right)^{\frac{1}{\nu^y}}=0. \tag{27}$$

Define

$$G\left(w^y,h^{yT}\right)=\left(\frac{w^y\varepsilon}{\psi^y}\right)^{-\frac{1}{\sigma^y}}\left(w^y h^{yT}\varepsilon+\zeta c^o\right)-\left(h^{yT}\right)^{-\frac{1}{\sigma^y\nu^y}}=0$$

then the Marshallian elasticity of labor supply is given by

$$\eta_{w^y}^{h^{yT}}=\left(\frac{w^y}{h^{yT}}\right)\frac{dh^{yT}}{dw^y}=\left(\frac{w^y}{h^{yT}}\right)\left(-\frac{\partial G/\partial w^y}{\partial G/\partial h^{yT}}\right)$$

where the second equality comes from the implicit function theorem. After some algebra we get

$$\frac{\partial G\left(h^{yT},w^y\right)}{\partial w^y}=\left(\frac{\sigma^y-1}{\sigma^y}\right)\left(\frac{w^y\varepsilon}{\psi^y}\right)^{-\frac{1}{\sigma^y}}\left[\varepsilon h^{yT}-\frac{\zeta c^o}{(\sigma^y-1)\,w^y}\right] \tag{28}$$

$$\frac{\partial G\left(h^{yT},w^y\right)}{\partial h^{yT}}=\left(\frac{(w^y)^{1-\sigma^y}\,\varepsilon^{1-\sigma^y}}{\psi^y}\right)^{-\frac{1}{\sigma^y}}+\left(\frac{1}{\sigma^y\nu^y}\right)\left(h^{yT}\right)^{-\frac{1}{\sigma^y\nu^y}-1}. \tag{29}$$

The optimality condition (27) implies

$$\left(h^{yT}\right)^{-\frac{1}{\sigma^y\nu^y}}=\left(\frac{w^y\varepsilon}{\psi^y}\right)^{-\frac{1}{\sigma^y}}\left(w^y h^{yT}\varepsilon+\zeta c^o\right),$$

which plugged into the (29) after rearranging yields

$$\frac{\partial G\left(h^{yT},w^y\right)}{\partial h^{yT}}=\left(\frac{w^y\varepsilon}{\psi^y}\right)^{-\frac{1}{\sigma^y}}\left[w^y\varepsilon\left(\frac{1+\sigma^y\nu^y}{\sigma^y\nu^y}\right)+\frac{\zeta c^o}{h^{yT}\sigma^y\nu^y}\right].$$

Combining all elements the elasticity of interest becomes

$$\begin{aligned}\eta_{w^y}^{h^{yT}} &= \left(\frac{w^y}{h^{yT}}\right)\frac{\left(\frac{\sigma^y-1}{\sigma^y}\right)\left[\varepsilon h^{yT}-\frac{\zeta c^o}{(\sigma^y-1)w^y}\right]}{\left[w^y\varepsilon\left(\frac{1+\sigma^y\nu^y}{\sigma^y\nu^y}\right)+\frac{\zeta c^o}{h^{yT}\sigma^y\nu^y}\right]}\\ &= \frac{\nu^y\left(1-\sigma^y\right)}{1+\sigma^y\nu^y}\frac{\left[1+\left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1-\sigma^y}\right)\right]}{\left[1+\left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1+\sigma^y\nu^y}\right)\right]},\end{aligned}$$

where second inequality follows after some algebra. As a result we get

$$\eta_{w^y}^{h^{yT}} = \eta_{w^y}^{h^{yA}}\frac{\left[1+\left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1-\sigma^y}\right)\right]}{\left[1+\left(\frac{\zeta c^o}{\varepsilon w^y h^{yT}}\right)\left(\frac{1}{1+\sigma^y\nu^y}\right)\right]} \tag{30}$$

which is the formula 24 in the main body of the paper.

C Measures of implicit transfers

C.1 Hours measure

This measure is developed as follows. Consider the utilities of the young with transfers and no transfers for an individual who enters the period living together or alone and chooses to live with the old in the current period. Fix productivity ε and threshold $\eta^*(\varepsilon)$ defined by 9 and let $\widehat{h}_{\varepsilon}^{yT}$ be hours worked which would make the individual indifferent, i.e.

$$\left[\frac{\left(\varepsilon w^y h^{yT}+\zeta c^o\right)^{1-\sigma^y}}{1-\sigma^y}-\varphi^y\frac{\left(h^{yT}\right)^{1+\frac{1}{\nu^y}}}{1+\frac{1}{\nu^y}}-\eta^*(\varepsilon)-\right]$$
$$\left[\frac{\left(\varepsilon w^y\widehat{h}_{\varepsilon}^{yT}\right)^{1-\sigma^y}}{1-\sigma^y}-\varphi^y\frac{\left(\widehat{h}_{\varepsilon}^{yT}\right)^{1+\frac{1}{\nu^y}}}{1+\frac{1}{\nu^y}}-\eta^*(\varepsilon)\right]=0$$

therefore averaging across young individuals living together we yield at

$$\widehat{h}^{yT}=\int_0^\infty\int_0^{\eta^*(\varepsilon)}\widehat{h}_{\varepsilon}^{yT}dF_\eta dF_\varepsilon$$

and hence the measure

$$\Delta_h = \left(\frac{\widehat{h}^{yT} - \overline{h}^{yT}}{\overline{h}^{yT}} \right) \times 100$$

where $\overline{h}^{yT}$ is the mean hours worked of the young together in the baseline calibration, defined by equation 21.

C.2 Productivity measure

This measure is developed as follows. This measure is developed as follows. Consider the utilities of the young with transfers and no transfers for an individual who enters the period living together or alone and chooses to live with the old in the current period. Fix hours worked h^{yT} and the threshold $\eta^*(\varepsilon)$ defined by 9 and let $\overline{\varepsilon}_T$ be the productivity which would make the individual indifferent, leading to

which yields

$$\widehat{\varepsilon}_T = \frac{\varepsilon w^y h^{yT} + \zeta c^o}{w^y h^{yT}}.$$

therefore averaging across young individuals living together we yield at

$$\widehat{\varepsilon} = \int_0^\infty \int_0^{\eta^*(\varepsilon)} \widehat{\varepsilon}_T \; dF_\eta dF_\varepsilon$$

and hence the measure is

$$\Delta_\varepsilon = \left(\frac{\widehat{\varepsilon} - \overline{\varepsilon}}{\overline{\varepsilon}} \right) \times 100.$$

where $\overline{\varepsilon}$ is the mean productivity of the young together in the baseline calibration.

D Additional tables

Table 16: Labor demand vs labor supply channel. Sensitiveness of the curvature of the utility from consumption.

Moments	Data	$\sigma = 1$	$\sigma = 0.8$	$\sigma = 0.6$	$\sigma = 0.4$	$\sigma = 0.2$	$\sigma = 0$
Means							
h^y/h^o	0.91	0.91	0.91	0.91	0.91	0.91	0.91
h^{yA}/h^o	1.06	-	-	-	-	-	-
h^{yT}/h^o	0.75	-	-	-	-	-	-
w^y/w^o	0.57	0.79	0.90	0.90	0.90	0.90	0.90
w^{yA}/w^o	0.72	-	-	-	-	-	-
w^{yT}/w^o	0.43	-	-	-	-	-	-
Second moments							
$\sigma\left(h^y\right)/\sigma\left(h^o\right)$	1.65	0.00	0.34	0.71	1.13	1.60	2.17
$\sigma\left(h^{yA}\right)/\sigma\left(h^o\right)$	1.33	-	-	-	-	-	-
$\sigma\left(h^{yT}\right)/\sigma\left(h^o\right)$	4.01	-	-	-	-	-	-
$\sigma\left(x\right)/\sigma\left(h^o\right)$	2.00	-	-	-	-	-	-
$\sigma\left(w^y\right)/\sigma\left(w^o\right)$	1.44	1.45	1.40	1.35	1.29	1.23	1.15
$\sigma(h)$	1.42	0.20	0.23	0.26	0.30	0.35	0.40
$autcorr(SR)$		0.94	0.94	0.94	0.94	0.94	0.94
$var(SR)$		3.19	3.19	3.19	3.19	3.19	3.19