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DYNASTIC PRECAUTIONARY SAVINGS

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ABSTRACT

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Abstract

This paper provides evidence that parents accumulate savings to insure their children against income risk. I refer to this behavior as *dynastic precautionary saving* and quantify its extent using matched parent-child pairs from the Panel Study of Income Dynamics and exploiting variation in income risk across age, industries and occupations. I then build a model of altruistically linked overlapping generations, in which parents and children interact strategically, that is quantitatively consistent with the empirical evidence. I argue that strategic interactions are important for generating the observed dynastic precautionary behavior and use the model to show this component of household savings is quantitatively important for wealth accumulation, intergenerational transfers and consumption insurance.

1 Introduction

The extent of private consumption insurance against income shocks is a subject of great importance for numerous reasons.[1] First, the ability of households to absorb shocks to their income has substantial implications for their welfare. Second, the value of government

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[1] Private consumption insurance encompasses all means (that go beyond government interventions) through which households can smooth consumption in response to adverse events like income shocks.

provided insurance is highly dependent on the extent of consumption insurance that prevails in the economy, and could be severely overstated if one fails to account for the crowding-out effect it might have on private risk-sharing. Third, it serves as a tool for discriminating between macroeconomic models in which imperfect consumption insurance against income shocks is at play.

This paper expands the existing knowledge on consumption insurance by providing evidence that parents accumulate savings to insure their children against income risk. I refer to this newly documented insurance channel as *dynastic precautionary saving*. The argument follows from extending the theory of precautionary saving across generations: in the face of uncertainty in children's income, altruistic parents postpone own current consumption in favor of precautionary saving against bad income realizations children might be subject to. Dynastic precautionary saving goes beyond self-insurance against income shocks, thus contributing towards bridging the gap between consumption insurance in the data and in standard life-cycle models.[2] Additionally, the existence of this saving motive is relevant for distinguishing between the two frameworks that are at the heart of essentially all macro models: the infinitely-lived agents model and the life-cycle model, providing support for the former. Finally, it provides much needed insight into the nature of the bequest motive and expands the pool of determinants of wealth accumulation after retirement.

In this paper, I present evidence on dynastic precautionary saving using parent-child pairs from the Panel Study of Income Dynamics (PSID). In particular, I examine how a parent's consumption responds to the uncertainty of his child's permanent income. To that end, I first propose a measure of permanent income uncertainty closely related to the theoretical definition of permanent income. I then conduct a regression analysis of the effect of dynastic uncertainty on parental consumption using the sample of parent-child pairs, and find a negative and statistically significant relationship. Motivated by the empirical evidence, I build a model of altruistically linked overlapping generations in which parents engage in dynastic precautionary saving. I use the model to assess the contribution of this new saving motive to wealth accumulation, intergenerational transfers and consumption insurance.

The measure of income uncertainty considered in this paper is defined as the standard deviation of the forecast error of permanent income. Intuitively, the higher the uncertainty, the more difficult it is to forecast earnings accurately, which translates into a larger standard deviation of the forecast error. Because of sample attrition and to minimize the effect of

[2] Kaplan and Violante (2010) find a substantial gap between the amount of consumption insurance implicit in a calibrated life-cycle model and the corresponding estimate from US data in Blundell, Pistaferri and Preston (2008). This gap is particularly large for the young.

measurement error, I follow the tradition of the precautionary saving literature and focus on properties of permanent income uncertainty that vary across age and work sectors (i.e. industries and occupations).[3] I find that permanent income uncertainty decreases with age. On average, more than half is resolved by age 40. Moreover, there is substantial variation across sectors, both in terms of the level of uncertainty and the speed at which it resolves with age.

Using this variation, I find that parental consumption responds negatively to the child's permanent income uncertainty. In particular, the elasticity of parental consumption to dynastic uncertainty is -0.076. This implies that parents of children younger than 40 consume on average $2,528 less per year because at that stage most of children's income uncertainty is yet to be resolved. Building on the heterogeneity of permanent income risk across sectors, the regression result implies that, holding everything else equal, the consumption of a parent whose child is a construction worker is 2.5% lower than the consumption of a parent whose child is a services worker because of the dynastic uncertainty difference.

I take a number of steps to address several endogeneity concerns. Notably, I explore the robustness of the results to *(i)* controlling for health status, as it may be the case that health and mortality risk are correlated with the sector in which an individual works, and *(ii)* addressing selection concerns that stem from children choosing to work in riskier sectors, knowing their parents save. When simultaneously addressing these concerns, the estimated consumption elasticity is approximately 1 percentage point lower than the baseline estimate, but significant and not different from the baseline estimate in a statistical sense. Additionally, I verify the robustness of the results to a series of alternative specifications which include controlling for heterogeneous bequest motives and using alternative consumption and permanent income uncertainty measures.

Motivated by the empirical evidence, I then explore the implications of dynastic precautionary saving for wealth accumulation, intergenerational transfers and consumption insurance in a partial equilibrium model of altruistically linked overlapping generations. The class of models consistent with dynastic precautionary saving features three key ingredients: income risk, incomplete markets, and altruism à la Barro (1974), with the parent valuing the child's utility from consumption.[4]

[3]Section 2.1 defines permanent income uncertainty at individual level and discusses in detail what are its shortcomings in practice, as well as the extent to which my approach of projecting income uncertainty on age, industry and occupation gets around these shortcomings.

[4]The direction of altruism (i.e. from parent to child, from child to parent or two-sided) is not essential. What matters is that the form of altruism considered extends the budget constraint across generations. Note that models with warm-glow bequest do not generate dynastic precautionary saving behavior in response

In light of existing evidence on imperfect risk-sharing within and between families, I model the decision making process between parents and children as a non-cooperative game without commitment. In my framework, individuals work in sectors characterized by different degrees of permanent income uncertainty. Each period, parents and children decide individually and sequentially how much to consume and save. In addition, altruistic parents can provide monetary support to their children through explicit financial transfers while they are alive and by leaving an inheritance upon their death. The allocations of interest are given by the Markov-perfect equilibrium of the parent-child repeated game.

I repeat the regression exercise with data generated from the calibrated model and find that the response of parental consumption to both own and child's income risk is of similar magnitude as in the data. In particular, the model estimates fall well within the 95% confidence interval of the empirical estimates. The model with strategic interactions between parents and children also accounts reasonably well for the age pattern of inter-vivos transfers. I show that strategic interactions between parents and children are important for matching the data by solving a version of the model in which they are absent – the unitary household model. In this framework, the dynastic precautionary saving motive is more important than the precautionary motive for parents, contrary to the empirical evidence.

I use the model to assess the contribution of dynastic precautionary saving to wealth accumulation, intergenerational transfers and consumption insurance. I find that in the model 16.7% of total wealth is held for dynastic precautionary reasons, and that children's income risk is the main driver of intergenerational transfers. The model predicts that parents' dynastic precautionary savings account for one fourth of children's consumption insurance against income shocks.

Related literature This paper is related to three strands of literature. First, it adds to the literature that analyzes the insurance role of the family, both from an empirical and a quantitative perspective. Empirically, this literature has focused on examining the degree of risk sharing within families and uncovering means through which risk sharing occurs. The early work of Altonji, Hayashi and Kotlikoff (1992) and Altonji, Hayashi and Kotlikoff (1996) rejects the hypothesis of perfect insurance within the extended family implied by the unitary household model. Using more recent data, Choi, McGarry and Schoeni (2016) still reject perfect insurance, but find evidence that the income of the extended family affects one's consumption. Attanasio, Meghir and Mommaerts (2018) argue that the extended

to the child's income risk, as the parent only derives utility from the amount bequeathed. But dynastic precautionary saving is embedded in virtually all models that feature the three elements enumerated above.

family has large insurance potential, but that no such insurance occurs on average as one's consumption responds equally to shocks to own income and to the income of the extended family.[5] Notwithstanding the rejection of perfect risk sharing, the literature has documented that parents do insure children by making inter-vivos transfers to less well-off children, as found by Cox (1990), McGarry (1999), McGarry (2016) and in ongoing work by Ameriks et al. (2016), or by allowing them to move back home around labor market events, as shown by Kaplan (2012). I complement this line of work by documenting an additional channel through which parents can insure children against labor market risk.

Quantitatively, there has been a revived interest in studying dynamic models of families and the insurance within, especially in settings that depart from the full commitment assumption and are thus consistent with the aforementioned empirical evidence on imperfect risk-sharing within the extended family.[6] Early examples of such models are Laitner (1988) and Lindbeck and Weibull (1988), which serve as building blocks for some of the subsequently enumerated papers, including this one. Most quantitative explorations of the role of the family assume non-cooperation as the decision making process between parents and children.[7] Examples are Nishiyama (2002), Kaplan (2012), Barczyk and Kredler (2014*a*), Barczyk (2016) and Barczyk and Kredler (2016). With the exception of Barczyk and Kredler (2014*a*) and subsequent work of the author(s), these models often impose additional assumptions on behavior, such as an inability of both individuals to save. My framework allows for savings by both the parent and the child, and results in a determinacy of the size and timing of intergenerational transfers. It is thus methodologically closest to Barczyk and Kredler (2014*a*), Barczyk (2016) and Barczyk and Kredler (2016). In Barczyk and Kredler (2014*a*), parents and children make consumption, saving and transfer decisions simultaneously. The authors bypass some of the complications that such a game poses by assuming the interaction takes place in continuous time, thus making consumption and savings decisions independent of the contemporaneous choices of the other player. My approach complements that of Bar-

[5] My finding that parents engage in dynastic precautionary saving might appear surprising in light of this work but, as will become apparent in Section 3, the model of the extended family that I propose is outside of the class of models that forms the basis for the aforementioned tests of family risk sharing.

[6] The earlier literature studying models of families generally worked in the context of full commitment, as in Altig and Davis (1989), Altig and Davis (1992), Altig and Davis (1993), or assumed perfect two-sided altruism, as in Laitner (1993), Laitner (1992), Fuster (1999), Fuster, Imrohoroglu and Imrohoroglu (2007), Imrohoroglu and Zhao (2018). Importantly, and differently from this paper, the aforementioned models have no predictions on the distribution of wealth within the family and nor on the size and timing of intergenerational transfers. Luo (2016) is able to make predictions on transfers, but does so by assuming that parents derive warm-glow utility both from bequests and from inter-vivos transfers.

[7] An exception is Mommaerts (2015), who studies the role of family care in shaping the demand for long-term care insurance in a cooperative framework with limited commitment.

czyk and Kredler (2014*a*), by maintaining the assumption of discrete time, but imposing an assumption on the timing of the parent-child interaction.

Second, this paper is related to the vast literature on precautionary savings from which I borrow in the design of the empirical exercise. Some notable examples are Kimball (1990), Carroll and Samwick (1997), Gourinchas and Parker (2002), Cagetti (2003), Kennickell and Lusardi (2005) and Hurst et al. (2010).[8]

Third, it complements the research aimed at understanding household consumption-saving behavior over the life cycle, and especially at older age. This literature advances, with no clear consensus, two main drivers of saving at older age: bequest motives and precautionary saving motives for mortality and medical risk. Hubbard, Skinner and Zeldes (1995), Palumbo (1999), de Nardi, French and Jones (2010) or Kopecky and Koreshkova (2014) find that given the significant medical spending risk faced by retirees, models without bequest motives can match well the wealth dynamics of middle-class retirees. While this suggests that bequest motives are relatively negligible, Kopczuk and Lupton (2007), Ameriks et al. (2011), Lockwood (2014) and de Nardi, French and Jones (2016*a*) conclude that bequest motives are important drivers of retirees' choices. The saving motive analyzed in this paper falls under the umbrella of the bequest motive broadly defined but unlike the previously mentioned papers, in which parental altruism can only manifest in the form of end-of-life bequests and often takes the form of joy-of-giving, here it is microfounded and can result in inter-vivos transfers.

The rest of the paper is organized as follows. Section 2 contains the empirical exercise of the paper. Section 3 explores dynastic precautionary savings further, in a quantitative model. Section 4 concludes and discusses several avenues for extending this work.

2 Evidence on Dynastic Precautionary Savings

In this section I provide empirical evidence on the existence of dynastic precautionary savings. The empirical exercise is aimed at exploring whether the consumption of parents responds to the resolution of their children's permanent income uncertainty. The argument derives from the theory of precautionary saving: in the face of income uncertainty, individuals postpone current consumption in favor of precautionary saving against bad income realizations.[9]

[8]See Carroll and Kimball (2008) for a review of this literature.

[9]I focus on income rather than consumption uncertainty for of two reasons. First, permanent consumption uncertainty is endogenous to individuals' (dynastic) precautionary behavior. Specifically, high (dynastic) precautionary savings translate not only in lower current consumption, but also in lower expected consumption uncertainty. Second, due to the fact that consumption data is available for a shorter time horizon than

2.1 Measuring Permanent Income Uncertainty

I begin with the measure of permanent income uncertainty. In the life cycle framework, individuals maximize an intertemporal utility function subject to a lifetime budget constraint, which links permanent consumption and permanent income. Uncertainty about an individual's own permanent income triggers the accumulation of precautionary wealth.[10] When the pure life cycle framework is enriched with altruism à la Barro (1974) (i.e. the parent values the child's utility from consumption), uncertainty about the permanent income of future generations becomes relevant and triggers the accumulation of dynastic precautionary wealth.[11]

I define permanent income uncertainty as the *standard deviation of the forecast error of lifetime earnings*. Intuitively, the higher the uncertainty the more difficult it is for an individual to forecast earnings accurately, which translates into a larger standard deviation of the forecast error. I only focus on the human capital component of permanent income, since individual assets are known at the time the consumption-saving decision is made. For simplicity, I abstract from the uncertainty associated to forecasting interest rates.

Income uncertainty at individual level

I now describe the measure of permanent income risk of an individual i, who earns labor income from age $\underline{H}$ to age H. At age $h \in [\underline{H}, H]$ the permanent income of the individual is the discounted sum of his remaining income stream, $\{y_j^i\}_{j=h}^{H}$, and it is equal to

$$Y_h^i \equiv y_h^i + \frac{y_{h+1}^i}{R} + \frac{y_{h+2}^i}{R^2} + ... + \frac{y_H^i}{R^{H-h}} = \sum_{j=h}^{H} \frac{y_j^i}{R^{j-h}}, \tag{1}$$

where R is the gross risk-free interest rate fixed at population level (i.e. not individual specific) and constant over time. Assuming that current income y_h^i is observed at the beginning of age h, the individual is uncertain about the income stream from age $h+1$ on-

income data and is collected only every other year for half of this horizon, it is not possible to construct an analog measure of permanent consumption uncertainty (i.e. one that refers to lifetime consumption). However, I do find that for ad-hoc forecast horizons there is a positive correlation between standard deviation of the forecast error of labor income and that of consumption. For example, for 2 and 6-years-ahead forecast horizons the correlation is 0.433 and 0.367, respectively.

[10] Note that uncertainty about permanent income is still the relevant measure of uncertainty even if individuals are up against borrowing constraints. The presence of borrowing constraints breaks the relationship between consumption and the level of permanent income, not the risk, and would show up empirically as lack of precautionary savings.

[11] A related argument is employed by Strawczynski (1994), who uses the term precautionary bequests in an analysis of government tax-transfer policies in a model of subsequent, but not overlapping generations that are subject to income risk.

ward, $\left\{y_j^i\right\}_{j=h+1}^H$, which he forecasts using the information set available at age h, denoted by $\mathcal{I}_h^i$ (to be defined later).[12] Let $\hat{y}_{j,h}^i = \mathbb{E}\left(y_j^i|\mathcal{I}_h^i\right)$ be the predicted labor earnings at age $j = h+1, \ldots, H$, based on information set $\mathcal{I}_h^i$. Labor earnings at age j are then equal to

$$y_j^i = \underbrace{\mathbb{E}\left(y_j^i|\mathcal{I}_h^i\right)}_{\hat{y}_{j,h}^i} + e_{j,h}^i, \tag{2}$$

where $e_{j,h}^i$ is the forecast error and is orthogonal to $\mathcal{I}_h^i$.

The predicted lifetime labor income as of age h is the discounted sum of the predicted income stream and it is equal to

$$\hat{Y}_h^i \equiv \hat{y}_{h,h}^i + \frac{\hat{y}_{h+1,h}^i}{R} + \frac{\hat{y}_{h+2,h}^i}{R^2} + \ldots + \frac{\hat{y}_{H,h}^i}{R^{H-h}} = \sum_{j=h}^H \frac{\hat{y}_{j,h}^i}{R^{j-h}}, \tag{3}$$

where $\hat{y}_{h,h}^i \equiv y_h^i$, by assumption. Therefore, the error in forecasting lifetime labor earnings as of age h is the difference between realized and predicted permanent income, $Y_h^i - \hat{Y}_h^i$, and it is equal to

$$\mathcal{E}_h^i \equiv \frac{e_{h+1,h}^i}{R} + \frac{e_{h+2,h}^i}{R^2} + \ldots + \frac{e_{H,h}^i}{R^{H-h}} = \sum_{j=h+1}^H \frac{e_{j,h}^i}{R^{j-h}}. \tag{4}$$

The permanent income uncertainty for individual i at age h, denoted by $\mathrm{Std}_i\left(\mathcal{E}_h^i\right)$, is defined as the standard deviation of this forecast error and is equal to

$$\mathrm{Std}_i\left(\mathcal{E}_h^i\right) = \left(\sum_{j=h+1}^H \frac{\mathrm{Var}_i\left(e_{j,h}^i\right)}{R^{2(j-h)}} + 2\sum_{j=h+1}^{H-1} \frac{1}{R^{j-h}} \sum_{k=j+1}^H \frac{\mathrm{Cov}_i\left(e_{j,h}^i; e_{k,h}^i\right)}{R^{k-h}}\right)^{\frac{1}{2}}. \tag{5}$$

The derivation of this result can be found in Section A.1 of Appendix A. This is a direct measure of permanent income uncertainty, that does not require imposing any restrictions on the statistical process of the forecast errors and allows for arbitrarily complex processes for income shocks.[13]

[12] The assumption that y_h^i is observed at the beginning of age h is analogous to the recursive formulation of the life cycle model in which current labor income is a state variable.

[13] Alternatively, it can be assumed, as it is often the case in the literature, that shocks to current income $\tilde{y}_h$ can be decomposed into a permanent component z_h (persistent or random walk) and a transitory component ε_h (usually iid) as follows:

$$\begin{aligned} \tilde{y}_h &= z_h + \varepsilon_h \\ z_h &= \rho z_{h-1} + \eta_h, \end{aligned}$$

with $\varepsilon_h \sim \left(0, \sigma_\varepsilon^2\right)$ and $\eta_h \sim \left(0, \sigma_\eta\right)$. The parameters ρ, σ_ε^2 and σ_η^2 can then be used to calculate the

Income uncertainty at sector level

There are various obstacles in directly implementing the measure of uncertainty previously described, even in longitudinal datasets as the PSID. First, it requires observing individuals over their entire career. This is not possible for respondents who have entered the survey mid-career, respondents who are still working or respondents who drop out of the survey. Second, even if one were to try to bypass this by estimating individual level income processes like the one described in footnote 13, often times parameters would be estimated based on a handful of observations per respondent, and thus very noisy. Lastly, the measure is subject to attenuation bias as a consequence of measurement error in income, which is a known problem of survey data like the PSID.

Instead, I take an alternative route and project permanent income uncertainty on doubtlessly influencing factors such as industry and occupation, following the tradition of the precautionary saving literature.[14] For example, Cubas and Silos (2017) and Cubas and Silos (2018) provide evidence that the size of income shocks varies by industry and occupation, respectively. Therefore, I construct the measure of income uncertainty previously described at sector level, where a sector s is an industry-occupation pair. The permanent income uncertainty for an individual of age h working in sector s is then equal to

$$\mathrm{Std}_s\left(\mathcal{E}_h^i\right) = \left(\sum_{j=h+1}^{H} \frac{\mathrm{Var}_s\left(e_{j,h}^i\right)}{R^{2(j-h)}} + 2\sum_{j=h+1}^{H-1} \frac{1}{R^{j-h}} \sum_{k=j+1}^{H} \frac{\mathrm{Cov}_s\left(e_{j,h}^i; e_{k,h}^i\right)}{R^{k-h}}\right)^{\frac{1}{2}}, \tag{6}$$

where the generic term $\mathrm{Var}_s\left(e_{j,h}^i\right)$ is the cross-sectional variance of the forecast errors of all individuals of age h who are forecasting age $j > h$ earnings and are in sector s at the time of the forecast. Similarly, the generic term $\mathrm{Cov}_s\left(e_{j,h}^i; e_{k,h}^i\right)$ is the cross-sectional covariance of the forecast errors of age j and age k earnings, made by age h individuals working in sector s at the time of the forecast. Note that this measure allows for sector changes over the career. What matters is the sector in which an individual is at the time the forecast is made.

Projecting individual level uncertainty on sectors mitigates the bias introduced by poten-

standard deviation of the forecast error of lifetime earnings as I define it (see Carroll and Samwick (1997) and Feigenbaum and Li (2012) for estimates of these parameters at individual level, and Guvenen (2007), Karahan and Ozkan (2013) and Guvenen and Smith (2014), among others, for estimates at population level, i.e. for certain demographic groups). In fact, this is the procedure I implement in the calibration of the quantitative model in Section 3. Therefore, the measure of permanent income uncertainty that I define is not to be confused with the standard deviation of the permanent component of current income, σ_η. The latter is only a component of the standard deviation of the forecast error of lifetime earnings.

[14] Projecting income risk on industry and occupation is a practice often used in the precautionary savings literature. Examples are Carroll and Samwick (1998) and Kennickell and Lusardi (2005), among many others.

tial measurement error in earnings in the survey. If existent, measurement error ultimately shows up in the forecast errors used to calculate the permanent income uncertainty, and affects the distribution of permanent income risk across individuals of a given age, which is one of the main sources of variation used to identify dynastic precautionary savings. If, given age, measurement error is assumed to be independent and identically distributed across sectors and uncorrelated with the true forecast error of labor earnings, then measuring permanent income uncertainty at sector level preserves the distribution of permanent income uncertainty across sectors. The formal discussion of this argument is in Appendix A.2.

The content of the information set $\mathcal{I}_h$

To compute the forecast error of lifetime earnings a stand must be taken on the content of the information set $\mathcal{I}_h$ used to predict labor earnings at ages $j > h$. I assume that individuals' expectations make rational use of the same conditioning information available to the econometrician and include in the information set characteristics of the individual that are know with certainty at the time the future income stream is predicted. In particular, I assume that age j labor earnings y_j predicted by an individual i of age $h = \underline{H}, \dots, j-1$ and working in sector s are given by

$$y_j^i = \underbrace{\theta_0 + g\left(\boldsymbol{\theta}_1, \mathbf{X}_h^i\right) + \theta_3 \boldsymbol{t}_j}_{\hat{y}_{j,h}} + e_{j,h}^i, \tag{7}$$

where the function g is linear in the vector of observables $\mathbf{X}_h^i$. The latter includes current and lagged income, an age polynomial, dummies for current educational attainment, marital status, race and family size. Current and lagged income y_h^i and y_{h-1}^i are included to control for the persistence of income over time. Omitting them would result in larger forecast errors, as individuals on a steep income profile would mechanically translate high observed income into a large forecast error. Finally, $\boldsymbol{t}_j$ is a time trend for the year when the individual is of age j and is meant to capture the effects of aggregate economic growth on future income. I estimate equation (7) for each sector s and use the errors $e_{j,h}^i$ to compute the sector level permanent income uncertainty as described in equation (6).

I perform two robustness exercises. First, I acknowledge the possibility that households may plan ahead and know more than the econometrician about their future self, especially when the forecast horizon is small. To that end, I augment $\mathcal{I}_h$ with a vector of demographics $\mathbf{X}_j^i$ that are available in the survey and could potentially be known in advance by the individual.[15] These include marital status, family size and educational attainment at the projection horizon j. Second, I build on the evidence in Guvenen (2009) that income growth rates are individual specific. To the extent individuals learn about their specific slopes over time, failing to account for this magnifies forecast errors. I attempt to control for the effect of individual specific growth rates by augmenting $\mathcal{I}_h$ with the last forecast error of an individual.[16]

2.2 Data description

Having laid out the theoretical framework for measuring permanent income uncertainty, I now turn to describing the data sets used in the analysis. The data are drawn from two sources: PSID and CEX. I use the PSID to construct the sector level permanent income risk measure previously described, and to form parent-child pairs for the main estimation. I use the CEX to impute total consumption in the years in which the PSID only collected information on food consumption and housing.

Sample selection. The main data source is the PSID, which contains longitudinal information on a representative sample of US individuals and families. The PSID started in 1968, collecting information on a sample of approximately $5,000$ households. In the following years both the original families and their splitoffs (children moving out of the parent household) have been followed. This is the essential feature of the survey that makes it suitable for the analysis in this paper. The PSID data were collected annually until 1996 and biennially starting in 1997. However, retrospective information on labor income in the past two years is collected in each of the biennial waves, so there are no gaps in labor income induced by this change in survey frequency.

To estimate the profile of income uncertainty I use information on the pre-tax labor earnings of the head of the household from all the waves of the survey, from 1968 to 2013. I apply fairly standard criteria when constructing the sample. First, I exclude households from the Survey of Economic Opportunity sample (low-income supplemental sample) and Latino sample to avoid any selection issues. Second, since the uncertainty measure previously defined refers to the human capital component of permanent income, I focus on individuals of working age, so I restrict the sample to heads of age between 22 and 65 who are either employed or not employed. Third, I exclude the observations with top coded an-

[15] The likelihood of these being known in advance decreases as the forecast horizon increases.

[16] For example, for an individual who is 23 and predicts age 24 income, the last forecast error he made (and is aware of at the time of the forecast) was at 22, when predicting age 23 income.

nual labor earnings and I winsorize the earnings variable at the 99^{th} percentile to minimize the bias caused by outliers and measurement error. I express earnings in 1996 US dollars. Fourth, a stand must be taken regarding the treatment of respondents with zero earnings. Eliminating them would shut down the uncertainty that comes from the extensive margin, thus underestimating the true uncertainty of permanent income. Instead, I impute labor earnings for such observations based on an estimated government transfer function, which is discussed in detail in Appendix A.3.[17] Finally, I drop all entries with missing information in labor earnings and any of the demographic characteristics used in estimating equation (7), as well as all individuals with fewer than 3 observations. The resulting sample has $126,476$ observations corresponding to $9,046$ individuals.

A sector s is defined as an industry-occupation pair, with the exception of the 'unemployment sector' which includes all individuals that are not employed at the time of the income forecast. Starting from 8 major industry groups, I expand along 5 major occupation groups. I aggregate some occupations further, based on the distribution of annual labor earnings as summarized by the coefficient of variation. The procedure yields a total of 17 sectors listed in Table 7 in Appendix A.4.[18] In forecasting permanent income, an individual is assigned to a sector based on his industry and occupation at the time of the forecast. This allows for transition between sectors over the course of a worker's career.[19]

Parent-child pairs. I test for the existence of dynastic precautionary savings on a sample of matched pairs of parents and children, constructed using the PSID Family Identification Mapping System. If a parent has $n > 1$ children, I treat that as n parent-child pairs. This might affect the estimation results via two channels. First, parents of multiple children working in different sectors can hedge against dynastic uncertainty, biasing the estimates downwards. In a later section I show that the strength of the dynastic precautionary motive for any one child does not vary with the number of children. Second, errors might be serially correlated between such pairs, contaminating the standard errors and implicitly the inference. I account for this by clustering the standard errors at parent level.

[17] I use the same estimated government transfer function to impute earnings for observations with positive annual labor earnings smaller than \$200, which are likely to be measured with error.

[18] Tables 8 and 9 in Appendix A.4 report descriptive statistics regarding the sector size and distribution of earnings. Because some sectors are smaller than others, there may be noise in estimating the variances and covariances that enter the measure of permanent income risk. This poses a problem for the subsequent regression analysis, where permanent income risk enters as a generated regressor. I address this by bootstrapping standard errors of regression coefficient estimates.

[19] For example, if an individual works as a construction worker at 25, his forecast errors as of age 25 will enter the measure of income uncertainty of construction workers of age 25. If at 26 he works as a transportation worker, his forecast errors as of age 26 enter the measure of income uncertainty of transportation workers of age 26.

The analysis requires demographic and economic information for both parent and matched child (e.g. parent and child income, parent and child sector, just to name a few). Therefore, I restrict the sample to those pairs in which the child is a splitoff.[20] In addition, given that the income uncertainty measure constructed here refers to heads that are at least 22 years old, I drop those pairs in which the splitoff child is not a head or is younger than 22. I also drop those pairs for which the age difference between the parent and the child is lower than 20 years or which have fewer than 4 entries in the sample. The resulting sample has 1525 parent-child pairs observed between 4 and 21 times over the sample period. The oldest child is 59 years old, while the age of parents ranges between 42 and 80 years old.

Consumption series. The empirical exercise in this paper requires data on consumption or savings. PSID collected information on household wealth across 11 interview waves. Researchers who use this information define savings as the change in wealth net of debt between two time periods (e.g. Dynan, Skinner and Zeldes (2004)). The measure is rather noisy and limited to the existing wealth supplements. Instead, I choose to focus on consumption expenditure.[21] This decision is motivated both by the fact that consumption data is arguably less noisy, and by the fact that in some models of dynastic precautionary saving the wealth position of different generations is not identified.[22]

With this approach, I face the problem that in the early waves of PSID information about consumption is limited to spending on food and rent. To overcome this, I follow the strategy of Blundell, Pistaferri and Preston (2008), who use the CEX to estimate the demand for food (available in both surveys) as a function of total consumption expenditure, relative prices and household characteristics, and then invert it to obtain a measure of total consumption expenditure in PSID. Since CEX data is only available starting 1980, I am able to construct the PSID measure of total consumption from 1981 until 2003 (calendar years 1980-2002), with breaks in 1988 and 1989 when PSID did not collect any information of food expenditure. The details of the procedure are discussed in Appendix A.5. For the survey years 2005-2011, the consumption information in PSID is rich and consistent enough in terms of categories covered to be used on its own. I aggregate these consumption categories following the guidelines in Andreski et al. (2014).

[20] A splitoff child is a child who moved out from the parent's house and established his own household. Therefore, his demographic and economic information is collected separately from the parent's.

[21] For robustness, I also verify how savings respond to permanent income risk. While the estimates are qualitatively consistent with the presence of (dynastic) precautionary saving motives, the standard errors are fairly large.

[22] Examples of such models are in Becker (1974), Laitner (1992), Fuster, Imrohoroglu and Imrohoroglu (2007), Imrohoroglu and Zhao (2018), among others. Other conceptual settings are summarized by Michel, Thibault and Vidal (2006).

I construct two measures of consumption expenditure. The first one includes only expenditure on non-durable consumption goods and services (food, utilities, personal care, transportation, health, education, etc.), and is the benchmark measure. The second measure of consumption also includes expenditure on durables (furniture, jewelry, cars, etc.). I examine both measures because expenditure on durables might affect utility for more than one period.

2.3 Uncertainty characterization

I now turn to characterizing the age profile of permanent income uncertainty. I compute the permanent income uncertainty measure described in equation (6) using a gross interest rate R of 1.04.[23] Because this uncertainty measure is unit of measurement dependent (in particular, $\mathrm{Std}_s\left(\mathcal{E}_h^i\right)$ is measured in US dollars), in what follows I report the standard deviation of the forecast error divided by expected permanent income.[24]

I begin by examining the income uncertainty estimated under the baseline information set. The average age profile of income uncertainty, normalized by permanent income, is displayed in Figure 1. Permanent income uncertainty is high at young ages and declines during the twenties and thirties. By the age of 40 approximately half of the relative uncertainty is resolved. Afterwards, it decreases at a lower pace, with only an extra 15% being resolved until mid fifties. As retirement age approaches, the resolution of uncertainty accelerates. The figure implies that relative permanent income uncertainty is very high, with an average over age and sectors of 56%. A similar magnitude is implied by a calibrated income process with relatively standard parameter values, as will be shown in Section 3. The age profiles at sector level are displayed in Figures 8-9 in Appendix A. The correlation between permanent income uncertainty and permanent income across sectors is 0.61, meaning that sectors that are subject to high risk also exhibit high levels of permanent income.

The fact that uncertainty is downward sloping over age is not an artifact of a shorter forecast horizon. Figure 2 shows, for each age, the relative standard deviation of the 1-year-ahead to the 10-year-ahead forecast errors. Specifically, each line in the figure plots the average over sectors s of $\frac{\sqrt{\mathrm{Var}_s\left(e_{j,h}^i\right)}}{\mathbb{E}_s\left(y_j^i|\mathcal{I}_h^i\right)}$, for a forecast horizon $j-h \in [1,10]$ and a given age $h \in [22,55]$. The fact that each of the lines in the figure is upward sloping shows that the longer the forecast horizon is, the less precise forecasts are. However, over age forecasts

[23] In Section 2.4 I show that the estimates of dynastic (precautionary) savings are larger when $R = 1.03$.

[24] Appendix A.6 contains additional details on the estimation of the projection equation (7) and the measurement of expected permanent income.

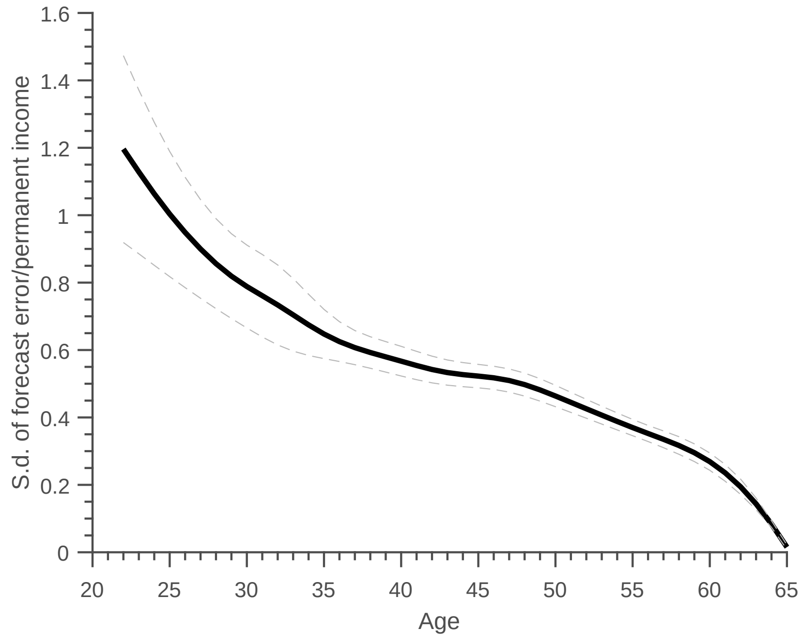

Figure 1: Age Profile of Income Uncertainty Relative to Permanent Income

Notes: The average uncertainty profile is the average over the age profiles of uncertainty at sector level weighted by the number of observations in each sector (Table 9 in Appendix A). The solid black line is obtained by fitting a local linear regression with bandwidth equal to 2 to the thus constructed average uncertainty. The dashed gray lines represent the 95% bootstrapped confidence interval.

become more precise, as implied by lower relative standard deviations.

As previously stated, I explore robustness with respect to the information set on which income forecasts are based by *(i)* assuming individuals have perfect knowledge of their future educational attainment, marital status and family size at all horizons at the time at which they make the forecast and *(ii)* using past forecast errors in forecasting future income to capture the possibility of learning about individual specific slopes. I find the latter has negligible effects on measured permanent income risk, but the former reduces measured income uncertainty relative to permanent income, on average, by approximately 6%. The difference is largest at young ages. This is, however, a rather extreme case as the likelihood of individuals having the aforementioned information about their future selves decreases with the forecast horizon.

In the next section I exploit differences in uncertainty across age and sectors to estimate the effect of own and dynastic uncertainty on parental consumption. This is a fruitful strategy insofar as there is enough variation in the level of permanent income uncertainty across sectors and in the speed at which it resolves over age. That is likely to be the case. The coefficient of variation of the level of permanent income uncertainty averages at 36%

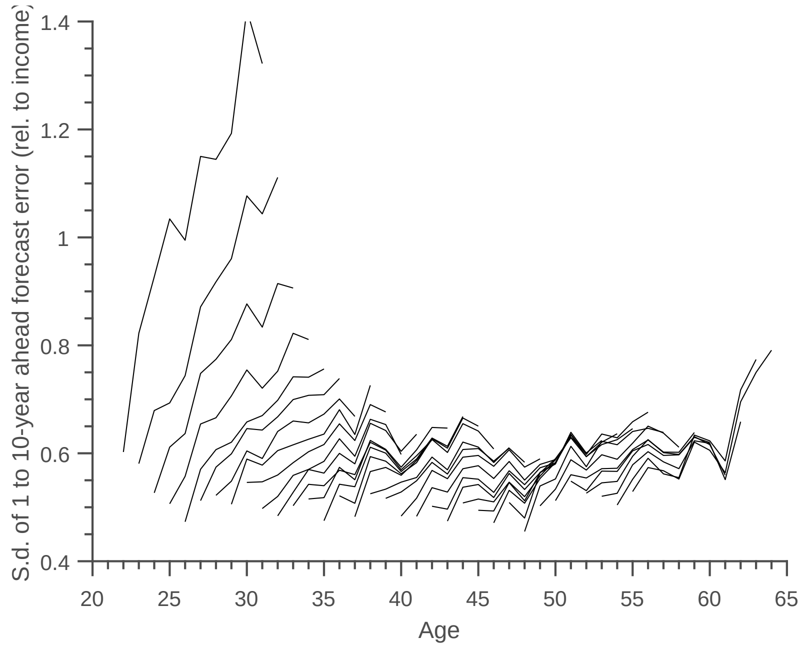

Figure 2: Relative Standard Deviation of the 1 to 10-years-ahead Income Forecast, by Age

Notes: Each line in the figure shows, for a given age, the relative standard deviation of the 1 to 10-years-ahead labor income forecast. For example, the first line corresponds to the 1 to 10-years-ahead forecast made at age 22, and the last line corresponds to the forecast made at age 55.

and that of the 1-year change in permanent income uncertainty (slope) averages at 22%. I find little variation across sectors in the speed at which uncertainty resolves in the twenties, suggesting that rapid resolution of uncertainty early in the career is a feature common to all industries and occupations. See Figure 10 in Appendix A.6 for a visual depiction of these results.

2.4 Empirical Estimation

I begin my analysis with an examination of the age profile of consumption expenditure of parents. This serves purely as suggestive evidence for the existence of a dynastic precautionary motive. Next, I test for dynastic precautionary saving directly, by building on the standard precautionary saving argument that implies a negative consumption response to uncertainty in permanent income. Extending this argument to include intergenerational considerations of the type entailed by altruism à la Barro (1974) implies that parental consumption responds negatively to uncertainty related to the child's permanent income. I test for this in a regression setting.

Life-cycle consumption patterns for parents

I construct the age profile of consumption by estimating the following specification on the sample of respondents who are parents:[25]

$$c_{it} = \beta_0 + \boldsymbol{\beta}_{age} f\left(Age_{it}\right) + \boldsymbol{\beta}_c Coh_i + \beta_t D_t + \boldsymbol{\beta}_x \mathbf{X}_{it} + \varepsilon_{it}. \tag{8}$$

In this specification, c_{it} is the logarithm of the equivalized consumption expenditure of household i in year t.[26] The terms $f\left(Age_{it}\right)$ and Coh_i are, respectively, a quartic polynomial in age and a full vector of cohort dummies, both referring to the head of the household, and D_t is a vector of normalized year dummies that capture cyclical fluctuations.[27] $\mathbf{X}_{it}$ is a vector of demographic and economic characteristics of the household head that includes a college dummy, a race dummy, dummies for family size, and a dummy for whether the head is working or not. The latter warrants some discussion. Aguiar and Hurst (2013) show that work-related expenses account for the entire decline in non-durable expenditures after middle age, coincident with the peak in market labor supply for the average household. Their work implies that, upon conditioning on working status, consumption should not drop after retirement. Later in this section, I compare the age profiles of consumption of parents and non-parents. Controlling for working status eliminates differences between the two groups in spending patterns over age that may result from different shares of work-related expenses in total spending. Lastly, ε_{it} is the residual term.

Figure 3 displays the estimated age profile of parental consumption. Results are only shown for consumption of non-durables and services, which includes health and education expenses, but non-durable expenditure net of health and education as well as total consumption expenditure exhibit a similar pattern, so results are not driven by realized medical expenses. The consumption profile has the hump-shaped pattern over the working life that has been previously documented, with the peak occurring in the late thirties. The new feature is that parental consumption is backloaded late in life.[28] This suggests that there is a precautionary motive at play in this stage of the life cycle. The argument derives from the theory of precautionary saving: in the face of income uncertainty, individuals postpone

[25] A respondent is classified as parent if any of following criteria is met: *(1)* respondent has positive number of total births, *(2)* respondent reported having a child under 18 living in the household in any wave of the survey. All other respondents are classified as non-parents.

[26] Equivalized consumption is obtained by dividing household consumption by the OECD equivalence scale. The OECD equivalence scale is defined as $ES = 1 + 0.7 \times$ (number of adult members $- 1) + 0.5 \times$ number of children.

[27] The normalization is as in Aguiar and Hurst (2013).

[28] This also holds by working status.

current consumption in favor of precautionary saving against bad income realizations. As uncertainty resolves, consumption increases, thus generating a consumption profile that is backloaded over age. For parents in the data, the backloading postdates the resolution of uncertainty in their own income stream, but coincides with times at which their children are in the beginning or prime of their careers and still resolving their income risk.

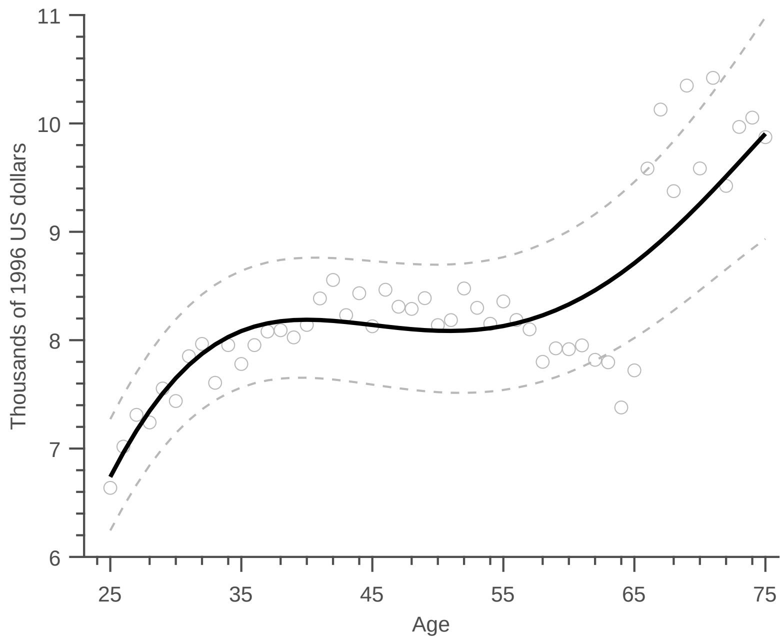

Figure 3: Age Profile of Consumption Expenditure of Parents

Notes: The figure shows the age profile of consumption of non-durables and services for parents in the black solid line, together with the 95% confidence interval in the gray dashed lines. The profiles are constructed using the estimates of $\boldsymbol{\beta}_{age}$ from equation (8). Gray circles are the non-parametric estimates. The sample has $57,980$ observations.

Naturally, risk in children's income is not the only type of uncertainty elderly face. Two other sources that have been previously examined in the literature are uncertain medical expenses and mortality risk (see de Nardi, French and Jones (2016*b*) for a survey). While these too resolve with age, and are thus consistent with a backloaded consumption profile, they affect all individuals, which means that the consumption of non-parents should exhibit the same qualitative pattern. This is not the case. Figure 4 shows that the consumption of non-parents continues to decline after retirement, albeit at a lower rate. Note, however, that results for non-parents are noisier, especially at older age. This is a consequence of the fact that the sample of non-parents is very small. In particular, the sample of parents is 7.5 times larger than the one of non-parents. Conditional on individuals being older than 60, there are 13 times more parents than non-parents. The small non-parent sample size together with the issue of selection into parenthood are among the main reasons why in the following section I present an alternative identification approach.

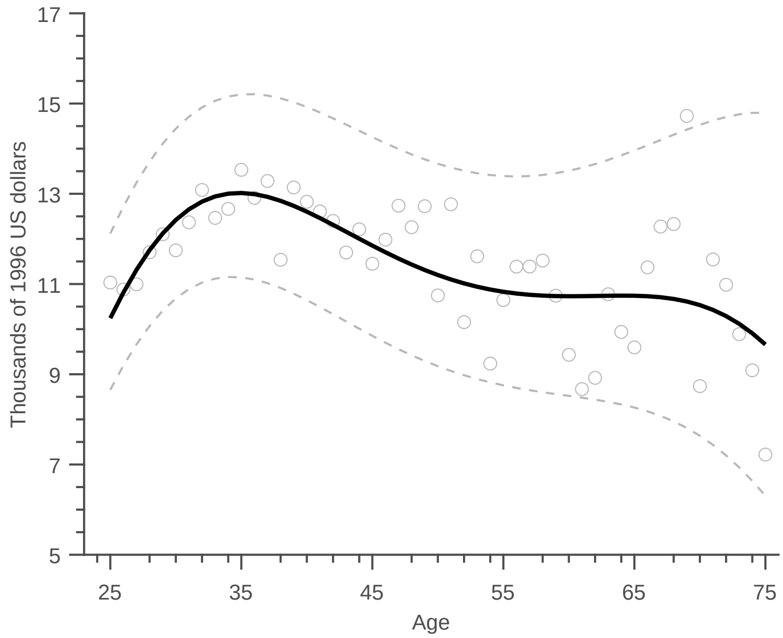

Figure 4: Age Profile of Consumption Expenditure of Non-Parents

Notes: The figure shows the age profile of consumption of non-durables and services for non-parents in the black solid line, together with the 95% confidence interval in the gray dashed lines. The profiles are constructed using the estimates of $\boldsymbol{\beta}_{age}$ from equation (8). Gray circles are the non-parametric estimates. The sample has $7,730$ observations.

The difference between the consumption profiles of parents and non-parents late in life could potentially be justified by increasing monetary transfers from children to their parents. This is unlikely to be the sole, or even the main driver of the observed difference. Data on monetary transfers between parents and their children from the PSID Family Rosters and Transfers Module show that only 5.2% of respondents report having received monetary transfers from their children. This fraction is increasing in age (albeit with large fluctuations) but, conditional on positive transfers, there is no trend in the amount transfered.

Estimates exploiting age and sectoral differences

I now present the results of a regression analysis of the effect of dynastic uncertainty on parental consumption. The baseline specification for exploring this effect is

$$c_{p_{it}} = \beta_0^p + \beta_t^p + \beta_1^p \sigma_{p_{hs}} + \beta_2^p \sigma_{c_{hs}} + \mathbf{X}_{p_{it}} \beta_3^p + \mathbf{X}_{c_{it}} \beta_4^p + \epsilon_{p_{it}}, \tag{9}$$

where $c_{p_{it}}$ is the logarithm of the consumption of parent household i in year t, $\sigma_{p_{hs}}$ is the logarithm of the permanent income uncertainty (as defined in equation (6)) of the parent and is assigned based on the age h and the sector s in which the head of the parent household i is in year t, while $\sigma_{c_{hs}}$ is the logarithm of the permanent income uncertainty of the child, assigned based on the age h and the sector s in which the child of the parent i is in year t.[29] β_t^p are time fixed effects, and $\mathbf{X}_{p_{it}}$ and $\mathbf{X}_{c_{it}}$ are vectors of demographic and economic controls included to deal with various selection concerns. They contain, for both the parent and the child: a full set of age dummies meant to capture consumption patterns that stem from pure life cycle considerations, dummies for marital status, race, gender, educational attainment, family size, as well as permanent income $\hat{Y}_{hs}$ (as defined in equation (17)) and wealth holdings.[30] These controls not only shape consumption, but are also potential determinants of occupation and industry choices.

There are three concerns regarding the implementation of this regression analysis. First, permanent income uncertainty is a generated regressor. This yields consistent estimates of the coefficients, but inconsistent estimates of their standard errors, as argued by Pagan (1984) and Murphy and Topel (1985). To address this concern, I report bootstrap estimates of the standard errors.[31] Second, there is a measurement error concern regarding the consumption variable on the left hand side due to the imputation procedure in the early years of the survey, and potential misreporting of consumption in the later years. I assume that, if present, measurement error in consumption is multiplicative in levels and uncorrelated with the explanatory variables.[32] Third, age and sector enter equation (9) in a restricted way, through the measure of permanent income uncertainty in equation (6). An obvious

[29]Note the assumption that permanent income risk varies by age h and by sector s, but not by time t. The time-invariance assumption is dictated by data limitations, as the survey is not yet long enough to fully observe two generations.

[30]In the years that are not covered in the wealth supplement I impute household wealth holdings by using a budget constraint equation and the series for consumption. Because 34.64% of children and 12.44% of parents have zero or negative wealth, wealth controls are in levels. Taking logarithm would amount to dropping 39.86% of the sample. For comparison, I also express permanent income in levels. I control for permanent labor income and wealth to capture potential non-homotheticity of preferences. For robustness, I also estimate equation (9) without wealth controls, as well as with controls for the slope of permanent income. In both cases I obtain results that are not statistically different from those reported in the paper.

[31]I employ the following two-step bootstrapping algorithm to compute standard errors. First, I draw a random sample with replacement from the full sample of parents and non-parents and repeat the permanent income uncertainty calculation described in Section 2.3. This yields a new value of permanent income uncertainty. Second, within this sample, I match parents and children and then estimate equation (9) with the new value of permanent income uncertainty. I store the OLS coefficients. I repeat this two-step procedure 500 times. The bootstrapped standard errors of the point estimates of the coefficients in equation (9) are the corresponding standard deviations in the sample of 500 coefficient estimates resulting from this procedure.

[32]Under this assumption the estimates are consistent, but the inference is subject to Type I error.

alternative is a statistical model in which they are not restricted by such a functional form. I estimate such an unrestricted model, in which I add interaction terms between age and sector dummies, for both the parent and the child, and perform a likelihood-ratio test. I fail to reject the null of the restricted model in favor of the unrestricted one.[33]

Because models of two-sided altruism, as well as various setups of models of one-sided altruism, are expected to imply that child's consumption also responds to the parent's permanent income uncertainty (in addition to that of own income), I estimate the following analogous specification for the child

$$c_{c_{it}} = \beta_0^c + \beta_t^c + \beta_1^c \sigma_{p_{hs}} + \beta_2^c \sigma_{c_{hs}} + \mathbf{X}_{p_{it}} \beta_3^c + \mathbf{X}_{c_{it}} \beta_4^c + \epsilon_{c_{it}}, \tag{10}$$

where the dependent variable is the logarithm child's consumption $c_{c_{it}}$ and the independent variables are the same as in the parent's regression. The estimation results are presented in Table 1. The first two columns display the estimated coefficients in regression equations (9) and (10) when the dependent variable is consumption expenditure on non-durables and services. The last two columns display the same results, but with consumption augmented to include expenditure on durables, health and education.

Of main interest in this paper is the estimate of β_2^p, which captures the strength of the dynastic precautionary saving motive. Regardless of the consumption measure considered, after controlling for an extensive set of covariates, the response of parental consumption to the uncertainty in the child's permanent income is negative and statistically significant. In particular, a 10% increase in dynastic uncertainty is associated with a 0.76% decrease in parent's consumption of non-durables and services, and a 0.79% decrease of his total consumption. A back of the envelope calculation suggest that parents of children younger than 40 consume, on average, \$2,528 less per year because at that stage most of their children's permanent income uncertainty is yet to be resolved. See Table 10 in Appendix A.7 for a stratification of the results by permanent income.

To better grasp the magnitude of the estimates of the dynastic precautionary motive, consider the case of three identical parents whose children are also identical, except for the sector in which they work.[34] In particular, their respective children work, in increasing order of the associated income risk, as a services worker, a construction worker and a financier. The estimates imply that the annual consumption of the parent of the construction worker is

[33] To perform the likelihood-ratio test, I estimate with maximum likelihood equation (9) and an augmented equation in which I add interaction terms between age and sector dummies, for both the parent and the child. The likelihood ratio is 1986.34 and the corresponding critical value at 5% is 1190.69.

[34] Here, identical means fixing all elements of $\mathbf{X}_p$ and $\mathbf{X}_c$.

Table 1: Regression of Consumption on Permanent Income Uncertainty

	Non-durables and services		Total consumption	
	Parent's consumption	Child's consumption	Parent's consumption	Child's consumption
Parent's uncertainty	-0.089**	-0.035	-0.082*	-0.040
	(0.042)	(0.038)	(0.044)	(0.039)
Child's uncertainty	-0.076**	-0.151**	-0.079**	-0.147**
	(0.038)	(0.059)	(0.037)	(0.059)
$\mathbf{X}_p$				
Marital status	0.249***	-0.021	0.258***	-0.032
	(0.024)	(0.028)	(0.024)	(0.027)
Race	0.133***	-0.014	0.136***	-0.022
	(0.023)	(0.033)	(0.023)	(0.034)
Educ: some college	0.260***	0.189***	0.25747***	0.178***
	(0.015)	(0.015)	(0.015)	(0.015)
Educ: college degree	0.278***	0.056***	0.271***	0.083***
	(0.015)	(0.014)	(0.015)	(0.015)
Permanent income	0.114***	0.056***	0.114***	0.058***
	(0.015)	(0.011)	(0.015)	(0.011)
Asset holdings	0.036***	0.012***	0.036***	0.012***
	(0.002)	(0.001)	(0.002)	(0.001)
$\mathbf{X}_c$				
Marital status	-0.058***	0.163***	-0.061***	0.178***
	(0.012)	(0.017)	(0.012)	(0.016)
Gender	-0.023*	0.300***	-0.018	0.301***
	(0.014)	(0.019)	(0.014)	(0.019)
Educ: some college	0.101***	0.108***	0.097***	0.105***
	(0.013)	(0.017)	(0.013)	(0.017)
Educ: college degree	0.171***	0.183***	0.166***	0.179***
	(0.013)	(0.017)	(0.013)	(0.017)
Permanent income	0.014**	0.064***	$0.014***$	0.05***
	(0.005)	(0.011)	(0.005)	(0.011)
Asset holdings	0.010***	0.046***	0.010***	0.046***
	(0.002)	(0.003)	(0.002)	(0.003)
Constant	10.223***	11.341***	10.232***	11.293***
	(0.431)	(0.671)	(0.428)	(0.674)
R^2	0.304	0.286	0.295	0.287
Sample size	8,851	8,330	8,861	8,323

Notes: Table entries are coefficient estimates from equations (9)-(10). Omitted explanatory variables are time fixed effects, full set age age and family size dummies (for both parent and child). Dummy variables are equal to 1 if married, white and make. The omitted education groups is high-school degree. Bootstraped standard errors clustered at parent and child level, respectively, are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

between 4 and 1% lower that that of the parent of the services worker, and that the relative consumption of the parent of the financier is even lower, with the gap fluctuating between 6 and 8.5%.[35] Figure 12 in Appendix A.7 offers a visual depiction of this calculation.

The estimates of β_1^p and β_2^c capture the strength of the precautionary saving motive from one's own permanent income uncertainty and are both negative and statistically significant. Note that precautionary saving appears to be stronger for the child than for the parent ($\hat{\beta}_1^p = -0.089$ and $\hat{\beta}_2^c = -0.151$). The reason for this difference lies in the age composition of the two groups, as children in the sample are a younger group than the parents (22-59 vs. 42-80). Gourinchas and Parker (2002) show that buffer saving is particularly important early in life, until about mid forties. Lastly, the estimate of β_1^c captures the response of child's consumption to the parent's permanent income uncertainty. While negative, this effect is not statistically significant.

I now turn to discussing a few concerns regarding the results presented thus far, as well as robustness of the findings to alternative specifications.

Health status and selection into risky sectors

There are two major concerns for identification. One is that working in certain occupations and industries has consequences for workers' health risk and implicitly their life expectancy (mortality risk). As previously discussed, such precautionary motives also depress consumption. I address this issue by including controls for the self-reported health status of parents and children, respectively, the assumption being that current health status is related to health risk. Health status is classified as: *(i)* excellent or very good, *(ii)* good or fair, or *(iii)* poor, the latter being the baseline group in the estimation.[36]

Another concern is individuals' attitude towards risk, insofar it is not captured by covariates. Individuals who are more risk tolerant may choose to work in riskier sectors and, at the same time, hold less precautionary wealth. This would render consumption less responsive to uncertainty resolution, meaning that the precautionary motive is even larger than what I estimate. Similarly, children who know their parents accumulate savings may choose to work in riskier sectors. This could be addressed by including child fixed effects in the estimation, in which case changes in the child's sector should be followed by changes in the parent's consumption. However, for a given parent-child pair, there are on average 3 sector

[35] The relative parental consumption gap is given by $-0.081 \times \left[\ln \mathrm{Std}_{s'}\left(\mathcal{E}_h^i\right) - \ln \mathrm{Std}_{15}\left(\mathcal{E}_h^i\right)\right]$, $s' \in \{3, 11\}$.

[36] This variable has been continuously collected since 1984. Another alternative for assessing health risk is aggregating information on various diseases collected since 1999, but the limited time coverage of these variables makes it unlikely to be able to distinguish anything statistically from the benchmark results.

transitions on the side of the child over the entire duration of the sample, which is not nearly enough variation to pick up any effect.

I perform two types of exercises to further address this concern. First, I estimate the probability that a child moves from a low to a high risk sector conditional on his parent being unemployed. The parent's employment status is arguably exogenous to the child's sector assignment. Therefore, if children whose parents have lost their jobs are less likely to move to riskier sectors, then this type of selection is indeed a concern. I find that, if anything, children whose parents are unemployed are more likely to switch to a high risk sector.[37] This effect is however small and not statistically significant. Second, I estimate equation (9) by simultaneously excluding from the sample the pairs in which the child is self-employed, a group for which self-selection is presumably more likely to occur, and augmenting the vector of covariates $\mathbf{X}_c$ with dummies for the child's initial sector, based on the presumption that a child's first sector choice may be influenced by the parent's wealth and that all sector changes a child goes through after the first sector choice are exogenous to the parent's consumption-saving behavior.[38]

Table 2 reports results for consumption of non-durables and services (see Table 11 in Appendix A.7 for results for total consumption).[39] Column (1) reproduces the baseline estimates, to facilitate comparison. Columns (2) and (3) show estimates from separately controlling for health risk and selection, and Column (4) shows estimates from simultaneously addressing these two concerns. Point estimates of precautionary and dynastic precautionary motives are a slightly smaller than the benchmark when factoring in health risk and selection, but the difference is not statistically significant.

Other robustness tests

The main results of the estimation are qualitatively and quantitatively robust to a wide range of specifications. First, I consider the sensitivity of the results to controlling for the

[37] The exact specification I estimate is:

$$\Pr\left(switch_{t,t+1} | emp\_parent_t, \mathbf{X_t}\right) = \alpha + \beta \times emp\_parent_t + \Phi\left(\mathbf{X_t}\gamma\right), \tag{11}$$

where $switch_{t,t+1}$ is an indicator variable equal to 1 if between two consecutive periods the child moved from a low risk to a high risk sector, emp_parent_t is an indicator variable equal to 1 if the parent is unemployed at time t and $\mathbf{X_t}$ is a vector of controls for the child's age, marital status, educational attainment and family size, as well as year dummies. I estimate equation (11) as a linear probability model, as well as a probit model. Irrespective of the specification, the point estimate of β is actually positive, but very small and never significantly different from zero. I also consider longer parental unemployment spells (i.e. control for both emp_parent_t and emp_parent_{t-1}) and obtain simiar results.

[38] There are 923 pairs with a self-employed child in the sample, representing 10% of the initial sample size.

[39] For space considerations, in this and all subsequent robustness exercises, I only report the estimates of interest for the discussion, but all regressions have the full set of controls enumerated in equation (9).

Table 2: Importance of Health and Selection

	Baseline (1)	Only health controls (2)	Only selection controls (3)	Health and selection controls (4)
Parent's uncertainty	-0.089**	-0.077**	-0.074**	-0.061**
	(0.042)	(0.037)	(0.036)	(0.031)
Child's uncertainty	-0.076**	-0.059	-0.080**	-0.065*
	(0.038)	(0.039)	(0.034)	(0.037)

Notes: Table entries are estimates of the effect of permanent income uncertainty on parental consumption of non-durables and services. Column (1) reproduces the estimates in Table 1. Column (2) reports the estimates when the parent's and child's health status is included in the set of controls. Column (3) shows results controlling for the child's initial sector and excluding self-employed children. Column (4) shows estimates when simultaneously controlling for health status, initial sector and excluding self-employed children from the sample. Bootstrapped standard errors clustered at parent level are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

heterogeneity of the bequest motive. If some parents are more altruistic than others and their response to children's income risk is a reflection of a more general altruism rather than a dynastic precautionary saving motive, this would bias upwards the coefficient of dynastic risk. I address this by *(i)* examining whether the strength of the dynastic precautionary saving motive varies with the number of children, a proxy often used in the literature to control for the strength of the bequest motive (see Hurd (1987) among the earlier papers, and Lockwood (2012) more recently), and *(ii)* purposely introducing extreme bequest motive heterogeneity in the estimation by appending non-parents, for which the dynastic precautionary motive is by construction zero, and examining to what extent this biases the coefficient upwards.[40] Table 3 shows the results for consumption of non-durables and services (see Table 12 in Appendix A.7 for total consumption.) As before, Column (1) reproduces the baseline estimates. Column (2) shows that the strength of the dynastic precautionary motive does not vary substantially with the number of children (no two point estimates are statistically different) and results in Column (3) show that extreme bequest heterogeneity introduces negligible upward bias.

Table 4 summarizes sensitivity results to alternative specifications. Columns (1) and (2) examine the degree to which the consumption imputation procedure biases downwards the estimates of (dynastic) precautionary motives by either estimating the elasticity of food consumption to income uncertainty or by using in the estimation only the later years, in which

[40]Specifically, for non-parents I set the regressor $\sigma_{c_{h,s}} = 0$.

Table 3: Importance of the Bequest Motive

	Baseline (1)	Child's uncertainty × Number of children (2)	Append non-parents (3)
Parent's uncertainty	-0.089** (0.042)	-0.077* (0.043)	-0.097*** (0.023)
Child's uncertainty	-0.076** (0.038)	−−	-0.078** (0.038)
Child's uncertainty $\times \mathbf{1}_{\{n=1\}}$	−−	-0.072* (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n=2\}}$	−−	-0.078** (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n=3\}}$	−−	-0.079** (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n=4\}}$	−−	-0.071* (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n\geq 5\}}$	−−	-0.097*** (0.037)	−−

Notes: Table entries are coefficient estimates of the effect of permanent income uncertainty on parent's consumption of non-durables and services. Column (1) reproduces the estimates in Table 1. Column (2) reports estimates of β_1^p and of β_2^p by number of children. Column (3) shows estimates when non-parents are added to the baseline sample, allowing for different intercepts. Bootstrapped standard errors clustered at parent level are in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

PSID collected information on multiple consumption categories.[41] I find a smaller effect on food consumption and qualitatively consistent but noisier effects on total consumption in the later years. In neither of these cases the estimates are statistically different from the benchmark estimates.

Columns (3) and (4) show that results are also robust to projecting income using information about individuals' future selves, as discussed in Section 2.1 (the estimate is noisier in this case, but not statistically different from the baseline value) and to using a different interest rate in discounting future income.

[41] Food consumption is a necessity, making it less likely to respond to income risk. In the early waves of PSID, I impute consumption based on an inverted food demand equation, so imputed consumption might inherit the inelastic properties of food. In the case in which I only use the later years in the estimation ($\geq$ 2005) the sample size is halved.

Table 4: Other Robustness Tests

	Food consumption (1)	PSID direct consumption (not imputed) (2)	Forecast w/ info about future (3)	Discounting with $R = 1.03$ (4)
Parent's uncertainty	-0.030 (0.032)	-0.100*** (0.037)	-0.074*** (0.029)	-0.090*** (0.033)
Child's uncertainty	-0.029 (0.025)	-0.013 (0.029)	-0.053 (0.034)	-0.079** (0.034)

Notes: Table entries are coefficient estimates of β_1^p and β_2^p from equation (9). Consumption of non-durables and services is the dependent variable in columns (3) and (4). Bootstrapped standard errors clustered at parent level are in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

3 Model

In this section, I build a model of dynastic precautionary saving that is quantitatively consistent with the empirics, which I then use it to evaluate the importance of dynastic precautionary saving for consumption insurance of the young and for wealth accumulation. In the model, overlapping generations are altruistically linked and altruism is one-sided, from the parent to his child.[42] The parent and his child decide individually how much to consume and save. In addition, the parent makes monetary transfers to the child. I model the decision making process between the parent and the child as non-cooperative and without commitment. This modeling choice is appealing because it enables clear predictions regarding the wealth position of overlapping generations, as well as the size and timing of inter-vivos transfers, both of which are relevant objects for the counterfactual experiments I consider.[43] It is worth noting that only three model ingredients are needed to qualitatively generate dynastic precautionary behavior: income risk, incomplete markets, and altruism à la Barro (1974), with the parent valuing the child's utility from consumption.[44] This paper proposes a framework that is also quantitatively consistent with the empirical evidence, and

[42]This is largely motivated by the fact that only a small number of chilren make monetary transfers to their parents (Attanasio, Meghir and Mommaerts (2018)) and that, as shown in the previous section, children's consumption does not respond strongly to the parent's income risk. Later in the section I discuss the effect that two sided altruism would have on the results.

[43]This is a characteristic of this class of models that has been previously pointed out by Barczyk and Kredler (2014*a*), Barczyk (2016) and Barczyk and Kredler (2016), and is absent in commitment models.

[44]Dynastic precautionary saving is a force that is embedded in all quantitative models that feature the aforementioned three elements. For example, it emerges in Nishiyama (2002), Fuster, Imrohoroglu and Imrohoroglu (2007), Barczyk and Kredler (2014*a*) , Barczyk (2016), Barczyk and Kredler (2016), Mommaerts (2015), Imrohoroglu and Zhao (2018), despite of it not being a focus of any of these papers.

contrasts it with the unitary household model – a classic framework in this literature.

3.1 Environment

Demographics. Agents are economically active (i.e. earn income and make decisions) from age of 22 until the end of age 79, when they die.[45] Figure 5 shows the life cycle of two overlapping generations. When an individual turns 29 his child is born. However, it is not until the parent turns 51 that his child becomes economically active. At 65 an individual retires. The generations overlap such that at every point in time only two generations are economically active, represented by 29 parent-child pairs indexed by the age of the parent and that of the child. A parent and his child overlap for 29 years.

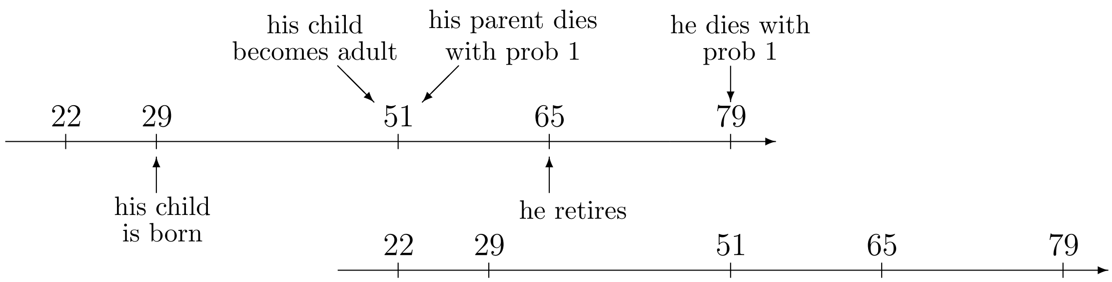

Figure 5: Life Cycle of Individuals

Altruism. The parent is altruistic towards the child in the spirit of Barro (1974). In particular, he places a weight γ on the utility of the adult child. Upon the death of the parent, the household wealth is bequeathed to the child. Altruism towards the young child (younger than 22) is not explicitly modeled.

Household income and sources of uncertainty. Household members can earn labor and asset income. An individual supplies labor inelastically to a sector s for the first 44 periods of his economic life and earns stochastic labor income y. The sector s in which an individual works evolves exogenously according to a Markov process. Labor earnings depend on age and a sector and age specific Markov process. Individuals retire at the of age 65 and earn constant pension benefit $\Phi(\cdot)$ for the remaining of their life. As described in Section 3.2,

[45] I introduce uncertain lifespans and medical expense risk in a later section, where I quantify the contribution of dynastic precautionary wealth to total wealth, so the model ought to contain a rich description of individuals' saving motives. I do not embed these sources of risk in the model from the beginning, nor model the sector choice as endogenous, because the first goal of the quantitative exercise is to gain insights into the nature of the parent-child interaction by comparing the empirical estimates of dynastic precautionary saving (presumably purged of all confounding factors), with those coming from a "clean" environment that is free of all the endogeneity concerns in the data.

pension income depends on the individuals last income realization prior to retirement in a way that parsimoniously accounts for lifetime average earnings. Agents hold a single asset (bond) a issued by the government and face a borrowing constraint. Their asset income depends on the asset holdings and the gross interest rate R.

Government. The government levies a proportional tax τ on individuals' labor earnings. The tax revenue and newly issued bonds B' are used to finance government expenditure G, which has no welfare enhancing role, to pay interest R on previously issued bonds B and to finance retirees' pension income. The government runs a balanced budget:

$$G + SS + RB = B' + \tau\bar{Y},$$

where $\bar{Y}$ denotes aggregate labor earnings of working individuals and SS denotes aggregate pension payments to retirees.

Timing. I impose a particular extensive form of the parent-child stage game and focus on the Markov-perfect equilibrium (MPE) of this sequential stage game.[46] The timing of the model is as follows: in the beginning of the period labor earnings shocks realize and are known both to the parent and his child. In the first stage, the parent chooses his consumption c_p, next period wealth holdings a'_p, and the monetary transfer to the child g_p. Given the parent's choices, in the second stage the child makes his own consumption-saving decision (c_c, a'_c). Given that it is unlikely that parents can force their adult children to adhere to a particular consumption path beyond the influence induced by their choice of transfers, this timing protocol could be an accurate description of how parent-child interactions take place in reality.

State variables. The state variables of a parent of age $h_p \in \{51, 52, \ldots, 79\}$ are: beginning of period wealth of the parent $a_p \in A$ and of the child $a_c \in A$, realized earnings for both the parent and the child $y_p, y_c \in Y$, as well as the sectors in which the two work $s_p, s_c \in S$. The value function of a parent household of age h_p is denoted as $V^p_{h_p}(\tilde{s}_p)$, where $\tilde{s}_p = (a_p, a_c, y_p, y_c, s_p, s_c)$. The state variables of a child of age $h_c \in \{22, 23, \ldots, 50\}$ are: cash-on-hand $\tilde{a}_c$ defined as $\tilde{a}_c = Ra_c + g_p$, where $a_c \in A$ is own beginning of period wealth and g_p is the parent's first stage choice of transfers g_p, realized earnings for both the parent and

[46] Without assumptions on the timing of the parent-child interaction, a setting like the one I consider can have a large set of Markov equilibria. An illustrative two period example can be found in Lindbeck and Weibull (1988). Barczyk and Kredler (2014*a*) maintain the assumption that altruistically linked players make consumption-saving-transfer decisions simultaneously, but study the game in continuous time, which greatly simplifies the characterization of equilibria by making consumption and savings decisions of a player independent of the contemporaneous choices of the other agent whenever the player is unconstrained.

the child $y_p, y_c \in Y$, the sectors of the two $s_p, s_c \in S$, as well as the parent's first stage choice of savings a'_p. The value function of a child of age h_c is denoted as $V^c_{h_c}(\tilde{s}_c)$, where $\tilde{s}_c = \left(\tilde{a}_c, y_c, y_p, a'_p, s_p, s_c\right)$.

Decision problems

The problem of a working parent-child pair. In the second stage, given $\tilde{s}_c = \left(\tilde{a}_c, y_c, y_p, a'_p, s_p, s_c\right)$ the child of age h_c solves

$$\begin{aligned} V^c_{h_c}(\tilde{s}_c) &= \max_{c_c, a'_c} u(c_c) + \beta \mathbb{E} V^c_{h_c+1}(\tilde{s}'_c | \mathbf{y}, \mathbf{s}) \\ \text{s.t.} \quad & c_c + a'_c = (1-\tau) y_c + \tilde{a}_c \\ & a'_c \geq \underline{A}_{h_c}, \end{aligned}$$

where $\tilde{s}'_c = \left(Ra'_c + g'^{\star}_p, y'_c, y'_p, a''^{\star}_p, s'_p, s'_c\right)$, $\mathbf{s} = (s_p, s_c)$ and $\mathbf{y} = (y_p, y_c)$. The next period's transfer $g'^{\star}_p$ and parental savings $a''^{\star}_p$ are equilibrium objects. Call the resulting optimal policy function $c^{\star}_c(h_c, \tilde{s}_c)$. In the first stage, given $\tilde{s}_p = (a_p, a_c, y_p, y_c, s_p, s_c)$, the parent of age h_p solves

$$\begin{aligned} V^p_{h_p}(\tilde{s}_p) &= \max_{c_p, a'_p, g_p} u(c_p) + \gamma u\left(c^{\star}_c\left(h_c, Ra_c + g_p, y_c, y_p, a'_p, s_p, s_c\right)\right) + \beta \mathbb{E} V^p_{h_p+1}\left(\tilde{s}'_p | \mathbf{y}, \mathbf{s}\right) \\ \text{s.t.} \quad & c_p + a'_p + g_p = (1-\tau) y_p + Ra_p \\ & a'_p \geq \underline{A}_{h_p}, g_p \geq 0, \end{aligned}$$

where $\tilde{s}'_p = \left(a'_p, a'^{\star}_c\left(h_c, Ra_c + g_p, y_c, y_p, a'_p, s_p, s_c\right), y'_p, y'_c, s'_p, s'_c\right)$. The expectation is taken over all possible sector and income transitions, for the parent and the child, as both of them are in the labor market in the following year.

The problem of a retired parent-child pair. At the end of age $H_{ret} = 65$ the parent retires and starts earning constant income $\Phi(\hat{y}_p)$, which is a function of predicted career earnings. In the second stage, given $\tilde{s}_c = \left(\tilde{a}_c, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c\right)$, the child of age h_c solves

$$\begin{aligned} V^c_{h_c}(\tilde{s}_c) &= \max_{c_c, a'_c} u(c_c) + \beta \mathbb{E} V^c_{h_c+1}(\tilde{s}'_c | y_c, s_c) \\ \text{s.t.} \quad & c_c + a'_c = (1-\tau) y_c + \tilde{a}_c \\ & a'_c \geq \underline{A}_{h_c}, \end{aligned}$$

where $\tilde{s}'_c = \left(Ra'_c + g'^{\star}_p, y'_c, \hat{y}_p, a''^{\star}_p, \hat{s}_p, s'_c\right)$. Again, denote by $c^{\star}_c(h_c, \tilde{s}_c)$ the optimal consumption policy function. In the first stage, given $\tilde{s}_p = (a_p, a_c, \hat{y}_p, y_c, \hat{s}_p, s_c)$, the problem of a retired parent of age $h_p = H_{ret} + 1, \ldots, H - 1$ is

$$\begin{aligned} V^p_{h_p}(\tilde{s}_p) &= \max_{c_p, a'_p, g_p} u(c_p) + \gamma u\left(c^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c\right)\right) + \beta \mathbb{E} V^p_{h_p+1}\left(\tilde{s}'_p | y_c, s_c\right) \\ \text{s.t.} \quad & c_p + a'_p + g_p = \Phi(\hat{y}_p) + Ra_p \\ & a'_p \geq \underline{A}_{h_p}, g_p \geq 0, \end{aligned}$$

where $\tilde{s}'_p = \left(a'_p, a'^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c\right), \hat{y}_p, y'_c, \hat{s}_p, s'_c\right)$. Only the child is in the labor force, so the expectation is taken only with respect to y_c and s_c.

The problem of a terminal parent-child pair. At the end of age H the parent dies. In the following period his child becomes a parent and his own child starts earning income. The second stage problem of the child is

$$\begin{aligned} V^c_{50}(\tilde{s}_c) &= \max_{c_c, a'_c} u(c_c) + \beta \mathbb{E} V^p_{51}\left(\tilde{s}'_p | \mathbf{y}, \mathbf{s}\right) \\ \text{s.t.} \quad & c_c + a'_c = (1 - \tau) y_c + \tilde{a}_c \\ & a'_c \geq \underline{A}_{h_c}, \end{aligned}$$

where $\tilde{s}'_p = \left(a'_c + a'_p, 0, y'_p, y'_c, s'_p, s'_c\right)$, $\mathbf{y} = \left(y_c, y'_p\right)$ and $\mathbf{s} = \left(s_c, s'_p\right)$. This allows for intergenerational correlation in sectors and income processes. I assume that young adults (age 22) have no assets. In the first stage, given $\tilde{s}_p = (a_p, a_c, \hat{y}_p, y_c, \hat{s}_p, s_c)$, the terminal parent solves

$$\begin{aligned} V^p_{79}(\tilde{s}_p) &= \max_{c_p, a'_p, g_p} u(c_p) + \gamma u\left(c^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c\right)\right) + \beta\gamma \mathbb{E} V^p_{51}\left(\tilde{s}'_p | \mathbf{y}, \mathbf{s}\right) \\ \text{s.t.} \quad & c_p + a'_p + g_p = \Phi(\hat{y}_p) + Ra_p \\ & a'_p \geq \underline{A}_{h_p}, g_p \geq 0, \end{aligned}$$

where $\tilde{s}'_p = \left(a'_p + a'^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c\right), 0, y'_p, y'_c, s'_p, s'_c\right)$.

Equilibrium definition and properties

A steady-state recursive equilibrium, which is also a Markov-Perfect equilibrium, is a collection of value functions $V_{h_p}(\tilde{s}_p)$ and $V_{h_c}(\tilde{s}_c)$, policy functions $c_p(h_p, \tilde{s}_p)$, $a'_p(h_p, \tilde{s}_p)$, $g_p(h_p, \tilde{s}_p)$, $c_c(h_c, \tilde{s}_c)$ and $a'_c(h_c, \tilde{s}_c)$, measures of households $f(h_p, \tilde{s}_p)$ and $f(h_c, \tilde{s}_p)$, and aggregate bond holdings B, such that: *(i)* given the payoff relevant state vectors, in each repetition of the parent-child stage game the parent decides optimally how much to consume, save and transfer to the child, after which the child makes an optimal consumption-saving choice of his own, *(ii)* the bond market clears, *(iii)* the government's budget is balanced and *(iv)* the measure of households is invariant. Details on the computational algorithm are in Section B.2 of Appendix B.

Two properties of this setup are worth noting. First, it is an infinitely repeated game. This means that, in spite of the assumption on timing which simplifies matters computationally, it need not be that the Markov-Perfect equilibrium is unique. I conjecture it is and verify this computationally by experimenting with different initial guesses in the value function iteration algorithm, and by also solving for the equlibrium that is the limit of a finite-horizon game as in Klein, Krusell and Rios-Rull (2008).[47] The equilibrium I find is always the same. See Section B.1 in Appendix B for a characterization.

Second, the setup features strategic behavior of the type encountered in the 'Samaritan's dilemma', with the child pursuing a consumption plan that exploits the parent's altruism through overconsumption (or undersaving).[48] Since the parent makes the first move in the stage game, he can limit the strategic behavior of the child through his transfer decision. I solve for the equilibrium in which the parent makes transfers to the child only when the latter is constrained.[49] Intuitively, the parent would always want to set the transfer so that the child achieves the level of consumption that the parent desires for him. Due to the fact that the child engages in overconsumption, the only scenario in which the child's consumption is below the parent's desired consumption for him is when the child is constrained.

3.2 Parameter values

Labor earnings. Individuals can work in one of two sectors: a sector with low permanent income risk and a sector with high permanent income risk. They can transition between the two sectors over their career. To calibrate the transition probabilities, I aggregate the 17 sectors from Section 2 into two groups based on whether average income uncertainty

[47]There may be other equilibria that depend crucially on the infinite-horizon assumption, such as the wealth-pooling equilibrium found in an infinite-horizon altruistic gift-giving game studied by Barczyk and Kredler (2014*b*).

[48]In the steady state 1.57% of children are constrained. If the transfer option would be removed unanticipatedly (i.e. every period the child thinks the parent will make a transfer and makes decisions accordingly, but the transfer is exogenously set to zero), then 50.96% of children would find themselves constrained. This shows that for children the constrained state is desirable, and that inter-vivos transfers distort children's savings decision in favor of less savings.

[49]This idea has been previously conjectured by Laitner (2001), Fuster, Imrohoroglu and Imrohoroglu (2007), McGarry (1999), McGarry (2016), Nishiyama (2002), emerges as an endogenous outcome in Barczyk and Kredler (2014*a*), and is also at play in Barczyk (2016). Numerically, I verify that the parent indeed finds it optimal to set the transfer to zero if the child is not constrained in the absence of the transfer.

a specific sector is below or above the average uncertainty over all sectors.[50] Transition probabilities are given by the empirical switching rates between these aggregate sectors at annual frequency and are equal to

$$\mathbf{P_s} = \begin{bmatrix} p_{ll} & p_{lh} \\ p_{hl} & p_{hh} \end{bmatrix} = \begin{bmatrix} 0.921 & 0.079 \\ 0.113 & 0.887 \end{bmatrix}.$$

In the matrix $\mathbf{P_s}$ the generic element $p_{ss'}$, with $s, s' \in \{l, h\}$, is the probability of switching to sector s' if currently working in sector s. I allow for correlation between the sector of a parent and that of his child. In particular, the sector a child first works in is correlated with his parent's sector at the time the child enters the labor market. I use the sample of parent-child pairs to estimate the probability that if the parent works in sector $s_p \in \{l, h\}$, the child works in sector $s_c \in \{l, h\}$.[51] These probabilities are

$$\mathbf{P_s^{ig}} = \begin{bmatrix} \hat{p}_{ll} & \hat{p}_{lh} \\ \hat{p}_{hl} & \hat{p}_{hh} \end{bmatrix} = \begin{bmatrix} 0.647 & 0.353 \\ 0.493 & 0.507 \end{bmatrix},$$

where the generic element $\hat{p}_{s_p s_c}$, with $s_p, s_c \in \{l, h\}$, is the probability that if the parent works in sector s_p then his 22 year old child begins his career in sector s_c.

I assume log labor earnings have two age-dependent components. The first is deterministic and is common to all individuals of age h, irrespective of the sector in which they work. The second is idiosyncratic and captures labor income risk at sector level.[52] Therefore, log earnings of an individual i of age $h \in [22, 65]$ working in sector s are given by

$$\ln y_{hs}^i = \underbrace{f(h)}_{\text{deterministic}} + \underbrace{\tilde{y}_{hs}^i}_{\text{idiosyncratic}}. \tag{12}$$

The deterministic component is a quartic age polynomial obtained from reestimating equation (8) with log annual labor income of the head as the dependent variable. Average labor earnings are hump-shaped over the life cycle, increasing by 43% until they peak in the forties, and then decreasing by 38% by retirement age.

In what concerns the idiosyncratic component, the goal is to feed in the model the sector

[50] The low income uncertainty group contains sectors $\{2, 3, 4, 5, 6, 7, 9, 11, 13, 15, 16\}$ and covers approximately 60% of the sample, while the high risk group includes sectors $\{0, 1, 8, 10, 12, 14\}$.

[51] In constructing these probabilities I use all parent-child pairs. However, results are robust to only using those observations for which the child is below age 35 (the difference is at the second and third decimal).

[52] I assume that in the event of a switch of sector, the individual inherits the idiosyncratic component from the previous sector.

level age profile of permanent income uncertainty estimated with the PSID data. To that end, I assume that, for a given sector s, the idiosyncratic component of log earnings follows an AR(1) process

$$\tilde{y}^{i}_{hs} = \rho_s \tilde{y}^{i}_{h-1,s} + \epsilon^{i}_{hs},\ \epsilon_{hs} \sim \left(0, \sigma^2_{hs}\right), \tag{13}$$

with sector specific persistence ρ_s and age and sector specific variance σ^2_{hs}, $h = 22, \ldots, 65$.[53] I calibrate parameters ρ_s and σ^2_{hs} such that, for each sector, the relative permanent income risk implied by the decomposition (12)-(13) matches the empirical profile of uncertainty relative to permanent income. Since for each sector there are only 44 data moments, estimating a fully non-parametric variance age profile is virtually impossible. Instead, I assume that the variance of the idiosyncratic component is a cubic polynomial in age. Section B.3 in Appendix B discusses the estimation procedure in detail.

The left panel of Figure 6 displays the fit of the estimation, for each of the two sectors. The right panel of the figure shows how the variance in each sector varies with age. The average variance is 0.070 in the low risk sector and 0.087 in the high risk sector. The estimated persistence parameters are 0.908 and 0.947, respectively. Both the persistence and the variance of the income process are larger for the high risk sector. While these parameters are estimated based on a different set of moments than it is common in the literature, the resulting values are comparable to existing ones.

Pension benefits. In a realistic analysis of retirement, pension benefits would be based on career (lifetime) average earnings. In terms of modeling, that requires introducing a new continuous state variable for each member of the family to what already is a large state space. To avoid that, I set pension benefits as a function of predicted lifetime average earnings, as in Guvenen et al. (2013). To that end, I first simulate the lifetime labor earnings profile of $10,000$ individuals and compute average earnings for each of them. I then regress average earnings on earnings in the last period of working life and use the estimated coefficients to predict the career average earnings of an individual, given earnings right before retirement. Letting $\hat{y}$ denote an individual's predicted lifetime average earnings and $\bar{y}$ denote average earnings in the economy, the individual's pension benefit is determined as follows:

$$\Phi\left(\hat{y}\right) = a\bar{y} + b\hat{y}$$

where $a = 0.168$ captures the insurance component of retirement income and $b = 0.355$

[53] Karahan and Ozkan (2013) provide evidence for age dependence of income process parameters. While such patterns are not very strong for the persistence parameter, they are for the variance.

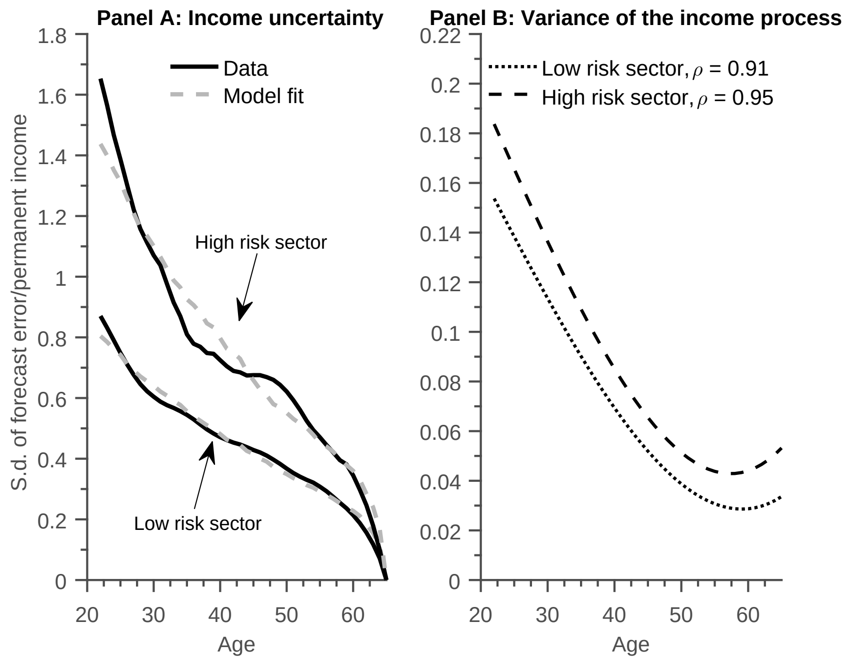

Figure 6: Parameters of the Income Process and Uncertainty Fit

Notes: The figure shows the estimated parameters of the income processes for the two sectors in the right panel and the fit of the estimation in the left panel. The variance is assumed to be a cubic polynomial in age: $\sigma^2_{hs} = a_s + b_s \frac{h}{10} + c_s \left(\frac{h}{10}\right)^2 + d_s \left(\frac{h}{10}\right)^3$, $s \in \{l, h\}$. For the low income sector the coefficients are: $a_l = 0.159$, $b_l = -0.051$, $c_l = 10^{-5}$, $d_l = 0.001$. For the high income sector the coefficients are: $a_h = 0.190$, $b_h = -0.061$, $c_h = 10^{-5}$, $d_h = 0.002$.

captures the private returns to lifetime earnings. The values of these two parameters are taken from Guvenen et al. (2013), who use the information reported by OECD for the US in "Pensions at a Glance 2007: Retirement Income Systems in OECD Countries".

Borrowing limit. I set the borrowing limit $\underline{A}_h$ to zero, but explore the sensitivity of the results under the natural borrowing limit. Irrespective of the type of borrowing limit considered, parents are not allowed to borrow against the income of future generations.

Preferences. Household utility is CRRA with the relative risk aversion equal to 2. Following the literature on quantitative macroeconomic models with heterogeneous households and incomplete markets, I set the discount factor β to 0.959 to match an average wealth to average income ratio of 6.218.[54] I calibrate the altruism coefficient γ to target the average ratio between parent's and child's consumption, as measured in the sample of parent-child pairs used in the empirical analysis. A parent who makes positive transfers sets them such

[54]This target is computed by averaging the respective ratios between 2001 and 2013, when the average wealth to average income ratio has been relatively stable. The yearly ratios are calculated using moments from the Survey of Consumer Finances reported on the Rios-Rull and Kuhn (2016) project webpage.

that $u'(c_p) = \gamma u'(c_c)$, so the ratio between the consumption of a parent and that of his child is directly influenced by the weight that parents place on their children's utility.[55] The calibrated value for γ is 0.201.

Government and interest rate. The proportional tax rate is set to 24.6%, corresponding to the net personal average tax rate for the US, as reported in the OECD Tax Database.[56] Government spending is set such that in the steady state the interest rate is 4% annually.

3.3 Results

I now discuss the quantitative results. First, I examine the model's performance in matching the empirical evidence on parental help, both from an ex-ante perspective via dynastic precautionary saving, and from an ex-post perspective through intergenerational transfers and end-of-life bequest.[57] Second, I quantify how much consumption insurance parents provide to children through dynastic precautionary saving and transfers. Third, I highlight the quantitative importance of the strategic interactions between parents and children by comparing the predictions of this model with the predictions of the unitary household model, which is a classic framework with no strategic considerations. Fourth, I augment the model with two additional sources of risk that are understood as being relevant at old age, medical expenses risk and longevity risk, and use it to evaluate the contribution of dynastic precautionary saving to aggregate wealth accumulation.

3.3.1 Model fit

Model regression. I repeat the regression analysis in Section 2 with model generated data to determine the model implied elasticities of consumption with respect to permanent income uncertainty. Precautionary and dynastic precautionary savings inform the choice of behavioral parameters such as risk aversion and intergenerational altruism. The purpose of this exercise is to verify whether standard calibration of these parameters is able to deliver consumption responses to both own and child's income risk consistent with those documented

[55]In particular, under the CRRA utility assumption with relative risk aversion σ, the intra-temporal optimality condition for positive transfers is $c_p^{-\sigma} = \gamma c_c^{-\sigma}$ or, equivalently, $\ln \frac{c_p}{c_c} = -\frac{1}{\sigma} \ln \gamma$. The altruism parameter γ is set such that the model implied average of $\ln \frac{c_p}{c_c}$ matches its empirical counterpart, which is equal to 0.171. The empirical moment is calculated based on the sample of parent-child pairs in which the parent is older than 51 and the child is older than 22, as in the model.

[56]Net personal average tax rate is the term used when the personal income tax and employee social security contributions net of cash benefits are expressed as a percentage of gross wage earnings. The value is an average over the 2000-2015 horizon.

[57]Appendix B.4 reports other measures of the model fit (e.g. wealth distribution).

in the previous section. To that end, I simulate 10,000 parent-child pairs from the steady state of the model, and follow them for as long as the parent is alive. I then estimate the following equation:

$$c_{p_{it}} = \beta^p_{m0} + \beta^p_{m1}\sigma_{p_{hs}} + \beta^p_{m2}\sigma_{c_{hs}} + \mathbf{X}_{p_{it}}\beta^p_{m3} + \mathbf{X}_{c_{it}}\beta^p_{m4} + \epsilon_{p_{it}}, \tag{14}$$

which is the model counterpart of equation (9) and where $c_{p_{it}}$ is the logarithm of the consumption of parent household i in year t, $\sigma_{p_{hs}}$ is the logarithm of permanent income uncertainty of the parent and is assigned based on the age $h \in \{51, \ldots, 79\}$ and the sector $s \in \{l, h\}$ in which the parent i is in year t, while $\sigma_{c_{hs}}$ is the logarithm of permanent income uncertainty of the child, assigned based on the age $h \in \{22, \ldots, 50\}$ and the sector $s \in \{l, h\}$ in which the child of parent i is in year t. $\mathbf{X}_{p_{it}}$ and $\mathbf{X}_{c_{it}}$ are vectors of controls for the parent and child's permanent labor income and wealth holdings, as well as a full set of age dummies for the parent.

Table 5 reports the results. Panel A of the table reproduces the empirical elasticity estimates for comparison. Panel B reports the corresponding estimates from the model generated sample. The first row of Panel B corresponds to the baseline scenario with no borrowing. As is the case in the data, parental consumption responds negatively to both own and child's permanent income uncertainty. Moreover, the consumption response to own income risk is stronger than the response to the child's income risk, albeit to a stronger extent in the model than in the data. However, the model estimates fall well within the 95% confidence interval of the empirical estimates. The second row of Panel B explores the sensitivity to the borrowing limit.[58] The option of borrowing provides extra insurance for young adults, reducing the parental response to dynastic uncertainty. However, the overall effect of looser borrowing constraints is quantitatively small.

Inter-vivos transfers and bequest. Figure 7 shows the predictions of the model regarding the size and timing of intergenerational transfers compared to the data. Though none of these dimensions are targeted, the model matches them remarkably well. The top panel shows the model implied inter-vivos transfers relative to parental wealth in black, and their data counterpart in gray. The data moment is measured from the 2013 PSID Family Rosters and Transfers Module and the dashed lines are the 95% confidence bands.[59] The model

[58]Following Kaplan and Violante (2014), I assume that in a given year working age individuals can borrow up to 18.5% of average annual income and retired individuals cannot borrow.

[59]Monetary transfers to children are directly reported by parents in the module. The average transfer-to-parental wealth ratio is calculated for respondents with positive wealth, as the borrowing limit is set to zero in the baseline.

Table 5: Regression Analysis with Model Generated Data

	Coefficient on parent's permanent income risk	Coefficient on child's permanent income risk
	Panel A. Empirical estimates from Table 1	
1. Non-durable consumption	-0.089** [-0.171 -0.007]	-0.076** [-0.150 -0.014]
2. Total consumption	-0.082* [-0.168 0.004]	-0.079** [-0.152 -0.006]
	Panel B. Model estimates	
1. Baseline	-0.097*** (0.012)	-0.067*** (0.013)
2. Borrowing allowed	-0.098*** (0.012)	-0.064*** (0.013)

Notes: Table entries are coefficient estimates of the effect of parent's and child's permanent income uncertainty on parental consumption. Panel A reports results from estimating equation (9) with the PSID sample, with the 95% bootstrapped confidence interval in parentheses. Panel B reports results from estimating equation (14) with model generated data with robust standard errors in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

matches well the evolution over age of the transfer-to-parental wealth ratio. In particular, the model implied average ratio is 3.06%, while the empirical counterpart is 3.01%. The middle panel of the figure shows the fraction of parents making inter-vivos transfers to their children. In the PSID 24.1% of all parents make inter-vivos transfers. When restricting the sample to parents older than 51, in line with the age structure of the model, this share becomes 39.73%, in comparison to 39.15% in the model. The bottom panel shows the average size of the transfers, measured in dollars and including zeros. Yearly tranfers made by parents older than 51 average at $1871 in the data and $1495 in the model.[60] A word of caution is in order. In the data, transfers refer to the "the total amount of money that Head/Wife/"Wife" gave to their child(ren) during 2012" and could, in principle, capture transfers made for reasons that are outside the scope of this model, such as reducing college debt, moving to a new location or helping with a home downpayment. In fact, while the model matches well the fraction of parents making transfers, it underestimates the dollar amount of transfers, potentially reflecting these additional transfer motives that are absent from the model.

[60]These dollar figures are expressed in 1996 US dollars.

Lastly, the model predicted bequest-to-aggregate wealth ratio of 0.49% is roughly in line with Gale and Scholz (1994), who estimate bequests to represent 0.88% of aggregate net worth. Total intergenerational transfers (end-of-life bequest and inter-vivos transfers) are 1.87% of aggregate wealth. Gale and Scholz (1994) estimate intended transfers and bequest to be 1.41% of aggregate net worth.

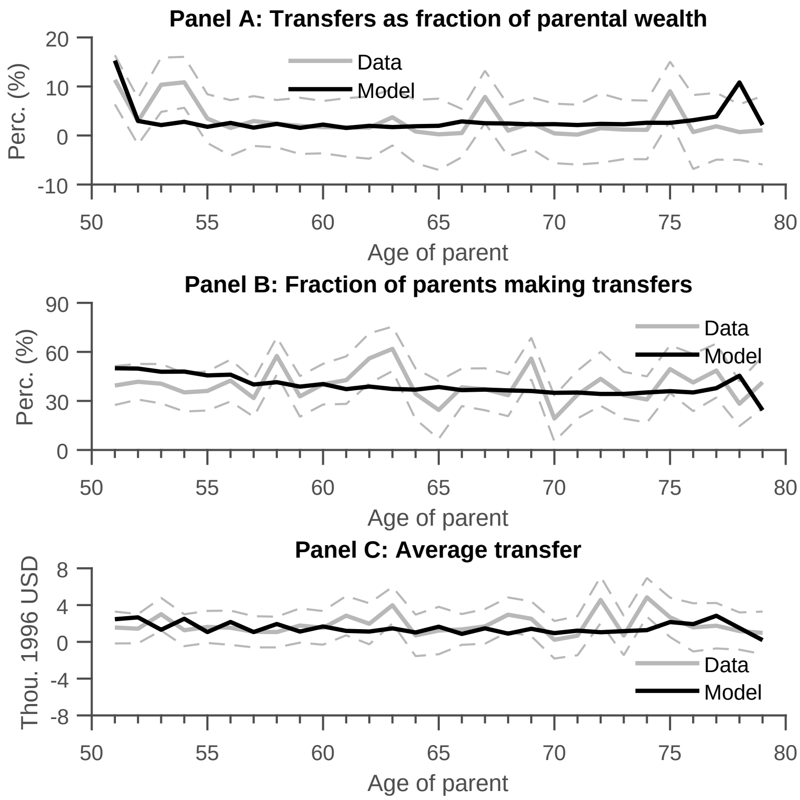

Figure 7: Age Profile of Transfers: Data vs Model

Notes: The top panel of the figure shows the ratio between inter-vivos transfers and parental wealth in the model (solid black line) and the 2013 PSID Family Rosters and Transfers Module (gray solid line). Dashed gray lines are the 95% confidence interval for the data. The bottom panel shows the same objects for the fraction of parents making transfers to their children.

3.3.2 How much insurance via dynastic precautionary savings?

For children, dynastic precautionary saving by parents is a form of private insurance against labor market shocks that goes over and above self-insurance through borrowing and saving.[61] In this section, I assess the degree of additional consumption smoothing induced by parents' dynastic precautionary saving by calculating consumption insurance coefficients against income shocks.

Following Kaplan and Violante (2010), I define the consumption insurance coefficient against a persistent income shock as $1 - \frac{\text{Cov}(\Delta c_{ih}, \epsilon_{ih})}{\text{Var}(\epsilon_{ih})}$, where c_{ih} denotes the log consumption of individual i of age h, ϵ_{ih} is the persistent income shock defined in equation (13), and the variance and covariance are taken cross-sectionally over the simulated sample of individuals.[62] The interpretation of the insurance coefficient is intuitive: it captures the share of the (variance of the) persistent shock that does not translate into movements in consumption.

I compare the consumption insurance coefficient for children implied by my model with that predicted by a pure life-cycle model (i.e. $\gamma = 0$). The difference between these two insurance coefficients is informative on the extent of additional consumption insurance coming from parent's dynastic precautionary savings. I find that 66% of labor income shocks faced by children are insured when parents accumulate dynastic precautionary savings, in comparison to only 49% otherwise.[63] This means that, in the dynastic model, consumption insurance through parents' dynastic precautionary savings accounts for a little over one fourth of children's total consumption insurance. The rest is through children's own savings.

3.3.3 Comparison with the unitary household model

In this section I show that strategic interactions between parents and children are essential for generating consumption responses to income risk that are in line with the data. I do this by repeating the analysis in the context of the unitary household model, which is a workhorse model of the family and notably lacks strategic interactions between family members.[64] In the unitary framework, parents and children pool their income and behave as a single decision maker, maximizing the weighted sum of their utilities. A complete description of the unitary model setup is in Appendix B.5. I normalize the weight on the parent's utility to 1 and denote the weight on the child's utility by δ. I use the same parameter values as in the baseline framework, except for the discount factor β and the weight on the child's utility δ,

[61] Altonji, Hayashi and Kotlikoff (1996) call for future research to be directed at estimating the extent of such insurance.

[62] To be consistent with Blundell, Pistaferri and Preston (2008) and Kaplan and Violante (2010), here log consumption is defined as the residual from a quartic age profile.

[63] It is worth pointing out, as a cross-check, that the insurance coefficient found in the life-cycle model is of a similar magnitude to that found by Kaplan and Violante (2010) for the corresponding age group and income shock persistence.

[64] See Alderman et al. (1995) for a comprehensive discussion of this framework.

which I recalibrate to match the same moments as the model with strategic interactions.[65] The calibrated values of β and δ are 0.958 and 0.710, respectively.

Table 6 reports the estimated consumption elasticities from the unitary household model in the first column, from the model with strategic interactions in the second column and from the PSID in the third column.[66] The top panel of the table reports the effect of permanent income risk on parental consumption, while the bottom panel reports the effect of uncertainty on child's consumption.

The unitary household model predicts (dynastic) precautionary saving behavior that is at odds with the data in two dimensions. First, in the unitary model the effect of income uncertainty on parent's and child's consumption is the same. This is a consequence of the child's consumption being a constant fraction of the parent's consumption and therefore holds irrespective of the parameterization of the model. Second, the effect of child's income risk on parental consumption is stronger than the effect of parent's own income risk. To understand why this is the case, recall that in the unitary model family labor income is the sum of two components with different degrees of risk: parent's labor earnings and child's labor earnings. The latter is more risky because of the age difference between parents and children. When the riskiness in child's income decreases, the effect on the overall riskiness of joint family income is larger than if the riskiness in parent's income would decrease by the same magnitude, which translates into a stronger consumption adjustment.[67]

In the model with strategic interactions, on the other hand, the relative importance of the two saving motives is in line with that observed in the PSID. This is because the nature of these strategic interactions is such that the child is pursuing a consumption plan that exploits the parent's altruism. In particular, the child behaves recklessly by overconsuming, to induce transfers from parents in the future.[68] The parent is aware of this behavior and would want the child to entertain a lower level of consumption than he actually does. This dampens the parent's incentive to provide private insurance via dynastic precautionary savings. The bottom panel of the table shows that in the setup with strategic interactions the child has to compensate with stronger precautionary saving relative to the unitary setup. Additionally,

[65] In the model without strategic interactions, child's consumption is always a constant fraction of the parent's consumption, as dictated by the intra-temporal optimality condition $u'(c_p) = \delta u'(c_c)$.

[66] Because the wealth holdings of parents and children are not separately identified, I estimate a slightly modified version of equations (9) and (10), in which I control for joint asset holdings of the family.

[67] This is a statistical property of the sum of two random variables and is true as long as the two income streams are not perfectly correlated, a condition that is satisfied by the parametrization of the model. Therefore, a different parameterization of preference and altruism parameters would yield similar qualitative predictions.

[68] Overconsumption is defined relative to the prevailing consumption in the unitary model.

he is subject to the parent's income risk insofar as it generates fluctuations in transfers, so he mildly insures against that.

The argument above could also be used to extrapolate the implications that the assumptions on the direction of altruism and the timing of the parent-child game have on the results. If altruism were two-sided, this would dampen the child's overconsumption incentives, increasing the relative importance of dynastic precautionary saving in the model. If the child were the first mover in the parent-child stage game, then he would have even stronger incentives to overconsume, further decreasing the relative importance of dynastic precautionary saving for the parent.

Table 6: Regression Analysis with Model Generated Data (comparison)

	Model without strategic interactions $\delta = 0.710$	Model with strategic interactions $\gamma = 0.201$	Data
	Panel A. Effect of uncertainty on parent's consumption		
Parent's uncertainty	-0.022**	-0.097***	-0.089**
	(0.009)	(0.012)	[-0.171 -0.007]
Child's uncertainty	-0.062***	-0.067***	-0.076*
	(0.009)	(0.013)	[-0.150 -0.014]
	Panel B. Effect of uncertainty on child's consumption		
Parent's uncertainty	-0.022**	-0.019*	-0.035
	(0.009)	(0.011)	[-0.109 0.039]
Child's uncertainty	-0.062***	-0.181***	-0.151**
	(0.009)	(0.013)	[-0.267 -0.035]

Notes: Table entries are estimates of the effect of permanent income uncertainty on parent's consumption in Panel A and child's consumption in Panel B. The first two columns show estimates from the model without strategic interactions and the model with strategic interactions, respectively. Robust standard errors are in parenthesis. The third column shows the estimates from the PSID sample, with the 95% confidence interval in parentheses. * significant at 10%; ** significant at 5% ; *** significant at 1%

3.3.4 How much dynastic precautionary wealth in total wealth?

I now turn to quantifying the contribution of dynastic precautionary wealth to total wealth in the model. To better capture individuals' saving motives, I augment the model with two additional sources of risk that, in addition to bequest, are understood as important drivers of late-in-life wealth accumulation: mortality risk and medical expenditure risk (de Nardi, French and Jones (2010)). I briefly discuss below how I model these two types of risk and defer to Appendix B.6 the complete description of the setup.

Mortality risk. Once retired, individuals are subject to mortality risk. Age-specific survival probabilities, ψ_{h_p}, are taken from the 2014 National Vital Statistics Report.[69]

Medical expenditure risk. Upon retirement, individuals also face uncertainty about medical expenses. I model this as in Kopecky and Koreshkova (2014). In particular, medical expenses evolve stochastically during retirement according to a function $\bar{m}(h_p, m)$. Thus, in each period a retiree's medical expenses depend on his current age h_p and current expense shock m. The medical expense shock m follows an age-invariant Markov process and the initial distribution of medical expense shocks is independent of the individual's state. The calibration of the process for medical expenses is taken from Kopecky and Koreshkova (2014) and is discussed in detail in Appendix B.6.

I evaluate the contribution of dynastic precautionary wealth to total wealth in the model through a decomposition exercise inspired by Gourinchas and Parker (2002), who measure precautionary wealth by comparing aggregate wealth in a pure life-cycle model with income risk and in a counterfactual model without income risk. In the setting of this paper, a literal application of this decomposition amounts to shutting down children's income risk in the counterfactual model. This, however, has the unintended effect of also suppressing children's precautionary saving motive, in addition to parents' dynastic precautionary saving motive. As a consequence, in the counterfactual model parental wealth holding is significantly lower (i.e. $\approx 67\%$ lower) because *(i)* parents no longer hold dynastic precautionary wealth, which is the effect of interest, and *(ii)* children enter parenthood with lower levels of wealth.

To purge the second effect, I instead apply a two step decomposition. First, I solve a counterfactual model in which I shut down income risk at all ages. The difference between total wealth in the baseline model and in this counterfactual model represents precautionary and dynastic precautionary wealth. Call this quantity $W_{PS,DPS}$. Second, I measure precautionary wealth the same way Gourinchas and Parker (2002) do. Specifically, I solve a model in which $\gamma = 0$, which is in fact a pure life-cycle model, and measure precautionary wealth as the difference between total wealth in the model with $\gamma = 0$ and income risk and total wealth in the model with $\gamma = 0$ and no income risk. Call this quantity W_{PS}. Lastly, dynastic precautionary wealth is the difference between $W_{PS,DPS}$ and W_{PS}. According to this definition, dynastic precautionary wealth represents 16.71% of total wealth.[70]

[69] I use the age-specific probabilities of dying reported in Table 1. Life table for the total population: United States, 2014.

[70] This decomposition is subject to the caveat that wealth components may be fungible, in which case the

I now turn to analyzing the contribution of risk in children's income to intergenerational transfers. To that end, I solve a counterfactual model in which children (i.e. individuals of age 22-50), are not subject to income risk, but average income is the same as in the baseline environment.[71] I find that intergenerational transfers are primarily driven by incentives to insure children against income risk. In particular, the dynastic precautionary motive accounts for 97.07% of total intergenerational transfers. Decomposing this effect into the effect of inter-vivos transfer and the effect on end-of-life bequest, I find that virtually all inter-vivos transfers are dictated by dynastic precautionary considerations. This shows that the primary role of such transfers is to provide insurance against bad income realizations, as argued by McGarry (1999) and McGarry (2016). A slightly smaller share of end-of-life bequest, 85.44%, is dictated by incentives to insure future generations against income risk.

4 Conclusion

In this paper I investigate, both empirically and in a quantitative model, the response of parents' consumption to their children's permanent income uncertainty. I find a negative relationship which I interpret as evidence for precautionary saving across generations and refer to as *dynastic precautionary saving.*

The first contribution of the paper is to document empirically that the consumption profile of retired parents is backloaded, a feature consistent with precautionary behavior. I show that this is a reflection of dynastic precautionary saving by regressing parental consumption on child's income uncertainty in a sample of parent-child pairs from the PSID. For this, I exploit variation in income uncertainty across age and industry-occupation groups.

The second contribution of the paper is to build a quantitative model of dynastic precautionary saving that can replicate the magnitude of the response of parental consumption to child's permanent income risk observed in the data. I use the model to evaluate the effect of dynastic uncertainty on parental wealth accumulation and intergenerational transfers, and to quantify the consumption insurance provided by parents against it.

In ongoing work, I explore the substitutability between private and social insurance and the ensuing implications for wealth accumulation and consumption inequality, by examining individuals' (dynastic) precautionary behavior in two environments that are fundamentally

result is a lower bound.

[71] Note that there is residual dynastic uncertainty in the counterfactual model. When individuals turn 51 and become parents they are again subject to income risk. This is a consequence of the fact that in the dynastic model every individual play every role. I conjecture this has a small quantitative effect, as most of income risk is resolved by age 51.

different in terms of the prevailing social safety net: U.S. and Denmark. Going forward, dynastic precautionary savings could potentially be important in explaining several empirical puzzles: *(i)* It has repeatedly been documented that upon retirement wealth declines slower than the life cycle model predicts, but the reason remains poorly understood; *(ii)* There is substantial wealth heterogeneity at retirement, even after controlling for realized lifetime income. These exercises could, in principle, be accommodated by variants of the model in this paper. More broadly, this framework could also be used to study issues related to the intergenerational mobility of wealth, income and consumption.

References

Aguiar, Mark and Erik Hurst. 2013. "Deconstructing Life Cycle Expenditure." *Journal of Political Economy* 121:437–492.

Alderman, Harold, Pierre-André Chiappori, Lawrence Haddad, John Hoddinott and Ravi Kanbur. 1995. "Unitary versus Collective Models of the Household: Is It Time to Shift the Burden of Proof?" *The World Bank Research Observer* 10(1):1–19.

Altig, David and Steve J. Davis. 1989. "Government debt, redistributive fiscal policies, and the interaction between borrowing constraints and intergenerational altrusim." *Journal of Monetary Economics* 24(1):3 – 29.

Altig, David and Steven J. Davis. 1992. "The Timing of Intergenerational Transfers, Tax Policy, and Aggregate Savings." *The American Economic Review* 82(5):1199–1220.

Altig, David and Steven J. Davis. 1993. "Borrowing constraints and two-sided altruism with an application to social security." *Journal of Economic Dynamics and Control* 17(3):467 – 494.

Altonji, Joseph, Fumio Hayashi and Laurence Kotlikoff. 1996. "Risk-Sharing between and within Families." *Econometrica* 64(2):261–294.

Altonji, Joseph G., Fumio Hayashi and Laurence J. Kotlikoff. 1992. "Is the Extended Family Altruistically Linked? Direct Tests Using Micro Data." *The American Economic Review* 82(5):1177–1198.

Ameriks, John, Andrew Caplin, Steven Laufer and Stijn Van Nieuwerburgh. 2011. "The Joy of Giving or Assisted Living? Using Strategic Surveys to Separate Public Care Aversion from Bequest Motives." *The Journal of Finance* 66(2):519–561.

Ameriks, John, Joseph Briggs, Andrew Caplin, Mi Luo, Matthew D. Shapiro and Christopher Tonetti. 2016. "Inter-generational Transfers and Precautionary Saving." *Working Paper* .

Andreski, Patricia, Geng Li, Mehmet Zahid Samancioglu and Robert Schoeni. 2014. "Estimates of Annyal Consumption Expenditure and Its Major Components in the PSID in Comparison to the CEX." *American Economic Review* 104(5):132–35.

Attanasio, Orazio, Costas Meghir and Corina Mommaerts. 2018. Insurance in extended family networks. Working paper.

Barczyk, Daniel. 2016. "Ricardian equivalence revisited: Deficits, gifts and bequests." *Journal of Economic Dynamics and Control* 63:1 – 24.

Barczyk, Daniel and Matthias Kredler. 2014*a*. "Altruistically motivated transfers under uncertainty." *Quantitative Economics* 5(3):705–749.

Barczyk, Daniel and Matthias Kredler. 2014*b*. "A dynamic model of altruistically-motivated transfers." *Review of Economic Dynamics* 17(2):303 – 328.

Barczyk, Daniel and Matthias Kredler. 2016. "Evaluating Long-Term-Care Policy Options, Taking the Family Seriously." *Working Paper* .

Barro, Robert J. 1974. "Are Government Bonds Net Wealth?" *Journal of Political Economy* 82(6):1095–1117.

Becker, Gary S. 1974. "A Theory of Social Interactions." *Journal of Political Economy* 82(6):1063–1093.

Blundell, Richard, Luigi Pistaferri and Ian Preston. 2008. "Consumption Inequality and Partial Insurance." *American Economic Review* 98(5):1887–1921.

Cagetti, Marco. 2003. "Wealth Accumulation over the Life Cycle and Precautionary Savings." *Journal of Business & Economic Statistics* 21(3):339–53.

Carroll, Christopher D. and Andrew A. Samwick. 1997. "The nature of precautionary wealth." *Journal of Monetary Economics* 40(1):41–71.

Carroll, Christopher D. and Andrew A. Samwick. 1998. "How Important is Precautionary Saving?" *The Review of Economics and Statistics* 80(3):pp. 410–419.

Carroll, Christopher D. and Miles S. Kimball. 2008. precautionary saving and precautionary wealth. In *The New Palgrave Dictionary of Economics*, ed. Steven N. Durlauf and Lawrence E. Blume. Basingstoke: Palgrave Macmillan.

Choi, HwaJung, Kathleen McGarry and Robert F. Schoeni. 2016. "Consumption and the extended family." *Economics Letters* 140:34 – 38.

Cox, Donald. 1990. "Intergenerational Transfers and Liquidity Constraints*." *The Quarterly Journal of Economics* 105(1):187–217.

Cubas, German and Pedro Silos. 2017. "Career choice and the risk premium in the labor market." *Review of Economic Dynamics* 26:1 – 18.

Cubas, German and Pedro Silos. 2018. Social Insurance and Occupational Mobility. DETU Working Papers 1802 Department of Economics, Temple University.

de Nardi, Mariacristina, Eric French and John B. Jones. 2010. "Why Do the Elderly Save? The Role of Medical Expenses." *Journal of Political Economy* 118(1):pp. 39–75.

de Nardi, Mariacristina, Eric French and John Bailey Jones. 2016*a*. "Medicaid Insurance in Old Age." *American Economic Review* 106(11):3480–3520.

de Nardi, Mariacristina, Eric French and John Bailey Jones. 2016*b*. "Savings After Retirement: A Survey." *Annual Review of Economics* 8(1):177–204.

Dynan, Karen E., Jonathan Skinner and Stephen P. Zeldes. 2004. "Do the Rich Save More?"

Journal of Political Economy 112(2):397–444.

Feigenbaum, James and Geng Li. 2012. "Life Cycle Dynamics of Income Uncertainty and Consumption." *The B.E. Journal of Macroeconomics* 12(1):1–49.

Fuster, Luisa. 1999. "Is Altruism Important for Understanding the Long-Run Effects of Social Security?" *Review of Economic Dynamics* 2(3):616 – 637.

Fuster, Luisa, Ayse Imrohoroglu and Selahattin Imrohoroglu. 2007. "Elimination of Social Security in a Dynastic Framework." *The Review of Economic Studies* 74(1):113–145.

Gale, William G. and John Karl Scholz. 1994. "Intergenerational Transfers and the Accumulation of Wealth." *Journal of Economic Perspectives* 8(4):145–160.

Gourinchas, Pierre-Olivier and Jonathan A. Parker. 2002. "Consumption Over the Life Cycle." *Econometrica* 70(1):47–89.

Guvenen, Fatih. 2007. "Learning Your Earning: Are Labor Income Shocks Really Very Persistent?" *American Economic Review* 97(3):687–712.

Guvenen, Fatih. 2009. "An empirical investigation of labor income processes." *Review of Economic Dynamics* 12(1):58–79.

Guvenen, Fatih and Anthony A. Smith. 2014. "Inferring Labor Income Risk and Partial Insurance From Economic Choices." *Econometrica* 82(6):2085–2129.

Guvenen, Fatih, Fatih Karahan, Serdar Ozkan and Jae Song. 2013. What Do Data on Millions of US Workers Say About Labor Income Risk? Technical report Working paper.

Hubbard, R Glenn, Jonathan Skinner and Stephen P Zeldes. 1995. "Precautionary Saving and Social Insurance." *Journal of Political Economy* 103(2):360–99.

Hurd, Michael D. 1987. "Savings of the Elderly and Desired Bequests." *The American Economic Review* 77(3):pp. 298–312.

Hurst, Erik, Annamaria Lusardi, Arthur Kennickell and Francisco Torralba. 2010. "The Importance of Business Owners in Assessing the Size of Precautionary Savings." *The Review of Economics and Statistics* 92(1):61–69.

Imrohoroglu, Ayse and Kai Zhao. 2018. "The chinese saving rate: Long-term care risks, family insurance, and demographics." *Journal of Monetary Economics* 96:33 – 52.

Kaplan, Greg. 2012. "Moving Back Home: Insurance against Labor Market Risk." *Journal of Political Economy* 120(3):446 – 512.

Kaplan, Greg and Gianluca Violante. 2010. "How Much Consumption Insurance Beyond Self-Insurance?" *American Economic Journals: Macroeconomics* 2:53–87.

Kaplan, Greg and Giovanni L. Violante. 2014. "A Model of the Consumption Response to Fiscal Stimulus Payments." *Econometrica* 82(4):1199–1239.

Karahan, Fatih and Serdar Ozkan. 2013. "On the persistence of income shocks over the life cycle: Evidence, theory, and implications." *Review of Economic Dynamics* 16(3):452 – 476.

Kennickell, Arthur and Annamaria Lusardi. 2005. Disentangling the importance of the precautionary saving motive. CFS Working Paper Series 2006/15 Center for Financial Studies (CFS).

Kimball, Miles S. 1990. "Precautionary Saving in the Small and in the Large." *Econometrica* 58(1):53–73.

Klein, Paul, Per Krusell and Jose-Victor Rios-Rull. 2008. "Time-Consistent Public Policy." *The Review of Economic Studies* 75(3):789–808.

Kopczuk, Wojciech and Joseph P. Lupton. 2007. "To Leave or Not to Leave: The Distribution of Bequest Motives." *Review of Economic Studies* 74(1):207–235.

Kopecky, Karen A. and Tatyana Koreshkova. 2014. "The Impact of Medical and Nursing Home Expenses on Savings." *American Economic Journal: Macroeconomics* 6(3):29–72.

Laitner, John. 1988. "Bequests, Gifts, and Social Security." *The Review of Economic Studies* 55(2):275–299.

Laitner, John. 1992. "Random earnings differences, lifetime liquidity constraints, and altruistic intergenerational transfers." *Journal of Economic Theory* 58(2):135 – 170.

Laitner, John. 1993. "Long-run equilibria with borrowing constraints and altruism." *Journal of Economic Dynamics and Control* 17(1):65 – 96.

Laitner, John. 2001. Wealth Accumulation in the U.S.: Do Inheritances and Bequests Play a Significant Role? Working Papers wp019 University of Michigan, Michigan Retirement Research Center.

Lindbeck, Assar and Jorgen W. Weibull. 1988. "Altruism and Time Consistency: The Economics of Fait Accompli." *Journal of Political Economy* 96(6):1165–1182.

Lockwood, Lee. 2014. "Incidental bequests: Bequest motives and the choice to self-insure late-life risks." *Working Paper* .

Lockwood, Lee M. 2012. "Bequest motives and the annuity puzzle." *Review of Economic Dynamics* 15(2):226 – 243.

Luo, Mi. 2016. "Unintended Effects of Estate Taxation on Wealth Inequality." *Working Paper* .

McGarry, Kathleen. 1999. "Inter vivos transfers and intended bequests." *Journal of Public Economics* 73(3):321–351.

McGarry, Kathleen. 2016. "Dynamic aspects of family transfers." *Journal of Public Eco-*

nomics 137(C):1–13.

Michel, Philippe, Emmanuel Thibault and Jean-Pierre Vidal. 2006. Chapter 15 Intergenerational altruism and neoclassical growth models. In *Applications*, ed. Serge-Christophe Kolm and Jean Mercier Ythier. Vol. 2 of *Handbook of the Economics of Giving, Altruism and Reciprocity* Elsevier pp. 1055 – 1106.

Mommaerts, Corina. 2015. "Long-Term Care Insurance and the Family." *Working Paper* .

Murphy, Kevin M. and Robert H. Topel. 1985. "Estimation and Inference in Two-Step Econometric Models." *Journal of Business & Economic Statistics* 3(4):370–379.

Nishiyama, Shinichi. 2002. "Bequests, Inter Vivos Transfers, and Wealth Distribution." *Review of Economic Dynamics* 5(4):892–931.

Pagan, Adrian. 1984. "Econometric Issues in the Analysis of Regressions with Generated Regressors." *International Economic Review* 25(1):221–247.

Palumbo, Michael G. 1999. "Uncertain Medical Expenses and Precautionary Saving Near the End of the Life Cycle." *The Review of Economic Studies* 66(2):395–421.

Rios-Rull, Jose-Victor and Moritz Kuhn. 2016. "2013 Update on the U.S. Earnings, Income, and Wealth Distributional Facts: A View from Macroeconomics." *Quarterly Review* (April):1–75.

Skinner, Jonathan. 1987. "A superior measure of consumption from the panel study of income dynamics." *Economics Letters* 23(2):213–216.

Strawczynski, Michael. 1994. "Government intervention as a bequest substitute." *Journal of Public Economics* 53(3):477–495.

Tauchen, George. 1986. "Finite state markov-chain approximations to univariate and vector autoregressions." *Economics Letters* 20(2):177–181.

Ziliak, James P. 1998. "Does the choice of consumption measure matter? An application to the permanent-income hypothesis." *Journal of Monetary Economics* 41(1):201 – 216.

Appendices

A Appendix for Empirical Analysis

A.1 Derivation of Permanent Income Uncertainty $\mathrm{Std}_i\left(\mathcal{E}_h^i\right)$

Permanent income uncertainty of individual i at age h is defined as

$$\mathrm{Std}_i\left(\mathcal{E}_h^i\right) = \left[\mathrm{Var}_i\left(\sum_{j=h+1}^{H} \frac{e_{j,h}^i}{R^{j-h}}\right)\right]^{\frac{1}{2}} = \left[\mathrm{Var}_i\left(\frac{e_{h+1,h}^i}{R} + \frac{e_{h+2,h}^i}{R^2} + ... + \frac{e_{H,h}^i}{R^{H-h}}\right)\right]^{\frac{1}{2}}$$

which is equal to the square root of the sum of all variance and covariance terms. The sum of variances is

$$\sum_{j=h+1}^{H} \frac{\mathrm{Var}_i\left(e_{j,h}^i\right)}{R^{2(j-h)}}$$

For $h+1$ the covariance terms are

$$\underbrace{\frac{2}{R}\left[\frac{\mathrm{Cov}_i\left(e_{h+1,h}^i; e_{h+2,h}^i\right)}{R^2} + \frac{\mathrm{Cov}_i\left(e_{h+1,h}^i; e_{h+3,h}^i\right)}{R^3} + \cdots + \frac{\mathrm{Cov}_i\left(e_{h+1,h}^i; e_{H,h}^i\right)}{R^{H-h}}\right]}_{\frac{2}{R}\sum_{k=h+2}^{H} \frac{\mathrm{Cov}_i\left(e_{h+1,h}^i; e_{k,h}^i\right)}{R^{k-h}}}$$

For $h+2$ the covariance terms are

$$\underbrace{\frac{2}{R^2}\left[\frac{\mathrm{Cov}_i\left(e_{h+2,h}^i; e_{h+3,h}^i\right)}{R^3} + \frac{\mathrm{Cov}_i\left(e_{h+2,h}^i; e_{h+4,h}^i\right)}{R^4} + \cdots + \frac{\mathrm{Cov}_i\left(e_{h+2,h}^i; e_{H,h}^i\right)}{R^{H-h}}\right]}_{\frac{2}{R^2}\sum_{k=h+3}^{H} \frac{\mathrm{Cov}_i\left(e_{h+2,h}^i; e_{k,h}^i\right)}{R^{k-h}}}$$

and so on, with the number of covariance terms decreasing each time. For $H-1$ there is only one covariance term left

$$\frac{2}{R^{H-h-1}}\left[\frac{\mathrm{Cov}_i\left(e_{H-1,h}^i; e_{H,h}^i\right)}{R^{H-h}}\right] = \frac{2}{R^{H-h-1}}\sum_{k=H}^{H} \frac{\mathrm{Cov}_i\left(e_{H-1,h}^i; e_{k,h}^i\right)}{R^{k-h}}$$

Summing all of the above gives

$$\begin{aligned}
\mathrm{Var}_i\left(\mathcal{E}_h^i\right) &= \sum_{j=h+1}^{H}\frac{\mathrm{Var}_i\left(e_{j,h}^i\right)}{R^{2(j-h)}}+\frac{2}{R}\sum_{k=h+2}^{H}\frac{\mathrm{Cov}_i\left(e_{h+1,h}^i;e_{k,h}^i\right)}{R^{k-h}}+\frac{2}{R^2}\sum_{k=h+3}^{H}\frac{\mathrm{Cov}_i\left(e_{h+2,h}^i;e_{k,h}^i\right)}{R^{k-h}}\\
&+ \cdots+\frac{2}{R^{H-h-2}}\sum_{k=H-1}^{H}\frac{\mathrm{Cov}_i\left(e_{H-2,h}^i;e_{k,h}^i\right)}{R^{k-h}}+\frac{2}{R^{H-h-1}}\sum_{k=H}^{H}\frac{\mathrm{Cov}_i\left(e_{H-1,h}^i;e_{k,h}^i\right)}{R^{k-h}}\\
&= \sum_{j=h+1}^{H}\frac{\mathrm{Var}_i\left(e_{j,h}^i\right)}{R^{2(j-h)}}+2\sum_{j=h+1}^{H-1}\frac{1}{R^{j-h}}\sum_{k=j+1}^{H}\frac{\mathrm{Cov}_i\left(e_{j,h}^i;e_{k,h}^i\right)}{R^{k-h}}
\end{aligned}$$

A.2 Measurement Error

Let $\tilde{e}_{j,h}^i = e_{j,h}^i + e_{j,h}^{0,i}$ be the measured forecast error made by the age h individual i in predicting age j income. This is the sum of the true forecast error, $e_{j,h}^i$, and the measurement error $e_{j,h}^{0,i}$. Then the measured variance of the forecast error of permanent income is

$$\begin{aligned}
\tilde{\mathrm{V}}\mathrm{ar}_s\left(\mathcal{E}_h^i\right) &= \sum_{j=h+1}^{H}\frac{\mathrm{Var}_s\left(e_{j,h}^i\right)}{R^{2(j-h)}}+\sum_{j=h+1}^{H}\frac{\overbrace{\mathrm{Var}_s\left(e_{j,h}^{0,i}\right)}^{=\sigma_{0,h}^2 \text{ by homoskedasticity}}}{R^{2(j-h)}}+\sum_{j=h+1}^{H}\frac{\overbrace{\mathrm{Cov}_s\left(e_{j,h}^i,e_{j,h}^{0,i}\right)}^{=0 \text{ uncorr. with true error}}}{R^{2(j-h)}}\\
&+ 2\sum_{j=h+1}^{H-1}\frac{1}{R^{j-h}}\sum_{k=j+1}^{H}\frac{\mathrm{Cov}_s\left(e_{j,h}^i;e_{k,h}^i\right)}{R^{k-h}}+2\sum_{j=h+1}^{H-1}\frac{1}{R^{j-h}}\sum_{k=j+1}^{H}\frac{\overbrace{\mathrm{Cov}_s\left(e_{j,h}^{0,i};e_{k,h}^{0,i}\right)}^{=0 \text{ uncorr. over time}}}{R^{k-h}}\\
&+ 2\sum_{j=h+1}^{H-1}\frac{1}{R^{j-h}}\sum_{k=j+1}^{H}\frac{\overbrace{\mathrm{Cov}_s\left(e_{j,h}^{0,i};e_{k,h}^i\right)}^{=0 \text{ uncorr. with true error}}}{R^{k-h}}+2\sum_{j=h+1}^{H-1}\frac{1}{R^{j-h}}\sum_{k=j+1}^{H}\frac{\overbrace{\mathrm{Cov}_s\left(e_{j,h}^i;e_{k,h}^{0,i}\right)}^{=0 \text{ uncorr. with true error}}}{R^{k-h}}\\
&= \sum_{j=h+1}^{H}\frac{\mathrm{Var}_s\left(e_{j,h}^i\right)}{R^{2(j-h)}}+\sum_{j=h+1}^{H}\frac{\sigma_{0,h}^2}{R^{2(j-h)}}+2\sum_{j=h+1}^{H-1}\frac{1}{R^{j-h}}\sum_{k=j+1}^{H}\frac{\mathrm{Cov}_s\left(e_{j,h}^i;e_{k,h}^i\right)}{R^{k-h}}\\
&= \mathrm{Var}_s\left(\mathcal{E}_h^i\right)+\sum_{j=h+1}^{H}\frac{\sigma_{0,h}^2}{R^{2(j-h)}}
\end{aligned}$$

Since the term $\sum_{j=h+1}^{H}\frac{\sigma_{0,h}^2}{R^{2(j-h)}}$ is constant across sectors for a fixed h, the distribution of variances of forecast errors of permanent income across sectors is unaffected by the measurement error, except for the mean which increases by exactly $\sum_{j=h+1}^{H}\frac{\sigma_{0,h}^2}{R^{2(j-h)}}$. However, it is the variation across sectors, which is not affected, that is exploited in the main empirical exercise of the paper.

A.3 Zero Earnings Observations

To estimate government transfers as a function of labor income I first remove from (head and wife total) government transfers the part that is predictable by demographics. To that end I estimate the following specification on the pooled sample:

$$government\ transfer = \alpha_0 + \boldsymbol{\alpha}_1 \mathbf{X} + u$$

where $\mathbf{X}$ is a vector of observables including employment status, marital status, family size, race, a cubic age polynomial and year dummies. I then project the residual u on labor income:

$$u = \tilde{\alpha}_0 + \tilde{\alpha}_1 \times labor\ earnings + \epsilon_t$$

and set annual labor earnings for zero earnings observations equal to $\tilde{\alpha}_0$. Additionally, I use the results above to impute earnings for observations with positive annual earnings smaller than \$200, which are likely to be measured with error.

A.4 Sector Definition

A sector s is an industry-occupation pair. There are 8 industry groups displayed in the first column of Table 7 and 5 occupation groups listed in the first row of the table. These are aggregated based on the major industries and occupations Census classification. Since the projection equation (7) estimates 13 parameters in its most general specification, there must be at least 14 individuals of each age in each sector. This is why for some industries such as construction or manufacturing occupation groups are aggregated even further. The aggregation is based on the distribution of annual labor earnings as summarized by the coefficient of variation. There is a total of 16 sectors in Table 7. An additional sector, which is an exception from the industry-occupation pair rule, is the 'unemployment sector', containing all individuals that are unemployed at the time they make the income forecast.

Table 8 summarizes some statistics at sector level. Sectors 5 and 12 are the largest, each covering approximately 14% or the sample, while sectors 2 and 15 are the smallest with only 3% of respondents. In light of this discrepancy, it is worth pointing out that sector 12 is at its maximum level of disaggregation, while an alternative disaggregation of sector 5 is not supported by the 'coefficient of variation' criterion. Annual labor earnings are highest in sector 4 and, not surprisingly, lowest for the unemployed.

Lastly, Table 9 reports the number of individuals in each age-sector cell.

Table 7: Sector definition

<table>
<tr><th>Industry/Occupation</th><th>Executive and professional specialty occ.</th><th>Technicians and admin. support</th><th>Sales and services occ.</th><th>Production operators, fabricators, laborers</th><th>Farming, forestry and fishing occ.</th></tr>
<tr><td>Agriculture and Mining</td><td colspan="5">Sector 1</td></tr>
<tr><td>Construction</td><td colspan="3">Sector 2</td><td>Sector 3</td><td></td></tr>
<tr><td>Manufacturing</td><td>Sector 4</td><td>Sector 5</td><td>Sector 4</td><td>Sector 5</td><td></td></tr>
<tr><td>Transp. and Utilities</td><td colspan="2">Sector 6</td><td colspan="2">Sector 7</td><td></td></tr>
<tr><td>Trade</td><td>Sector 8</td><td>Sector 9</td><td>Sector 10</td><td>Sector 9</td><td></td></tr>
<tr><td>Finance</td><td colspan="4">Sector 11</td><td></td></tr>
<tr><td>Services</td><td>Sector 12</td><td>Sector 13</td><td>Sector 14</td><td>Sector 15</td><td></td></tr>
<tr><td>Public administration</td><td colspan="4">Sector 16</td><td></td></tr>
</table>

Notes: Table entries are labels allocated to each sector. The unemployment sector is labeled Sector 0.

Table 8: Sector statistics

Sector/Statistic	Percentage of sample (%)	Average age	Average log annual labor earnings	St. dev. of log annual labor earnings
Sector 0	6.38	39	7.92	1.84
Sector 1	4.47	41	9.95	1.12
Sector 2	2.81	42	10.49	0.94
Sector 3	5.91	38	10.06	0.93
Sector 4	6.35	42	10.87	0.72
Sector 5	14.01	40	10.28	0.71
Sector 6	4.04	41	10.69	0.67
Sector 7	4.90	41	10.36	0.81
Sector 8	4.50	40	10.46	0.92
Sector 9	4.80	39	10.03	0.79
Sector 10	5.38	39	9.97	0.99
Sector 11	5.03	41	10.51	0.91
Sector 12	13.83	41	10.55	0.88
Sector 13	3.97	39	10.07	0.79
Sector 14	4.57	41	9.63	1.01
Sector 15	2.98	40	9.98	0.89
Sector 16	6.07	40	10.52	0.69

A.5 Consumption Imputation Procedure

I impute total consumption in the PSID by using the data available in the CEX. Variations of this technique have been used several times in the literature (for example Skinner (1987) and Ziliak (1998)). Here, I follow the strategy of Blundell, Pistaferri and Preston (2008) who

Table 9: Number of observations

Age/Sector	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
22	191	76	14	154	33	317	45	61	64	133	187	58	96	97	124	63	63
23	247	99	22	190	72	400	61	92	78	180	234	115	208	131	157	84	113
24	295	134	41	225	111	479	83	123	106	202	262	156	318	167	162	100	153
25	322	146	61	257	154	529	94	136	134	217	287	176	371	177	184	113	175
26	305	154	70	269	186	563	116	146	146	246	259	185	443	187	191	120	188
27	281	148	83	277	188	564	126	181	188	213	239	197	501	196	191	113	205
28	274	173	85	286	197	565	138	192	190	208	218	201	541	203	199	126	207
29	269	172	98	275	218	553	150	190	190	199	238	203	522	202	197	122	225
30	262	167	113	270	230	571	140	213	193	210	197	208	527	184	191	117	242
31	285	178	110	280	246	550	155	193	203	195	200	189	554	165	164	117	243
32	263	169	109	274	246	580	167	195	209	188	193	184	579	150	157	103	250
33	240	163	116	259	243	582	168	207	201	197	182	190	559	145	155	107	251
34	244	154	117	237	252	541	166	201	177	196	203	188	532	135	169	126	256
35	225	168	126	238	245	533	166	184	196	195	189	176	547	124	156	130	253
36	220	154	138	221	255	510	159	201	200	184	182	182	534	135	152	101	247
37	238	154	130	210	255	509	159	186	183	167	187	177	504	130	139	118	252
38	211	155	107	226	249	499	170	174	171	163	179	162	530	136	135	110	260
39	222	146	107	196	257	485	173	181	159	173	165	167	516	129	133	108	253
40	196	151	120	183	257	490	162	183	167	167	157	167	514	123	130	112	251
41	177	147	118	172	255	494	160	160	173	173	148	172	497	122	126	128	242
42	176	151	108	198	254	470	158	167	164	162	147	164	493	113	125	113	230
43	190	147	94	202	252	451	149	167	152	148	137	173	480	96	132	110	223
44	175	139	97	193	257	438	144	178	148	138	133	175	478	106	122	102	218
45	172	143	102	180	234	441	146	178	142	136	130	164	473	102	125	96	227
46	169	141	95	175	235	438	136	168	152	131	141	164	470	95	126	78	212
47	166	137	85	163	232	428	139	169	158	124	130	167	454	88	120	71	207
48	158	138	88	148	214	421	139	159	148	127	135	158	429	100	121	74	201
49	164	131	87	138	197	408	132	162	135	121	138	156	410	110	112	72	196
50	137	118	88	152	205	392	127	154	119	104	129	139	415	95	126	66	194
51	131	117	89	141	201	381	119	148	121	100	114	123	407	91	126	62	185
52	132	119	84	130	195	364	113	153	98	95	124	119	385	97	107	59	166
53	119	122	77	122	168	356	108	139	88	82	125	123	371	93	107	70	145
54	135	117	74	113	163	325	104	121	87	85	128	126	350	84	100	65	130
55	148	114	70	100	168	298	96	116	78	83	123	120	337	84	100	61	125
56	126	115	62	89	153	274	91	109	70	84	119	113	328	74	114	59	117
57	101	103	64	89	139	256	81	104	69	85	112	112	308	86	112	61	105
58	85	103	59	89	123	243	78	86	73	77	107	108	282	84	111	53	101
59	115	91	48	82	108	228	75	73	69	69	106	104	269	67	110	53	84
60	105	91	47	74	100	201	62	62	60	73	88	89	240	66	104	49	82
61	94	87	47	62	79	184	40	55	54	66	83	82	210	62	99	49	57
62	88	68	34	49	74	149	37	47	57	51	79	70	160	61	79	42	57
63	83	57	27	34	56	120	35	38	50	50	69	61	132	51	69	35	42
64	76	52	25	32	45	84	28	28	43	42	59	55	118	44	63	31	28
65	62	40	21	18	32	50	13	21	33	29	48	39	95	29	57	25	20

Notes: Table entries are number of observations in each age-sector cell.

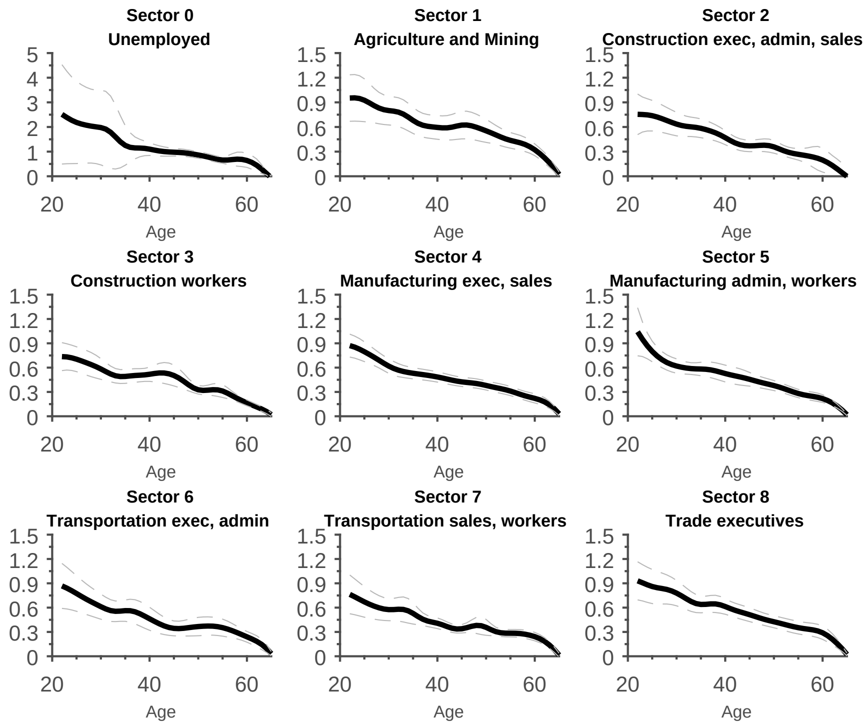

Figure 8: Age Profile of Relative Income Uncertainty - by sector

Notes: The detailed definition of sectors is in Table 7 in Appendix A. In each graph, the solid black line is the relative permanent income uncertainty in the secotor and the dashed gray lines represent the 95% bootstrapped confidence interval.

estimate the demand for food (available in both surveys) as a function of total consumption, relative prices and household characteristics using the data in CEX, and then invert it to obtain a measure of total consumption in the PSID.

The first step in the imputation procedure is the estimation of the food demand function for individual i at time t:

$$f_{i,t} = Z'_{i,t}\delta + p'_t\theta + \beta\left(D_{i,t}\right)C_{i,t} + \epsilon_{i,t}$$

where f is the log of real food expenditure, Z is a set of household characteristics available in both surveys (a quadratic term in age, education, region, cohort, number of children and race dummies, family size), p is a set of prices (of food, alcohol and tobacco, transport, fuel and utilities), C is the log of total consumption expenditure and ϵ is the error term. The elasticity $\beta\left(\cdot\right)$ is allowed to vary with observed household characteristics. To account for potential measurement error in total expenditure, the latter is instrumented with the

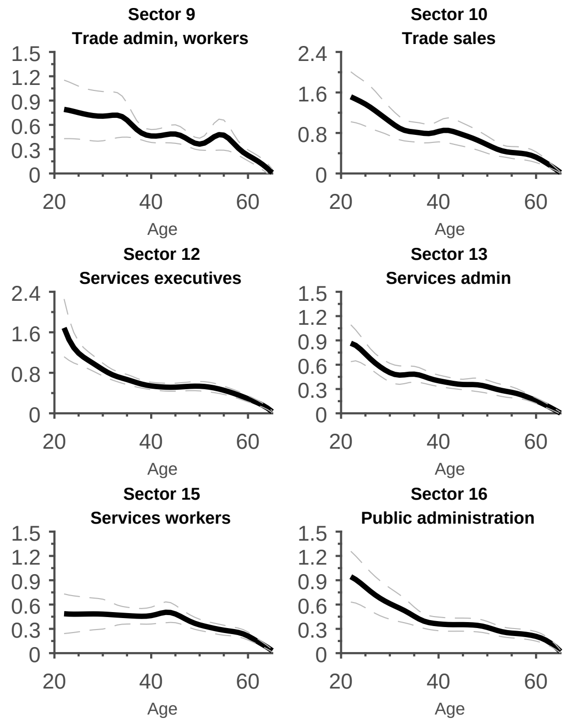

Figure 9: Age Profile of Relative Income Uncertainty - by sector (cont.)

Notes: The detailed definition of sectors is in Table 7 in Appendix A. In each graph, the solid black line is the relative permanent income uncertainty in the secotor and the dashed gray lines represent the 95% bootstrapped confidence interval.

average hourly wages of the husband and the wife by cohort, year and education level. In both surveys food expenditure is the sum of annual expenditure on food at home and away from home.

In the second step of the imputation procedure, under the assumption of normality of food demand, the function can be inverted to obtain a measure of non-durable and total consumption in the PSID. The food demand is estimated with the sample of CEX male heads with ages between 22 and 80, born between 1921 and 1970. The imputation is done on a similarly constructed PSID sample, which does not include the SEO, immigrants and Latino sub-sample. The latter are excluded to avoid selection issues and allow a one to one mapping between the age profile of savings and the lifetime profile of income uncertainty previously constructed. Since CEX data is only available starting 1980, I am able to construct the PSID measure of total consumption from 1981 until 2003 (calendar years 1980-2002), with breaks in 1988 and 1989 when PSID did not collect information of food expenditure. When inverting the food demand equation, I set the constant term so that the average savings rate in the PSID matches the average savings rate reported in the NIPA Tables for the same horizon of 8.2%.

Savings are defined as after-tax income less consumption expenditure. After-tax income is constructed as total family money income less federal income taxes. Total family money income includes the taxable income and transfers of all members. The taxable income covers labor and asset income. Transfers are not removed from family income because for part of the survey years it is impossible to separate social security income from other forms of transfers (e.g. children aid for unemployed parents). In constructing disposable income I face the complication that PSID stopped determining taxes paid in 1991. To calculate taxes owed for calendar years 1991 – 2010 (survey years 1992 – 2011) I use TAXSIM with PSID variables as inputs.

A.6 Uncertainty estimation (extra)

I estimate the projection equation (7) at the sector level using log annual labor earnings of the head as the dependent variable. That is, for each sector s and for all $h < j$ I run the following regression

$$\ln y_j^i = \underbrace{\tilde{\theta}_0 + \tilde{\boldsymbol{\theta}}_1 \mathbf{X}_h^i + \tilde{\theta}_3 \boldsymbol{t}_j}_{\ln \hat{y}_{j,h}^i} + \varepsilon_{j,h}^i, \tag{15}$$

where the contents of $\mathbf{X}_h^i$ and $\boldsymbol{t}_j$ are as previously described. The residuals $\varepsilon_{j,h}^i$ are used to construct the forecast errors $e_{j,h}^i$ from equation (7) according to[72]

$$e_{j,h}^i = \exp\left(\ln \hat{y}_{j,h}^i\right)\left(\exp\left(\varepsilon_{j,h}^i\right) - 1\right). \tag{16}$$

The forecast errors $e_{j,h}^i$ are then used to compute the permanent income uncertainty measure as described in equation (6), using a gross interest rate R of 1.04 for discounting.

Because the uncertainty measure defined in equation (6) is unit of measurement dependent (in particular, $\text{Std}_s\left(\mathcal{E}_h^i\right)$ is measured in US dollars), I report the standard deviation of the forecast error divided by expected permanent income, $\hat{Y}_{h,s}$. Expected permanent income is calculated as

$$\hat{Y}_{h,s} = \sum_{j=h}^{H} \frac{\mathbb{E}_s\left(y_j^i | \mathcal{I}_h^i\right)}{R^{j-h}} = \sum_{j=h}^{H} \frac{\hat{y}_{j,h}}{R^{j-h}}, \tag{17}$$

where $\hat{y}_{j,h}$ is defined in equation (7) and H is set to 80. Individuals between 66 and 80 years

[72]If $y = \hat{y} + e$ and $\ln y = \ln \hat{y} + \varepsilon$, then $e = y - \hat{y} = \exp(\ln y) - \exp(\ln \hat{y}) = \exp(\ln \hat{y} + \varepsilon) - \exp(\ln \hat{y}) = \exp(\ln \hat{y})(\exp(\varepsilon) - 1)$.

old are treated as retired and thus not subject to labor income risk.[73] Their income stream is given by the social security income of the head.[74]

Figure 10 displays the coefficient of variation across sectors, by age, of the level of permanent income uncertainty in gray and the 1-year change in permanent income uncertainty in black for the baseline information set. Variation across sectors in the level of income risk is roughly constant across age groups, averaging at 36% and suggesting that level differences in risk between different sectors are an important source of identification at all ages. For the slopes of the permanent income risk the average over age is 22%. There is little variation across sectors in the speed at which uncertainty resolves in the twenties, suggesting that rapid resolution of uncertainty early in the career is a feature common to all industries and occupations.

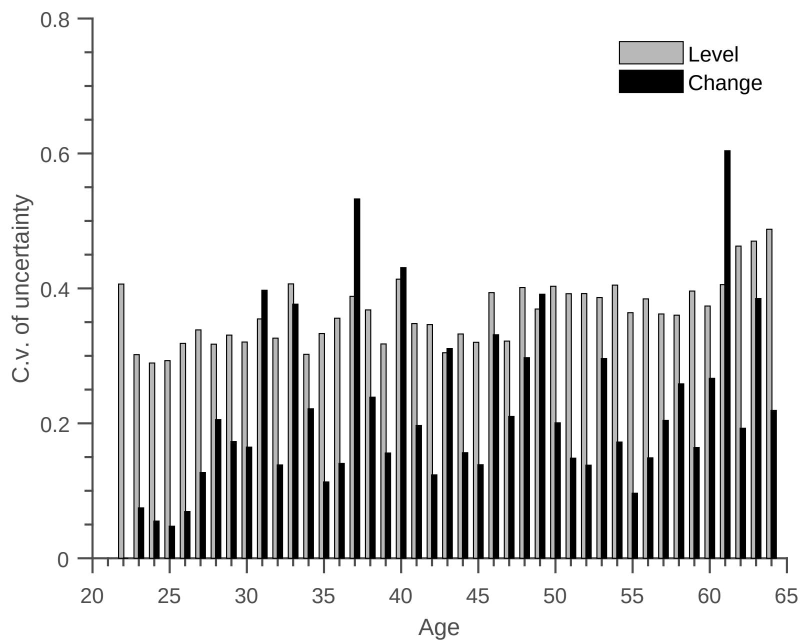

Figure 10: Coefficient of Variation of Income Uncertainty across Sectors, by Age

Notes: The gray bars represent the coefficient of variation of permanent income risk as defined in equation (6) across the 17 sectors, by age. The black bars represent the coffiecient of variation of the 1-year change in permanent income uncertainty calculated as the ratio between the permanent income risk at age h and permanent income risk at age $h-1$.

[73] 77% of the entries of age between 66 and 80 years old are retired. The rest of 23% are either employed or unemployed.

[74] A retired individual is assigned to the sector in which he last worked before retirement age.

A.7 Additional Empirical Results

A.7.1 Age profile of consumption (extra)

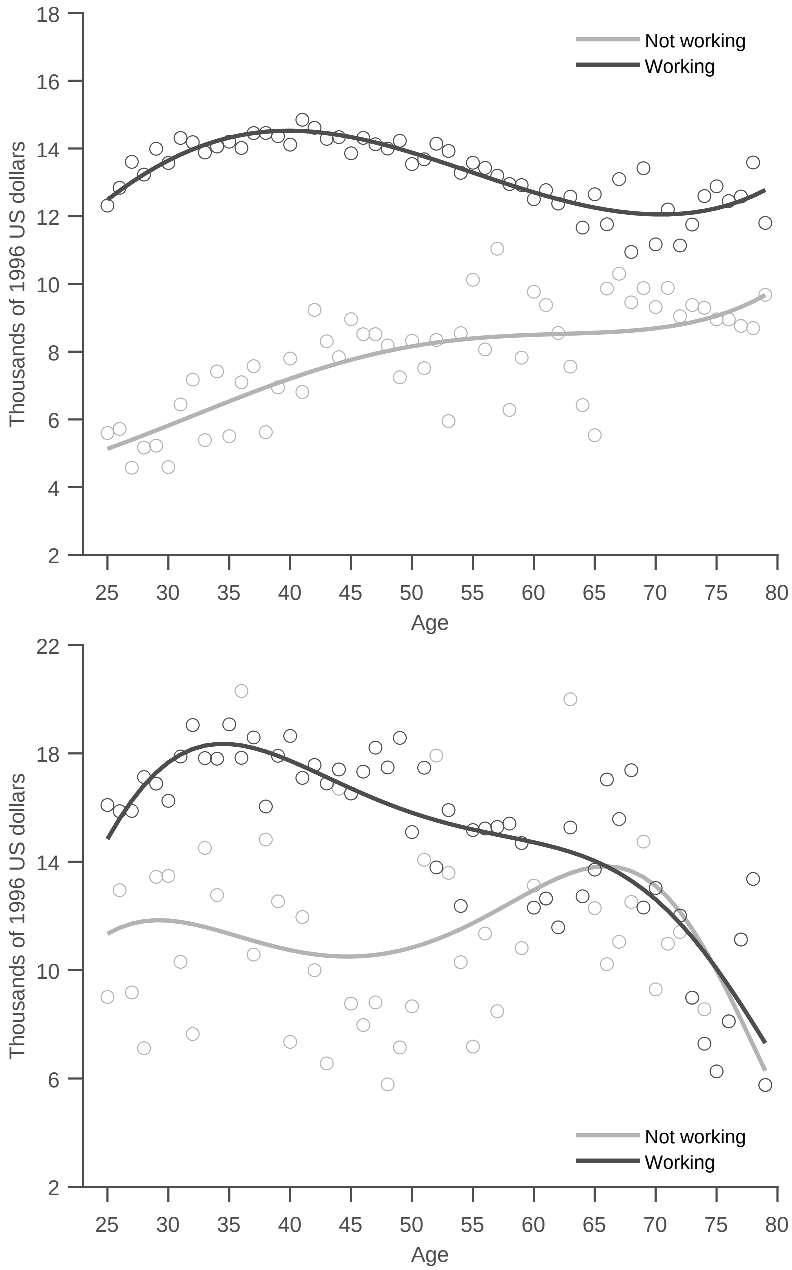

Figure 11: Age Profile of Consumption Expenditure of Parents

Notes: The figure shows the age profile of consumption of non-durables and services for employed parents in the dark gray solid line and non-employed parents in the light gray solid line. The scatter plot is the nonparametric profile.

A.7.2 Back of the envelope calculation

The left panel of Figure 12 shows how dynastic uncertainty varies with the age of the child, for three children: a services worker, a construction worker and a financier. Irrespective of age, services workers have the lowest income risk among the three categories. Construction workers face higher income uncertainty, but the speed of resolution is slightly higher than that of services workers. Lastly, individuals in the finance sector have the highest level of income risk and very little of it is resolved over time. The differences in parental consumption (of non-durables and services) implied by the estimates in Table 1 are plotted in the right panel of Figure 12. For every age of the child, the consumption of the parent of the services worker is normalized to zero, and the consumption of the other two parents is expressed relative to his consumption.

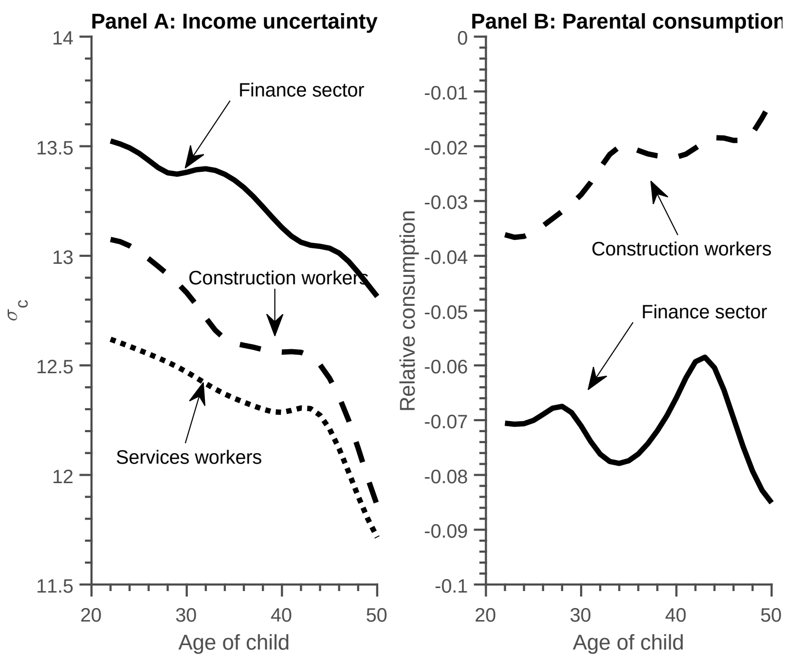

Figure 12: Regression Implied Consumption Gap

A.7.3 Response to income uncertainty by wealth

A natural question to ask, which has implications for issues like intergenerational mobility, is whether dynastic precautionary saving occurs throughout the income distribution, or is it just the rich parents who can provide such a security blanket for their children. To explore this, I stratify children and parents in wealth quartiles, where (with a slight abuse of languange) wealth is the sum between their permanent income (as defined in equation (17)) and wealth holdings. I then estimate a new version of equation (9), which includes interaction terms between dynastic uncertainty and the parent's wealth quartile in columns (1)-(4) of Table 10 and between dynastic uncertainty and the child's wealth quartile in columns (5)-(8). The strength of the dynastic precautionary saving motive is quite stable across both the parent and the child's wealth distribution, with no two estimates being statistically different.

Table 10: Response of Parental Consumption to Income Uncertainty by Wealth

	Parent's wealth quartile				Child's wealth quartile			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Parent's uncertainty	-0.081* (0.041)				-0.088** (0.042)			
Child's uncertainty	-0.086** (0.038)	-0.075* (0.038)	-0.070* (0.038)	-0.070* (0.038)	-0.099** (0.040)	-0.098** (0.040)	-0.095** (0.039)	-0.089** (0.039)

Notes: Table entries are coefficient estimates from equation (9). The dependent variable is parental consumption of non-durables and services. Wealth is defined as the sum of expected permanent income and wealth holdings. Bootstrapped standard errors clustered at parent level are in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

A.7.4 Robustness

Health status and selection into risky sectors

Table 11: Importance of Health and Selection

	Baseline (1)	Only health controls (2)	Only selection controls (3)	Health and selection controls (4)
Parent's uncertainty	-0.082* (0.044)	-0.071* (0.039)	-0.067* (0.037)	-0.055* (0.032)
Child's uncertainty	-0.079** (0.037)	-0.063 (0.039)	-0.085** (0.034)	-0.073** (0.036)

Notes: Table entries are estimates of the effect of permanent income uncertainty on total parental consumption. Column (1) reproduces the estimates in Table 1. Column (2) reports the estimates when the parent's and child's health status is included in the set of controls. Column (3) shows results controlling for the child's initial sector and excluding self-employed children. Column (4) shows estimates when simultaneously controlling for health status, initial sector and excluding self-employed children from the sample. Bootstrapped standard errors clustered at parent level are in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Heterogeneity of the bequest motive

Table 12: Importance of the Bequest Motive

	Baseline (1)	Child's uncertainty × Number of children (2)	Append non-parents (3)
Parent's uncertainty	-0.082* (0.044)	-0.072 (0.045)	-0.093*** (0.023)
Child's uncertainty	-0.079** (0.037)	−−	-0.081** (0.038)
Child's uncertainty $\times \mathbf{1}_{\{n=1\}}$	−−	-0.075** (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n=2\}}$	−−	-0.080** (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n=3\}}$	−−	-0.082** (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n=4\}}$	−−	-0.074** (0.037)	−−
Child's uncertainty $\times \mathbf{1}_{\{n\geq 5\}}$	−−	-0.100** (0.037)	−−

Notes: Table entries are coefficient estimates of the effect of permanent income uncertainty on parent's total consumption. Column (1) reproduces the estimates in Table 1. Column (2) reports estimates of β_1^p and of β_2^p by number of children. Column (3) shows estimates when non-parents are added to the baseline sample, allowing for different intercepts. Bootstrapped standard errors clustered at parent level are in parenthesis. * significant at 10%; ** significant at 5%; *** significant at 1%

B Appendix for the Quantitative Model

B.1 Equilibrium of the model with strategic interactions

I discuss the equilibrium properties in a simplified version of the model in the main text, in which parents and children overlap for two periods only, as in Figure 13. I focus the discussion on interior solutions, at which first order conditions can be used to characterize the optimum. For expositional purposes only, in I keep track of g_p as a separate state variable in the child's problem, but what matters for the child is cash-on-hand $Ra_c + g_p$, and not its origin. For added notational simplicity, assume there is no distiction between sectors. In the full model, this acts towards adding more uncertainty (on top of income uncertainty), thus smoothing payoff functions.

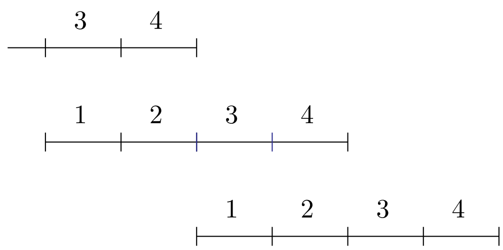

Figure 13: Simple Lifecycle Structure

I now discuss the equations that characterize the decision problems of the two possible parent-child pairs backwards: an age-4 parent with an age-2 child, and an age-3 parent with an age-1 child.

Age-4 parent with age-2 child

In the parent's terminal period, the problem of the child (second stage) is:

$$\begin{aligned} V^c\left(2, a_c, y_c, g_p, a_p'\right) \quad &= \quad \max_{c_c, a_c'} u\left(c_c\right) + \beta \mathbb{E} V^p\left(3, a_p' + a_c', 0, y_p', y_c'\right) && (1) \\ \text{s.t.} \quad & \quad c_c + a_c' = y_c + R a_c + g_p && (2) \\ & \quad a_c' \geq 0, && (3) \end{aligned}$$

where $\mathbb{E}$ denotes the expectation operator over all possible future income realizations of y_p' conditional on y_c (next period the child becomes a parent) and of y_c' conditional on y_p'. The first order condition is

$$u'\left(c_c\right) = \beta \mathbb{E} V_2^p\left(3, a_p' + a_c', 0, y_p', y_c'\right) + \lambda_{a_c}, \tag{4}$$

where $\lambda_{a_c} \geq 0$ is the multiplier on the borrowing constraint and V_2^p denotes the derivative of the value function with respect to its second argument. The optimal policy functions are $c_c^\star\left(2, a_c, y_c, g_p, a_p'\right)$ and $a_c'^\star\left(2, a_c, y_c, g_p, a_p'\right)$. This is the standard condition that states that savings are chosen to equate the marginal cost of forgone current consumption with the marginal benefit of having an extra unit of resources available in the following period.

In the first stage, the parent solves

$$\begin{aligned}
V^{p}\left(4, a_{p}, a_{c}, y_{p}, y_{c}\right) &= \max_{c_{p}, a_{p}^{\prime}, g_{p}} u\left(c_{p}\right)+\gamma u\left(c_{c}^{\star}\left(2, a_{c}, y_{c}, g_{p}, a_{p}^{\prime}\right)\right) \\
&+ \beta \gamma \mathbb{E} V^{p}\left(3, a_{p}^{\prime}+a_{c}^{\prime \star}\left(2, a_{c}, y_{c}, g_{p}, a_{p}^{\prime}\right), 0, y_{p}^{\prime}, y_{c}^{\prime}\right) && (5) \\
\text{s.t.} \quad & c_{p}+a_{p}^{\prime}+g_{p}=y_{p}+R a_{p} && (6) \\
& a_{p}^{\prime} \geq 0, g_{p} \geq 0, && (7)
\end{aligned}$$

given that the child sets $u^{\prime}\left(c_{c}^{\star}\left(2, a_{c}, y_{c}, g_{p}, a_{p}^{\prime}\right)\right)=\beta \mathbb{E} V_{2}^{p}\left(3, a_{p}^{\prime}+a_{c}^{\prime \star}\left(2, a_{c}, y_{c}, g_{p}, a_{p}^{\prime}\right), 0, y_{p}^{\prime}, y_{c}^{\prime}\right)+\lambda_{a_{c}}$ in the second stage. The resulting optimal policy functions are $a_{p}^{\prime \star}\left(4, a_{p}, a_{c}, y_{p}, y_{c}\right)$, $g_{p}^{\star}\left(4, a_{p}, a_{c}, y_{p}, y_{c}\right)$ and $c_{p}^{\star}\left(4, a_{p}, a_{c}, y_{p}, y_{c}\right)$.

The first order condition with respect to $a_{p}^{\prime}$ is:

$$u^{\prime}\left(c_{p}\right) = \gamma u^{\prime}\left(c_{c}^{\star}\right) \frac{\partial c_{c}^{\star}}{\partial a_{p}^{\prime}}+\beta \gamma \mathbb{E} V_{2}^{p}\left(3, a_{p}^{\prime}+a_{c}^{\prime \star}, 0, y_{p}^{\prime}, y_{c}^{\prime}\right)\left(1+\frac{\partial a_{c}^{\prime \star}}{\partial a_{p}^{\prime}}\right)+\lambda_{a_{p}}, \tag{8}$$

where $\lambda_{a_{p}}$ is the multiplier on the borrowing constraint. From the child's budget constraint we have $\frac{\partial c_{c}^{\star}}{\partial a_{p}^{\prime}}=-\frac{\partial a_{c}^{\prime \star}}{\partial a_{p}^{\prime}}$, so the above becomes

$$\begin{aligned}
u^{\prime}\left(c_{p}\right) &= \beta \gamma \mathbb{E} V_{2}^{p}\left(3, a_{p}^{\prime}+a_{c}^{\prime \star}, 0, y_{p}^{\prime}, y_{c}^{\prime}\right)+\lambda_{a_{p}} \\
&+ \gamma \frac{\partial c_{c}^{\star}}{\partial a_{p}^{\prime}} \underbrace{\left[u^{\prime}\left(c_{c}^{\star}\right)-\beta \mathbb{E} V_{2}^{p}\left(3, a_{p}^{\prime}+a_{c}^{\prime \star}, 0, y_{p}^{\prime}, y_{c}^{\prime}\right)\right]}_{\text{standard optimality condition of child}} .
\end{aligned} \tag{9}$$

In the terminal period, the parent sets the size of the bequest to equate the marginal cost from lower consumption with the marginal benefit from providing the child with an extra unit of resources in the beginning of parenthood. If the child is unconstrained, then the term in the brackets of equation (9) vanishes, and the standard optimality condition for savings (here bequest) holds. If the child is constrained, then there is an additional benefit from higher parental bequest that measures the net marginal utility for the parent when the child increases current consumption in response to higher parental savings in the current period.

The first order condition with respect to g_{p} is:

$$u^{\prime}\left(c_{p}\right) = \gamma u^{\prime}\left(c_{c}^{\star}\right) \frac{\partial c_{c}^{\star}}{\partial g_{p}}+\beta \gamma \mathbb{E} V_{2}^{p}\left(3, a_{p}^{\prime}+a_{c}^{\prime \star}, 0, y_{p}^{\prime}, y_{c}^{\prime}\right) \frac{\partial a_{c}^{\prime \star}}{\partial g_{p}}+\lambda_{g}, \tag{10}$$

where $\lambda_{g_{p}}$ is the multiplier on the non-negativity of transfers constraint. From the child's budget constraint we have $\frac{\partial c_c^\star}{\partial g_p} = 1 - \frac{\partial a_c'^\star}{\partial g_p}$, so the above becomes

$$u'\left(c_p\right) \;=\; \gamma u'\left(c_c^\star\right) - \gamma \frac{\partial a_c'^\star}{\partial g_p} \underbrace{\left[u'\left(c_c^\star\right) - \beta \mathbb{E} V_2^p\left(3, a_p' + a_c'^\star, 0, y_p', y_c'\right)\right]}_{\text{standard optimality condition of child}} + \lambda_g. \tag{11}$$

The properties of the parent's transfer function are discussed after characterizing the equilibrium allocation for the pair in which the parent is age 3 and the child is age 1.

Age-3 parent with age-1 child

In the first period, the problem of the child (second stage) is:

$$\begin{aligned} V^c\left(1, a_c, y_c, g_p, a_p', y_p\right) \;&=\; \max_{c_c, a_c'} u\left(c_c\right) \\ &+\; \beta \mathbb{E} V^c\left(2, a_c', y_c', g_p^\star\left(4, a_p', a_c', y_p', y_c'\right), a_p'^\star\left(4, a_p', a_c', y_p', y_c'\right)\right) && (12) \\ \text{s.t.} \;\; & c_c + a_c' = y_c + R a_c + g_p && (13) \\ & a_c' \geq 0, && (14) \end{aligned}$$

where $\mathbb{E}$ denotes the expectation operator over all possible future income realizations of y_p' conditional on y_p and of y_c' conditional on y_c. The first order condition is

$$u'\left(c_c\right) = \beta \mathbb{E} V_2^c\left(2, a_c', y_c', g_p^\star, a_p'^\star\right) + \beta \mathbb{E} V_4^c\left(2, a_c', y_c', g_p^\star, a_p'^\star\right) \frac{\partial g_p^\star}{\partial a_c'} + \beta \mathbb{E} V_5^c\left(2, a_c', y_c', g_p^\star, a_p'^\star\right) \frac{\partial a_p'^\star}{\partial a_c'} + \lambda_{a_c}, \tag{15}$$

where $\lambda_{a_c} \geq 0$ is the multiplier on the borrowing constraint and V_n^c denotes the derivative of the child's value function with respect to its n^{th} argument. At an interior solution, this can be further written as

$$u'\left(c_c\right) = \beta R \mathbb{E} u'\left(c_c'\right) + \underbrace{\beta\left[\mathbb{E} u'\left(c_c'\right) \frac{\partial g_p^\star}{\partial a_c'} + \beta \mathbb{E} V_2^p\left(3, a_p'^\star + a_c'^\star, 0, y_p'', y_c''\right) \frac{\partial a_p'^\star}{\partial a_c'}\right]}_{\text{taxation of child savings by parent/disincentive to save}}. \tag{16}$$

The term in the brackets of equation (16) illustrates the strategic interactions that appear in this setting: the parent "taxes" savings of children by reducing inter-vivos transfers and own saving when the child saves more. This decreases the marginal benefit of saving for the child and induces him to over-consume relative to a setting with full commitment (i.e. a setting without the term in the brackets of equation (16)).

In the first stage, the age 3 parent solves

$$\begin{aligned} V^p(3, a_p, a_c, y_p, y_c) &= \max_{c_p, a_p', g_p} u(c_p) + \gamma u\left(c_c^\star\left(1, a_c, y_c, g_p, a_p'\right), y_p\right) \\ &+ \beta \mathbb{E} V^p\left(4, a_p', a_c'^\star\left(1, a_c, y_c, g_p, a_p', y_p\right), y_p', y_c'\right) \qquad (17) \\ \text{s.t.} \quad & c_p + a_p' + g_p = y_p + R a_p \qquad (18) \\ & a_p' \geq 0, g_p \geq 0, \qquad (19) \end{aligned}$$

given that $c_c^\star\left(1, a_c, y_c, g_p, a_p', y_p\right)$ and $a_c'^\star\left(1, a_c, y_c, g_p, a_p', y_p\right)$ satisfy the child's first order condition and budget constraint previously discussed.

The first order condition with respect to a_p' is:

$$\begin{aligned} u'(c_p) &= \gamma u'(c_c^\star) \frac{\partial c_c^\star}{\partial a_p'} + \beta \mathbb{E} V_2^p\left(4, a_p', a_c'^\star\left(1, a_c, y_c, g_p, a_p', y_p\right), y_p', y_c'\right) \\ & + \beta \mathbb{E} V_3^p\left(4, a_p', a_c'^\star\left(1, a_c, y_c, g_p, a_p', y_p\right), y_p', y_c'\right) \frac{\partial a_c'^\star}{\partial a_p'} + \lambda_{a_p}, \qquad (20) \end{aligned}$$

where λ_{a_p} is the multiplier on the borrowing constraint and V_n^p denotes the derivative of the parent's value function with respect to its n^{th} argument. At an interior solution, this can be further written as[75]

$$u'(c_p) = \beta R \mathbb{E} u'\left(c_p'\right) + \gamma \frac{\partial c_c^\star}{\partial a_p'} \underbrace{\left[u'(c_c^\star) - \beta R \mathbb{E} u'(c_c^{\star\prime})\right]}_{\text{standard EE of child}}. \qquad (21)$$

If no transfers occur in the following period and the parent is constrained, then the standard Euler Equation of the child holds, and the parent's choice of savings in characterized by the standard trade-off between the marginal cost of forgone consumption and the marginal benefit of additional resources in the future. With positive transfers, the term in the brackets of equation (21) does not vanish. The first part of this term measures the marginal utility for the parent when the child increases current consumption in response to higher parental savings in the current period due to consumption smoothing. It enters the Euler Equation with a positive sign and is therefore an additional benefit for the parent from saving. Since the child consumes more in response to an increase in parental wealth, he will have less wealth in the following period. This enters the parent's Euler Equation with a negative sign

[75] This step uses three intermediate results: *(i)* the envelope condition in the problem of the age-4 parent $V_2^p\left(4, a_p', a_c'^\star, y_p', y_c'\right) = R u'\left(c_p'\right)$, *(ii)* that $\frac{\partial c_c^\star}{\partial a_p'} + \frac{\partial a_c'^\star}{\partial a_p'} = 0$, which follows from the child's budget constraint and *(iii)* that $V_3^p\left(4, a_p', a_c'^\star, y_p', y_c'\right) = \gamma R u'(c_c^\star)$.

and therefore represents for the parent a disincentive to save.

The parent's first order condition with respect to g_p is:

$$u'\left(c_p\right) \quad = \quad \gamma u'\left(c_c^\star\right)\frac{\partial c_c^\star}{\partial g_p} + \beta\mathbb{E}V_3^p\left(4, a_p', a_c'^\star\left(1, a_c, y_c, g_p, a_p', y_p\right), y_p', y_c'\right)\frac{\partial a_c'^\star}{\partial g_p} + \lambda_g, \tag{22}$$

where λ_{g_p} is the multiplier on the non-negativity of transfers constraint. Using that $\frac{\partial c_c^\star}{\partial g_p} = 1 - \frac{\partial a_c'^\star}{\partial g_p}$, at an interior solution, this can be further written as

$$u'\left(c_p\right) = \gamma u'\left(c_c^\star\right) - \frac{\partial a_c'^\star}{\partial g_p}\gamma\underbrace{\left[u'\left(c_c^\star\right) - \beta\mathbb{E}u'\left(c_c'^\star\right)\right]}_{\text{standard EE of child}}. \tag{23}$$

The properties of the parent's transfer function are discussed in the following subsection.

A heuristic discussion of the properties of the transfer function

Equations (11) and (23) show that as long as the child's savings respond to the parent's transfer (i.e. the child is not borrowing constrained and $\frac{\partial a_c'^\star}{\partial g_p} \neq 0$), then the parent's transfer decision is distorted relative to the first best setup with full commitment (and no strategic interactions). Since the parent makes the first move in the stage game, he can limit the strategic behavior of the child by setting the transfer according to $u'\left(c_p\right) = \gamma u'\left(c_c^\star\right)$, as he would in a setup without the strategic interactions that are operative here.

In terms of equations (11) and (23), this amounts to the parent wanting to set $\frac{\partial a_c'^\star}{\partial g_p} = 0$. In other words, the parent would want to set the transfer such that the child consumes it all and achieves the level of consumption that the parent desires for him. Due to the fact that the child engages in over-consumption, as savings are taxed by the parent through lower future transfers, in this model the only scenario in which the child's consumption is below the parent's desired level of consumption for him is when the child is constrained. Otherwise the child consumes at least as much as the parent would want him to consume, so there is no scope for positive transfers.

Therefore, the parent sets transfers as follows. If in the absence of transfers the child is unconstrained, i.e. $a_c'\left(\cdot, a_c, y_c, 0, a_p'\right) > 0$, then transfers are set to zero (in this case, if the parent were to transfer another dollar, part of it would be saved). If in the absence of transfers the child is constrained, i.e. $a_c'\left(\cdot, a_c, y_c, 0, a_p'\right) = 0$, then set g_p to satisfy $u'\left(c_p\right) = \gamma u'\left(c_c\left(\cdot, a_c, y_c, g_p, a_p'\right)\right)$. Numerically, I verify that the parent indeed finds it optimal to set the transfer to zero if the child is not constrained in the absence of the transfer.

B.2 Computational Algorithm

The algorithm to compute a steady-state equilibrium amounts to finding the value functions and the associated decision rules, as well as the stationary measure of households of different ages. The two steps are now further detailed. The algorithm is written for the general case in which the child's age runs from 1 to H_c, the parent's age runs from $H_c + 1$ to H and there is a d periods age difference between parents and children.

Finding the policy functions

I solve the model using value function iteration with linear interpolation. This is because in a setting like this one ex-ante there are concerns about multiplicity of equilibria and non-smooth policy functions, and one cannot rely merely on Euler Equations for solving for the optimal policy functions. The algorithm for finding the optimal policy functions for the parent $a'_p(h_p, a_p, a_c, y_p, y_c, s_p, s_c)$, $g_p(h_p, a_p, a_c, y_p, y_c, s_p, s_c)$ and the child $a'_c\left(h_c, \tilde{a}_c, y_c, a'_p, y_p, s_p, s_c\right)$, where $\tilde{a}_c = a_c + g_p$, $h_p = H_c + 1, \ldots, H$ and $h_c = h_p - d$ is as follows:

Step 1. Place a grid on the asset, labor income and sector spaces spaces. Let NA be the number of notes in the asset space, NY be the number of nodes in the income space and NS the number of sectors. This means the state space has $d \times NA^2 \times NY^2 \times NS^2$ nodes. The labor income grid and the corresponding age specific transition probabilities are approximated using the algorithm in Tauchen (1986).

Step 2. Initialize the value function $V_0^p(H_c + 1, a_p, a_c, y_p, y_c, s_p, s_c)$, for all $a_p, a_c = 1, \ldots, NA$, $y_p, y_c = 1, \ldots, NY$ and $s_p, s_c = 1, \ldots, NS$.

Step 3. Starting from this guess, iterate backwards over all parent-child age pairs $(h_p, h_c) \in \{(H, H_c), (H-1, H_c-1), \ldots, (H_c+1, 1)\}$ to update the initial guess to $V_1^p(H_c + 1, a_p, a_c, y_p, y_c, s_p, s_c)$. To that end, for each parent child pair solve the two-stage game backwards, as follows:

Step 3.1 Solve the child's optimization problem to get the policy functions $c_c^\star\left(h_c, \tilde{a}_c, y_c, a'_p, y_p, s_p, s_c\right)$ and $a_c'^\star\left(h_c, \tilde{a}_c, y_c, a'_p, y_p, s_p, s_c\right)$. The child's optimization problem is solved by value function iteration with linear interpolation. In particular, for $h_c = H_c$, I solve

$$V_1^c\left(H_c, \tilde{a}_c, y_c, a_p', y_p, s_p, s_c\right) = \max_{a_c'} \Big\{ u\left(\left(1-\tau\right) y_c + \tilde{a}_c - a_c'\right)$$
$$+\beta \sum_{s_p'} \sum_{s_c'} \sum_{y_p'} \sum_{y_c'} \pi^s_{H_c+1}\left(s_p'|s_c\right) \pi^s_{ch}\left(s_c'|s_p'\right) \pi^y_{H_c+1}\left(y_p'|y_c, s_p'\right) \pi_{ch}\left(y_c'|y_p', s_c'\right)$$
$$\times V_0^p\left(H_c+1, a_p' + a_c', 0, y_p', y_c', s_p', s_c'\right) \Big\}.$$

For $h_c = H_c - 1, \ldots, 1$, I solve [76]

$$V_1^c\left(h_c, \tilde{a}_c, y_c, a_p', y_p, s_p, s_c\right) = \max_{a_c'} \Big\{ u\left(\left(1-\tau\right) y_c + \tilde{a}_c - a_c'\right)$$
$$+\beta \sum_{s_p'} \sum_{s_c'} \sum_{y_p'} \sum_{y_c'} \pi^s_{h_c+1}\left(s_c'|s_c\right) \pi^s_{h_p+1}\left(s_p'|s_p\right) \pi^y_{h_c+1}\left(y_c'|y_c, s_c'\right) \pi^y_{h_p+1}\left(y_p'|y_p, s_p'\right)$$
$$\times V_1^c\left(h_c+1, Ra_c' + g_p, y_c', a_p'', y_p', s_p', s_c'\right) \Big\}.$$

Step 3.2 At each step of the backward iteration, given the child's policy function, solve the parent's optimization problem to get policy functions $c_p^\star\left(h_p, a_p, a_c, y_p, y_c, s_p, s_c\right)$, $g_p^\star\left(h_p, a_p, a_c, y_p, y_c, s_p, s_c\right)$ and $a_p'^\star\left(h_p, a_p, a_c, y_p, y_c, s_p, s_c\right)$ in two steps, as described below.

First, solve for the optimal transfer g_p, conditional on a_p'. As discussed in the previous section, given a_p', the transfer g_p is set as follows: *(i)* if $a_c'^\star\left(h_c, Ra_c + 0, y_c, a_p', y_p, s_p, s_c\right) > \underline{A}_{h_c}$, then $g_p^\star\left(h_p, a_p, a_c, y_p, y_c, s_p, s_c, a_p'\right) = 0$ and *(ii)* if $a_c'^\star\left(h_c, Ra_c + 0, y_c, a_p', y_p, s_p, s_c\right) = \underline{A}_{h_c}$, then $g_p^\star\left(h_p, a_p, a_c, y_p, y_c, s_p, s_c, a_p'\right) = \max\left\{0, \hat{g}_p\right\}$, where $\hat{g}_p$ solves

$$u'\left(y_p + Ra_p - a_p' - g_p\right) - \gamma u'\left(c_c^\star\left(h_c, Ra_c + g_p, y_c, a_p', y_p, s_p, s_c\right)\right) = 0.$$

Second, solve for the optimal savings a_p' that maximize the parent's value function. This step is also solved by value function iteration with linear interpolation. In

[76] For h_c at which parent is retired the transition probabilities are adjusted to reflect the absence of income risk.

particular, for $h_p = H_p$ I solve

$$V_1^p(H_p, a_p, a_c, y_p, y_c, s_p, s_c) = \max_{a'_p}\Big\{u\left((1-\tau)\, y_p + Ra_p - g_p^\star - a'_p\right)$$
$$+\beta\gamma \sum_{s'_p}\sum_{s'_c}\sum_{y'_p}\sum_{y'_c} \pi^s_{H_c+1}\left(s'_p|s_c\right)\pi^s_{ch}\left(s'_c|s'_p\right)\pi^y_{H_c+1}\left(y'_p|y_c, s'_p\right)\pi_{ch}\left(y'_c|y'_p, s'_c\right)$$
$$\times V_0^p\left(H_c+1, a'_p + a'_c, 0, y'_p, y'_c, s'_p, s'_c\right)\Big\}.$$

For $h_p = H_p - 1, \ldots, H_c + 1$, I solve

$$V_1^p(h_p, a_p, a_c, y_p, y_c, s_p, s_c) = \max_{a'_p}\Big\{u\left((1-\tau)\, y_p + Ra_p - g_p^\star - a'_p\right)$$
$$+\beta \sum_{s'_p}\sum_{s'_c}\sum_{y'_p}\sum_{y'_c} \pi^s_{h_c+1}\left(s'_c|s_c\right)\pi^s_{h_p+1}\left(s'_p|s_p\right)\pi^y_{h_c+1}\left(y'_c|y_c, s'_c\right)\pi^y_{h_p+1}\left(y'_p|y_p, s'_p\right)$$
$$\times V_1^p\left(h_p+1, a'_p, a'_c, y'_p, y'_c, s'_p, s'_c\right)\Big\}.$$

Let $a_p'^\star(h_p, a_p, a_c, y_p, y_c, s_p, s_c)$ denote the optimal parental savings. Additionally, let $\bar{g}_p'^\star(h_p, a_p, a_c, y_p, y_c, s_p, s_c) = g_p^\star\left(h_p, a_p, a_c, y_p, y_c, s_p, s_c, a_p'^\star(h_p, a_p, a_c, y_p, y_c, s_p, s_c)\right)$ denote the implied optimal transfer. Then, the child's consumption and savings defined on the same state space as the parent's can be backed out by interpolation. For example, consumption is

$$c_c(h_c, a_p, a_c, y_p, y_c, s_p, s_c) =$$
$$c_c^\star\left(h_c, Ra_c + g_p^\star(h_p, a_p, a_c, y_p, y_c, s_p, s_c), y_c, a_p'^\star(h_p, a_p, a_c, y_p, y_c, s_p, s_c), y_p, s_p, s_c\right).$$

Step 4. If V_0 and V_1 are close enough for all grid points, the value and policy functions are found. Otherwise, set $V_0^p(H_c+1, a_p, a_c, y_p, y_c, s_p, s_c) = V_1^p(H_c+1, a_p, a_c, y_p, y_c, s_p, s_c)$ and go back to Step 3.

Finding the stationary distribution

Let $A = [-\underline{a}, \bar{a}]$, $Y = \left[\underline{y}, \bar{y}\right]$ and $S = [\underline{s}, \bar{s}]$ be the asset, labor efficiency and sector space, respectively. Define $\tilde{S} \equiv A^2 \times Y^2 \times S^2$ as the state space with the generic element $\tilde{s} = (a_p, a_c, y_p, y_c, s_p, s_c)$. Denote as $\tilde{\mathcal{S}}$ the Borel σ-algebra of the state space, with typical subset $\mathcal{A}^2 \times \mathcal{Y}^2 \times \mathcal{S}^2$. Let $f_h(\tilde{s})$ be a probability measure defined over $\left(\tilde{S}, \tilde{\mathcal{S}}\right)$. $f_h(\tilde{s})$ denotes the measure of households of age h which have state variable s. Denote as $F_h(\tilde{s})$ the corresponding cumulative distribution function. In a stationary (partial) equilibrium, the invariant measures for this economy need to satisfy the consistency conditions enumerated below.

The consistency condition for a child household of age $h_c = 1$ is:

$$\begin{aligned} f_1(\tilde{s}') &= \int_{\tilde{S}} \mathbf{1}_{\left\{a'_p = a'_{H_c}(\tilde{s}) + \frac{a'_H(\tilde{s})}{n}\right\}} \mathbf{1}_{\{a'_c=0\}} \pi^s_{H_c+1}\left(s'_p|s_c\right) \pi^s_{\text{ch}}\left(s'_c|s'_p\right) \\ &\quad \pi^y_{H_c+1}\left(y'_p|y_c, s'_p\right) \pi_{\text{ch}}\left(y'_c|y'_p, s'_c\right) \mathrm{d}F_{H_c}(\tilde{s}), \end{aligned}$$

and that for child households of age $h_c = 2, \ldots, H_c$ is:

$$\begin{aligned} f_{h_c}(\tilde{s}') &= \int_{\tilde{S}} \mathbf{1}_{\left\{a'_p = a'_{h_p-1}(\tilde{s})\right\}} \mathbf{1}_{\left\{a'_c = a'_{h_c-1}(\tilde{s})\right\}} \pi^s_{h_p}\left(s'_p|s_p\right) \pi^s_{h_c}\left(s'_c|s_c\right) \\ &\quad \pi^y_{h_p}\left(y'_p|y_p, s'_p\right) \pi^y_{h_c}\left(y'_c|y_c, s'_c\right) \mathrm{d}F_{h_c-1}(\tilde{s}). \end{aligned}$$

Since every parent household has one child, the measure of parent households of age $h_p = H_c + 1, \ldots, H$ is $f_{h_p}(\tilde{s}') = f_{h_c}(\tilde{s}')$.

B.3 Parameters of the income process

The permanent income uncertainty profiles for the low and high risk sectors are constructed by averaging over the uncertainty profiles of the component sectors, weighted by the number of observations in each component sector. The variance of the idiosyncratic component of earnings is assumed to be a cubic polynomial in age:

$$\sigma^2_{hs} = a_s + b_s \frac{h}{10} + c_s \left(\frac{h}{10}\right)^2 + d_s \left(\frac{h}{10}\right)^3$$

Parameters ρ_s, a_s, b_s, c_s, d_s are estimated by minimizing, for each sector, the weighted distance between the empirical age profile of income risk relative to permanent income and that implied by the decomposition (12)-(13) and the polynomial assumption. I use the identity matrix as the weighting matrix. The steps to construct the permanent income risk implied by the parametric assumptions in the model are as follows:

Step 1. Discretize the idiosyncratic component of income using the Tauchen (1986) method.

Step 2. Simulate the earnings path of $5,000$ individuals.

Step 3. Compute forecast errors for the simulated individuals as difference between realized earnings and expected earnings.

Step 4. Use these forecast errors to compute permanent income risk in sector s according to equation (6) and then divide by expected permanent income using gross discount rate $R = 1.04$.

B.4 Model fit (extra)

I begin with examining the model implied age profile of consumption, displayed in Figure 14. Qualitatively, consumption over the life-cycle displays similar patterns as those documented in Figure 3 in terms of the backloading after retirement. In the model, this is solely a reflection of dynastic precautionary savings. After retirement, which occurs at age 65, parents' income is no longer subject to risk, but their children's income still is. The resolution of children's permanent income stimulates parental consumption and generates the backloaded consumption profile. Note however that, while the model matches the level of average consumption over the life-cycle (\$7,929 in the model versus \$7,998 in the data), it understates the consumption of the young and overstates the consumption of the old.

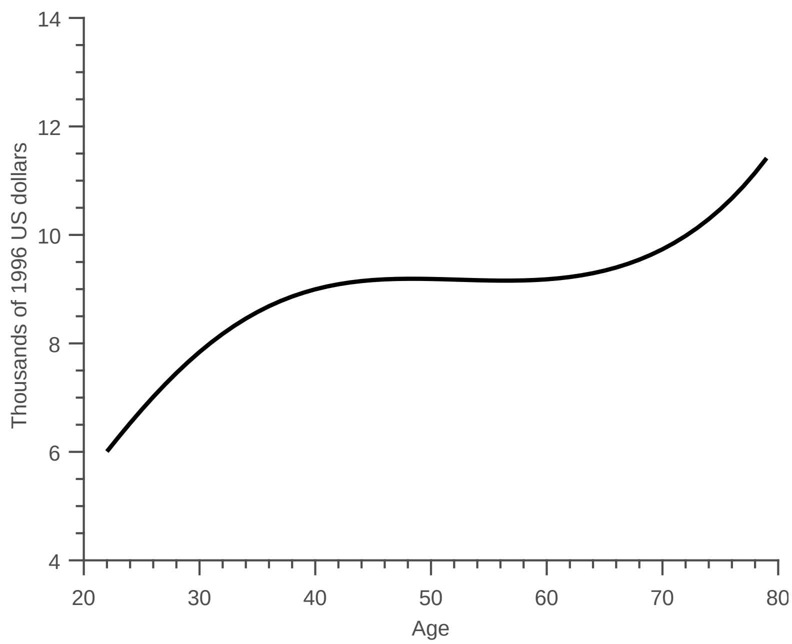

Figure 14: Model Implied Age Profile of Consumption

Notes: The figure shows the model implied average age profile of consumption, obtained by estimating equation (8) with model generated data.

Since the model is meant to capture various motives for which individuals hold wealth, it is desirable that it generates a distribution of wealth that resembles the US data. This is largely the case, as shown in Table 13, which compares quintiles of cross-sectional wealth and after-tax income found in the model and in the data, and in Figure 15, which plots the wealth shares of 5 wealth quintiles for different age groups. The data moments are calculated based on the pooled PSID sample.

Table 13: Characteristics of the Wealth and Income Distribution

	Quintiles				
	Q1	Q2	Q3	Q4	Q5
Wealth distribution					
US data	0.57	2.73	6.97	16.50	73.23
Model	0.59	1.73	5.68	17.81	74.19
Income distribution					
US data	4.93	10.84	16.77	24.09	43.37
Model	4.56	9.96	12.98	20.93	51.57

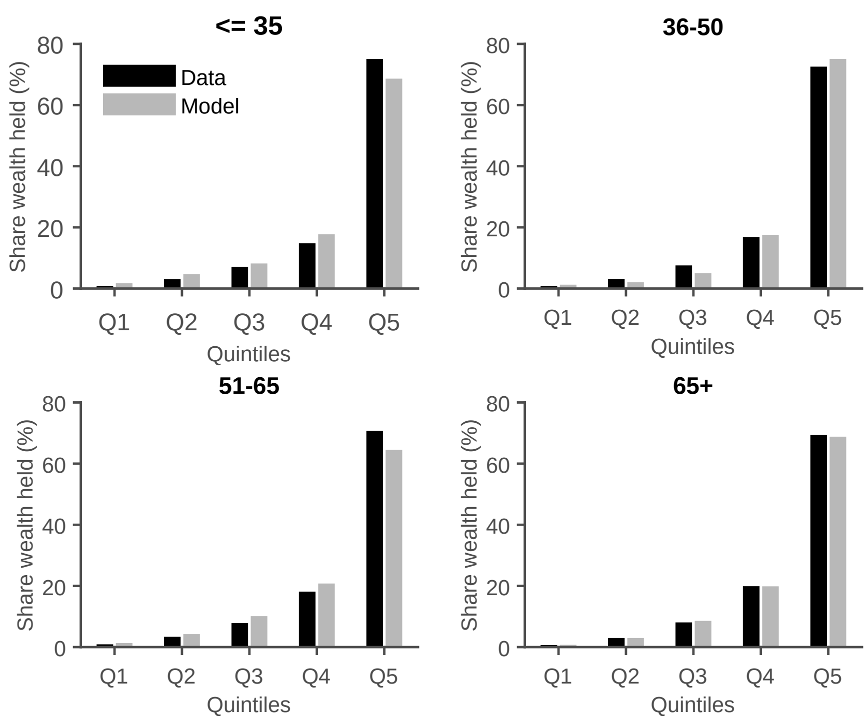

Figure 15: Wealth Distribution, By Age

B.5 Unitary household model

In the unitary model, given $\tilde{s} = (a, y_p, y_c, s_p, s_c)$, a non-terminal parent of age h_p solves

$$\begin{aligned} V^p_{h_p}(\tilde{s}_p) &= \max_{c_p, c_c, a'} u(c_p) + \delta u(c_c) + \beta \mathbb{E} V^p_{h_p+1}(\tilde{s}' | \mathbf{y}, \mathbf{s}) \\ \text{s.t.} &\quad c_p + c_c + a' = (1-\tau)(y_p + y_c) + Ra \\ &\quad a' \geq \underline{A}_{h_p} \geq 0, \end{aligned}$$

where $\tilde{s}' = \left(a', y'_p, y'_c, s'_p, s'_c\right)$. The expectation is taken over all possible sector and income transitions, for the parent and the child. Note that if the parent is retired his net income is $\Phi(\hat{y}_p, \hat{s}_p)$, and the expectation is taken only over possible sector and income transitions for the child. A terminal parent with state variables $\tilde{s} = (a, \hat{y}_p, y_c, s_p, s_c)$ solves

$$\begin{aligned} V^p_{79}(\tilde{s}_p) &= \max_{c_p, c_c, a'} u(c_p) + \delta u(c_c) + \beta \gamma \mathbb{E} V^p_{51}\left(\tilde{s}'_p | \mathbf{y}, \mathbf{s}\right) \\ \text{s.t.} &\quad c_p + c_c + a' = \Phi(\hat{y}_p) + (1-\tau) y_c + Ra \\ &\quad a' \geq \underline{A}_{h_p} \geq 0, \end{aligned}$$

where $\tilde{s}' = \left(a', y'_p, y'_c, s'_p, s'_c\right)$.

B.6 Model with mortality and medical expenditure risk

Assume retired individuals, who are always parents, face survival probability ψ_{h_p} and uncertain health status m which determines their medical spending $\bar{m}(h_p, m)$. Below is the model with medical expenditure and mortality risk.

Decision problems

The problem of a working parent-child pair. There is no change in this probem with respect to the baseline case without mortality risk. In the second stage, given $\tilde{s}_c = \left(\tilde{a}_c, y_c, y_p, a'_p, s_p, s_c\right)$ the child of age h_c solves

$$\begin{aligned} V^c_{h_c}(\tilde{s}_c) &= \max_{c_c, a'_c} u(c_c) + \beta \mathbb{E} V^c_{h_c+1}(\tilde{s}'_c | \mathbf{y}, \mathbf{s}) \\ \text{s.t.} &\quad c_c + a'_c = (1-\tau) y_c + \tilde{a}_c \\ &\quad a'_c \geq \underline{A}_{h_c} \end{aligned}$$

where $\tilde{s}'_c = \left(Ra'_c + g'^{\star}_p, y'_c, y'_p, a''^{\star}_p, s'_p, s'_c\right)$, $\mathbf{s} = (s_p, s_c)$ and $\mathbf{y} = (y_p, y_c)$. The next period's transfer $g'^{\star}_p$ and parental savings $a''^{\star}_p$ are equilibrium objects. Call the resulting optimal policy function $c^{\star}_c(h_c, \tilde{s}_c)$. In the first stage, given $\tilde{s}_p = (a_p, a_c, y_p, y_c, s_p, s_c)$, the parent of age h_p solves

$$\begin{aligned}
V^p_{h_p}(\tilde{s}_p) \quad &= \quad \max_{c_p, a'_p, g_p} u(c_p) + \delta u\left(c^{\star}_c\left(h_c, a_c, y_c, y_p, g_p, a'_p, s_p, s_c\right)\right) + \beta \mathbb{E} V^p_{h_p+1}\left(\tilde{s}'_p|\mathbf{y}, \mathbf{s}\right) \\
\text{s.t.} \quad & c_p + a'_p + g_p = (1-\tau) y_p + Ra_p \\
& a'_p \geq \underline{A}_{h_p}, g_p \geq 0
\end{aligned}$$

where $\tilde{s}'_p = \left(a'_p, a'^{\star}_c\left(h_c, Ra_c + g_p, y_c, y_p, a'_p, s_p, s_c\right), y'_p, y'_c, s'_p, s'_c\right)$. The expectation is taken over all possible sector and income transitions, for the parent and the child, as both of them are in the labor market in the following year.

The problem of a retired parent-child pair. At the end of age $H_{ret} = 65$ the parent retires and starts earning constant income $\Phi(\hat{y}_p)$, which is a function of predicted career earnings. Retired parents face uncertainty about survival and medical expenses. Medical expenses evolve stochastically during retirement according to the function $\bar{m}(h_p, m)$. Thus, in each period a retiree's medical expenses depends on current age h_p and current expense shock m. At the end of each period, the parent dies with probability $1 - \psi_{h_p}$, in which case the child inherits his parent's end of period assets. In the second stage, given $\tilde{s}_c = \left(\tilde{a}_c, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c, m\right)$, the child of age h_c whose parent is alive solves

$$\begin{aligned}
V^c_{h_c}(\tilde{s}_c) \quad &= \quad \max_{c_c, a'_c} u(c_c) + \beta \psi_{h_p} \mathbb{E} V^c_{h_c+1}(\tilde{s}'_c|y_c, s_c, m) + \beta\left(1 - \psi_{h_p}\right) \mathbb{E} \bar{V}^c_{h_c+1}(\bar{s}'_c|y_c, s_c) \\
\text{s.t.} \quad & c_c + a'_c = (1-\tau) y_c + \tilde{a}_c \\
& a'_c \geq \underline{A}_{h_c}
\end{aligned}$$

where $\tilde{s}'_c = \left(a'_c, y'_c, \hat{y}_p, g'^{\star}_p, a''^{\star}_p, \hat{s}_p, s'_c, m'\right)$ and $\bar{s}'_c = \left(a'_c + a'_p, y'_c, s'_c\right)$. Call the resulting optimal policy function $c^{\star}_c(h_c, \tilde{s}_c)$.

A child whose parent is no longer alive solves:

$$\begin{aligned}
\bar{V}^c_{h_c}(\bar{s}_c) \quad &= \quad \max_{c_c, a'_c} u(c_c) + \beta \mathbb{E} \bar{V}^c_{h_c+1}(\bar{s}'_c|y_c, s_c) \\
\text{s.t.} \quad & c_c + a'_c = (1-\tau) y_c + Ra_c \\
& a'_c \geq \underline{A}_{h_c},
\end{aligned}$$

where $\bar{s}_c = (a_c, y_p, s_c)$.

In the first stage, given $\tilde{s}_p = (a_p, a_c, \hat{y}_p, y_c, \hat{s}_p, s_c, m)$, the problem of a retired parent of age $h_p = H_{ret}+1, \ldots, H-1$ is

$$
\begin{aligned}
V^p_{h_p}(\tilde{s}_p) &= \max_{c_p, a'_p, g_p} u(c_p) + \gamma u\left(c^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c, m\right)\right) \\
&+ \beta\psi_{h_p}\mathbb{E}V^p_{h_p+1}\left(\tilde{s}'_p|y_c, s_c, m\right) + \beta\left(1-\psi_{h_p}\right)\gamma\mathbb{E}\bar{V}^c_{h_c+1}\left(\bar{s}'_c|y_c, s_c\right) \\
\text{s.t.}\quad & c_p + a'_p + g_p + \bar{m} = \Phi(\hat{y}_p) + Ra_p \\
& a'_p \geq \underline{A}_{h_p}, g_p \geq 0
\end{aligned}
$$

where $\tilde{s}'_p = \left(a'_p, a'^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c, m\right), \hat{y}_p, y'_c, \hat{s}_p, s'_c, m'\right)$ and $\bar{s}'_c$ is as previously defined. Only the child is in the labor force, so the expectation is taken only with respect to y_c and s_c.

The problem of a terminal parent-child pair. At the end of age H the parent dies with probability one. In the following period his child becomes a parent and his own child starts earning income. Given $\tilde{s}_c = \left(\tilde{a}_c, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c, m\right)$, the second stage problem of a child whose parent is alive is:

$$
\begin{aligned}
V^c_{50}(\tilde{s}_c) &= \max_{c_c, a'_c} u(c_c) + \beta\mathbb{E}V^p_{51}\left(\tilde{s}'_p|\mathbf{y}, \mathbf{s}\right) \\
\text{s.t.}\quad & c_c + a'_c = (1-\tau)y_c + \tilde{a}_c \\
& a'_c \geq \underline{A}_{h_c}
\end{aligned}
$$

where $\tilde{s}'_p = \left(a'_c + a'_p, 0, y'_p, y'_c, s'_p, s'_c\right)$, $\mathbf{y} = \left(y_c, y'_p\right)$ and $\mathbf{s} = \left(s_c, s'_p\right)$. This allows for intergenerational correlation in sectors and income processes. I assume that young adults (age 22) have no assets. The problem of a child whose parent is dead is:

$$
\begin{aligned}
\bar{V}^c_{50}(\bar{s}_c) &= \max_{c_c, a'_c} u(c_c) + \beta\mathbb{E}V^p_{51}\left(\tilde{s}'_p|\mathbf{y}, \mathbf{s}\right) \\
\text{s.t.}\quad & c_c + a'_c = (1-\tau)y_c + Ra_c \\
& a'_c \geq \underline{A}_{h_c}
\end{aligned}
$$

where $\tilde{s}'_p = \left(a'_c, 0, y'_p, y'_c, s'_p, s'_c\right)$.

In the first stage, given $\tilde{s}_p = (a_p, a_c, \hat{y}_p, y_c, \hat{s}_p, s_c, m)$, the terminal parent solves

$$\begin{aligned}
V^p_{79}\left(\tilde{s}_p\right) \quad &= \quad \max_{c_p, a'_p, g_p} u\left(c_p\right) + \gamma u\left(c^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c, m\right)\right) + \beta\gamma\mathbb{E}V^p_{51}\left(\tilde{s}'_p|\mathbf{y}, \mathbf{s}\right) \\
\text{s.t.} \quad & c_p + a'_p + g_p + \bar{m} = \Phi\left(\hat{y}_p\right) + Ra_p \\
& a'_p \geq \underline{A}_{h_p}, g_p \geq 0
\end{aligned}$$

where $\tilde{s}'_p = \left(a'_p + a'^\star_c\left(h_c, Ra_c + g_p, y_c, \hat{y}_p, a'_p, \hat{s}_p, s_c, m\right), 0, y'_p, y'_c, s'_p, s'_c\right)$.

Calibration of the medical expense process

The calibration is taken from Kopecky and Koreshkova (2014), who assume that medical expenses can be decomposed into a deterministic age component and a stochastic component, as follows:

$$\ln \bar{m}\left(h_p, m\right) = \beta_{m,0} + \beta_{m,1}h_p + \beta_{m,2}h_p^2 + \beta_{m,3}h_p^3 + \beta_{m,4}h_p^4 + m,$$

where $m \in \{m_1, m_2, m_3, m_4\}$ follows a finite state Markov chain with probability transition matrix $\Lambda_{mm'}$ and initial distribution Γ_m. The coefficients of the age polynomial are: $\beta_{m,0} = 91.56$, $\beta_{m,1} = -5.08$, $\beta_{m,2} = 0.103$, $\beta_{m,0} = -9.16 \times 10^{-4}$, $\beta_{m,0} = 3.01 \times 10^{-6}$. The grid for the medical shock is $m \in \{0, 2, 3.5, 6\}$ and the initial distribution is $\Gamma_m = [0.2, 0.16, 0.61, 0.03]$. Lastly, the probability transition matrix for the medical shock is:

$$\Lambda_{mm'} = \begin{bmatrix} 0.7165 & 0.1894 & 0.0783 & 0.0158 \\ 0.1746 & 0.5130 & 0.2901 & 0.0224 \\ 0.0772 & 0.2784 & 0.6233 & 0.0211 \\ 0.0633 & 0.3851 & 0.4576 & 0.0940 \end{bmatrix}$$