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Overpersistence Bias in Individual Income Expectations and its Aggregate Implications

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Abstract
Using micro-level data, we document a systematic, income-related component in household income forecast errors. We show that these errors can be formalized by a modest deviation from rational expectations, where agents overestimate the persistence of their income process. We then investigate the implications of these distortions on consumption and savings behavior and find two effects. First, these distortions allow an otherwise fully optimization-based quantitative model to match the empirical joint distribution of liquid assets and income. Second, the bias alters the distribution of marginal propensities to consume which makes government stimulus policies less effective.

Resume
Ved hjælp af data på mikroniveau dokumenterer vi en systematisk indkomstrelateret komponent i husholdningers fejlskøn for deres forventede fremtidige indkomst. Vi viser, at denne bias kan formaliseres ved en beskeden afvigelse fra rationelle forventninger, hvor agenter overvurderer persistensen af deres indkomstproces. Vi undersøger derefter konsekvenserne for forbrug og opsparing og finder to effekter. For det første sætter biasen en ellers fuldt optimeringsbaseret kvantitativ model i stand til at matche fordelingen af likvide aktiver og indkomst. For det andet ændrer biasen fordelingen af marginale forbrugstilbøjeligheder, hvilket reducerer effektiviteten af stimulerende politiske tiltag.

Key words
household balance sheets
JEL classification
D84; E21; D91

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The authors alone are responsible for any remaining errors.

Overpersistence Bias in Individual Income Expectations and its Aggregate Implications *

Filip Rozsypal† Kathrin Schlafmann‡

Abstract

Using micro-level data, we document a systematic, income-related component in household income forecast errors. We show that these errors can be formalized by a modest deviation from rational expectations, where agents overestimate the persistence of their income process. We then investigate the implications of these distortions on consumption and savings behavior and find two effects. First, these distortions allow an otherwise fully optimization-based quantitative model to match the joint empirical distribution of liquid assets and income. Second, the bias alters the distribution of marginal propensities to consume which makes government stimulus policies less effective.

JEL codes: D84, E21, D91
KEYWORDS: expectations, survey forecasts, savings, MPC

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1 Introduction

Fluctuations in income represent one of the most important sources of economic risk for households. Households who have different expectations about their future income realizations will hence make different decisions about consumption and saving today. Unfortunately, data on individual income expectations and corresponding realizations are not readily available. Despite the importance of household income expectations, testing their rationality or the identification of systematic biases has therefore been difficult.

In this paper we first use micro data on household income expectations, devise a new way to construct individual-level forecast errors and provide evidence of non-rationality in the form of a systematic bias related to the level of income. Second, we show that these empirical findings are consistent with a process of expectation formation where households are perfectly forward-looking but overestimate the persistence of their individual income process and are too pessimistic about the development of the aggregate economy. This formulation of expectations is in the spirit of Kahneman and Tversky's (1973) finding of non-regression to the mean in people's probabilistic judgments. Third, we show how this bias affects consumption and savings behavior in an otherwise standard, fully optimization-based model of durable consumption. Including the bias allows the model to fit the joint distribution of liquid assets and income. In particular, this mechanism can explain why low-income households do not borrow more to smooth consumption. We compare the model with biased income expectations to a rational model that requires a tighter borrowing constraint to fit the data. The two models generate different distributions of marginal propensities to consume, which results in government stimulus policies being less effective in the model with biased expectations: In a balanced budget experiment, the rational model predicts the increase in aggregate non-durable consumption to be 3.5 times larger than what the model with biased expectations predicts.

The first contribution of the paper is to empirically analyze forecast errors in individual household income expectations. Using data from the Michigan Surveys of Consumers, we show that current income is systematically correlated with the error people make when they forecast their individual future nominal income growth. Specifically, people in the upper part of the income distribution overestimate their future income growth while the opposite is true for lower income households: they are too pessimistic and underestimate their future income growth. In terms of magnitudes, on average people in the highest income quintile overestimate their income growth by 2 percentage points while people in the lowest income quintile underestimate it by 7 percentage points. Moreover, we show that people across the whole income distribution are too pessimistic about aggregate variables such as inflation and the unemployment rate. However, we show that these forecast errors about aggregate variables are not able to explain the magnitudes nor the differential signs of the forecast errors observed in individual nominal income growth expectations.

Analyzing errors in income expectations requires the knowledge of both a household's income expectation and the same household's ex post income realization over the corresponding time period. However, to the best of our knowledge none of the existing panel surveys satisfy these requirements.[1] We exploit that the Michigan Surveys of Consumers reinterview a subset of households after 6 months. We obtain expectation errors for each household which allows us to document the systematic patterns in individual income forecast errors. We also ensure that our findings are not an artifact of the data construction procedure by conducting several robustness checks.

The second contribution of the paper is to present a rule for expectation formation that can explain the empirical findings and that is easy to implement in quantitative models. We show that the observed patterns in forecast errors are consistent with a form of expectation formation where people are fully forward-looking but overestimate the persistence of their income process. We hence call this bias *overpersistence bias*. It implies that people overreact to shocks to their income and that this overreaction is persistent. The distorted expectations can be expressed as the sum of rational expectations and a function of current income, i.e. a function of all past shocks. Our formulation of expectations is therefore similar to "Diagostic Expectations" proposed by Gennaioli and Shleifer (2010) and Bordalo et al. (2018). The difference is that in their setup the bias term is a function of only the latest news, whereas in our setup it is a function of the full history of shocks.

The distorted expectations can be formulated parsimoniously in the context of a standard income process with persistent and transitory income shocks as in Storesletten et al. (2004): We implement the overpersistence bias by allowing the agents' belief about the autocorrelation parameter to differ from the true underlying parameter. Moreover, we allow households to be too pessimistic about aggregate variables. This parsimonious representation of distorted expectations with only two free parameters is able to match the empirically observed forecast errors across the whole income distribution. The reason is that even though households share the same (distorted) beliefs about the data-generating process of income, the overpersistence bias leads to heterogeneous expectation errors depending on the particular income realization of a given household. Households with currently high income expect their future income to remain higher than what their true income process would predict. Ex post they hence turn out to be too optimistic on average. The converse is true for households with currently low income: They underestimate their future income and turn out to be too

[1] See appendix B for a detailed discussion of income expectation and realization data in other surveys.

pessimistic. While the overpersistence bias leads to heterogeneous effects, the aggregate pessimism affects households in the same way across the whole income distribution: People are too pessimistic about the future aggregate economy which biases downward their individual income expectations. We show that the combination of the two effects allows the expectations process to match the empirically observed magnitudes of forecast errors across the income distribution.

How does the overpersistence bias in income expectations affect the consumption-saving behavior of households? And what are the aggregate consequences of the bias? To answer these questions, we insert the fitted representation of expectation bias into an otherwise standard incomplete markets, heterogeneous agent model in the tradition of Bewley (1986) and Deaton (1991). Moreover, marginal propensities to consume (MPCs) have been the focus of much recent literature in the field of economics and household finance. Kaplan and Violante (2014) argue that it is crucial to include illiquid assets into the modeling framework to be able to capture the distribution of MPCs across the wealth distribution. In order to analyze how biased income expectations affect the distribution of MPCs we therefore include a durable consumption good in our analysis. We calibrate it to capture vehicle purchases as this allows the model to make simultaneous predictions about different categories of consumption which can be directly tested against empirical estimates.

Biased income expectations turn out to have differential effects on the behavior of households depending on their relative position in the income distribution. High-income households hold similar portfolios under biased and under fully rational expectations. For them the overpersistence bias and aggregate pessimism have opposing effects and cancel each other out. In contrast, low-income households choose different portfolios if they have biased income expectations. Low-income households with biased expectations are too pessimistic about their future income and hence do not want to borrow to smooth consumption even though they would be able to borrow.

We show that this mechanism allows an otherwise standard, fully optimization-based model to fit the distribution of liquid assets as well as durable holdings across different income groups. In particular, including biased income expectations enables the model to match the distribution of liquid assets for low-income households. The model with fully rational income expectations, on the other hand, would predict counterfactually large amounts of borrowing. Including the bias in income expectations as seen in the data allows the model to overcome this counterfactual behavior and to fit the distribution of borrowing.

Next, we study the effects of the bias on the level of MPCs for different consumption goods. Even though the MPCs were not targeted in the calibration, the model replicates the empirical estimates both in total consumption as well as the split between durable and nondurable goods: Households spend on average about 25% of the transfer on nondurable consumption in the first year. When taking into account durable expenditures this share increases to 75%. Moreover, the model also matches the heterogeneity in MPCs found by Misra and Surico (2014): Only a small fraction of agents drives the large response in durable spending. We find that all else being equal, biased agents have a smaller MPC in nondurable consumption than fully rational agents. However, they are more willing to shift their durable expenditures in time, resulting in higher overall marginal propensities to spend the transfer.

How much does the bias matter economically? We show that since the model with rational expectations generates larger amounts of borrowing than the model with biased expectations, it also requires a tighter borrowing constraint to fit the data. This tighter borrowing constraint amplifies the effects that the overpersistence bias has on MPCs. The rational model leads to a greater dispersion of MPCs across the income distribution: It generates a larger relative MPC of low-income households compared to the MPC of high-income households. The model with biased expectations, on the other hand, generates a relative MPC that is in line with empirical estimates (Johnson et al., 2006; Parker et al., 2013). Relative MPCs are an important determinant of the government's ability to boost aggregate demand using fiscal transfers (Oh and Reis, 2012). Such policies have become popular during recessions. For example, the U.S. government handed out one-off cash transfers in both 2001 and 2008. To highlight the importance of the distribution of MPCs for these programs, we consider a balanced budget policy that levies a lump sum tax on high income households to pay for a lump sum transfer to low-income households. In such an environment the higher aggregate consumption response, the larger is the difference between the MPC of households with high and low-income. The differences in MPC distributions between the models with biased and rational expectations translate into a different assessment of the effectiveness of fiscal stimulus packages: The rational model predicts such policies to be much more effective than what the model with biased expectations predicts. In particular, the increase in aggregate nondurable consumption turns out to be 3.5 times larger than in the model with biased expectations.

The paper contributes to the literature in three fields. First, it contributes to the growing body of empirical studies analyzing expectations of households, firms and professional forecasters. To evaluate whether agents' expectations are rational one has to compare these expectations with the corresponding realizations. Most of this literature has therefore analyzed expectations about aggregate variables, where the realizations are readily available. Examples are Carroll (2003), Andolfatto et al. (2008), Malmendier and Nagel (2015), Coibion et al. (2015), Cavallo et al. (2017), Abildgren and Kuchler (2021) and Vellekoop and Wiederholt (2017) for inflation expectations, Gerardi et al. (2008), Piazzesi and Schneider (2009), Case et al. (2012), and Kuchler and Zafar (2018) for house price expectations, Kuchler and Zafar (2018) for unemployment expectations, Piazzesi et al. (2015) for expectations about excess bond returns and Bordalo et al. (2018) for expectations about credit spreads. In contrast, we focus on *individual*-level *income* expectations and realizations. Due to data availability, this area has received much less attention in the literature, Dominitz and Manski (1997), Dominitz (1998), Das and van Soest (1999) and recently D'Haultfoeuille et al. (2018) and Massenot and Pettinicchi (2018) being notable exceptions. Compared to the first two papers, the current paper has the advantage of analyzing a much larger sample of expectations and realizations, both in terms of the number of households and in terms of the time period covered. We are hence able to document systematic biases in household income expectations which are present throughout the past 25 years. Das and van Soest (1999) analyze household income expectations in a panel data set from the Netherlands, but in their data set households are only asked about the direction of expected income changes, not about the magnitude of these changes. While the authors also find that income expectations are too pessimistic in general they do not speak to the systematic bias we find with respect to the current level of income. Massenot and Pettinicchi (2018) also use data from the Netherlands and have similar data limitations. D'Haultfoeuille et al. (2018) propose an alternative test of rationality of expectations and use it to argue that income expectations are not rational. We build on Souleles (2004), who, using the same data set as the present paper, explored forecasting errors in a wide range of variables and noted the presence of systematic biases. We improve on his methodology of constructing the income forecast errors by explicitly taking the timing of survey questions into account. Studying the forecasting errors in a much more detailed way allows us to argue for overpersistence beliefs as the cause of the observed patterns in income expectation errors. The structural model further enables us to study the effects of this bias on savings and on the distribution of MPCs. Our paper is also related to a recent study by Das et al. (2017). They document a relationship between socioeconomic status and expectations about a range of aggregate variables and interpret their results as low-status agents being too pessimistic. In contrast, our findings suggest that all agents are too pessimistic towards aggregate outcomes. For individual income expectations, on the other hand, we find a differential effect: The overpersistence bias leads high-income households to be too optimistic while low-income households turn out to be too pessimistic.

One might worry about the degree to which agents act on the expectations they express in a survey. However, there is growing evidence that people indeed make decisions that are consistent with their stated beliefs. In a financially incentivized experiment in the context of inflation expectations, Armantier et al. (2015) show that agents' actions correlate with their beliefs. Moreover, there is growing evidence that agents' expectations are sensible in the sense that different ways of eliciting beliefs are consistent with each other (point forecast versus distributions) and actions – where available – are compatible with rational expectations (De Bruin et al., 2011; Zafar, 2011). In an experiment in the housing context, Armona et al. (2018) show that financial decisions of households are informed by their expectations. Wiswall and Zafar (2015) demonstrate the connection between expectations and actions in the context of education.

The second strand of literature this paper relates to is the formulation of expectation formation. Some of the recent research has focused on assessing whether predictable forecast errors – which are at odds with standard models of rational expectations – can be generated by rational models of information frictions such as sticky information (Mankiw and Reis, 2002) or noisy information (Woodford, 2003; Sims, 2003; Mackowiak and Wiederholt, 2009). Examples here include Coibion and Gorodnichenko (2012, 2015), Andrade and Le Bihan (2013) and Kohlhas and Walther (2018). On the other hand, an increasing number of studies suggest that decision-makers do not form their expectations fully rationally (see, e.g., Cutler et al. (1990); DeLong et al. (1990); Greenwood and Shleifer (2014); Barberis et al. (2015); Gennaioli et al. (2016); Fuhrer (2017); Barberis et al. (2018); Broer and Kohlhas (2018) and Carroll et al. (2018)). The paper that is the closest to the present study in this area is Bordalo et al. (2018). They propose that decision-makers form their expectations under a representativeness bias, which effectively leads to overweighthing of the most recent innovation to income when forming expectations. In contrast, in the present setting where households overestimate the persistence of their income process, it is the current *level* of their income (rather than the last shock) that determines the forecasting error, which is supported by the predictive power of the level of income for the expectation errors that households make.

The third strand of literature that this paper directly contributes to is the literature on marginal propensities to consume. Empirically, examples of recent analyses include studies estimating the MPC out of government transfers (Johnson et al., 2006; Parker et al., 2013; Misra and Surico, 2014; Parker, 2017), housing wealth (Mian et al., 2013; Kaplan et al., 2016), transitory income shocks (Jappelli and Pistaferri, 2014), lottery winnings (Fagereng et al., 2018) or interest rate changes (Crawley and Kuchler, 2020). Recent structural models investigate the relationship between MPCs and wealth (see, e.g., Kaplan and Violante (2014) and Carroll et al. (2017)) and between MPCs and the business cycle (Berger and Vavra, 2015; Harmenberg and Öberg, 2017). The two most relevant studies for this paper in terms of modeling approach are Kaplan and Violante (2014) and Berger and Vavra (2015). Kaplan and Violante (2014) demonstrate that the presence of an asset with adjustment costs can generate realistic marginal propensities to consume out of transfer payments. Berger and Vavra (2015) show in a setting similar to ours that the phase of the business cycle further affects the MPC. We contribute to this literature by analyzing the effects of empirically relevant biases in income expectations on the behavior and MPC of households, in a model that matches both the empirical asset distributions as well as the MPCs in nondurable and durable consumption found in the literature. We show that biased and fully rational expectations have different implications for the joint distribution of liquid assets and income. Furthermore, the bias alters the distribution of MPCs across goods and across income, which affects the effectiveness of stimulus policies.

2 Household Income Expectations in the Data

In this section, we analyze micro-level data on household income expectations and show that low-income households underestimate their income growth while high-income households overestimate their income growth.

The data we analyze comes from the Michigan Surveys of Consumers. This survey interviews a representative cross-section of 500 households every month, with detailed expectation and income data available since July 1986. The households are asked about a wide range of topics, from expectations about the state of the aggregate economy, unemployment and inflation to purchasing conditions. Most importantly for the present analysis, people are also asked about their individual income expectations. Crucially, around one third of households are re-interviewed once after 6 months and they answer the same set of questions in both interviews. While we have income expectations for all households, for a subset of households we thus also have information about realized income growth. See appendix A.1 for a detailed description of the sample selection and a comparison of the income information with the Panel Study of Income Dynamics (PSID).

The survey asks households about their expected percentage growth in both income and prices. Specifically, the following questions are asked:

> *Q1a: During the next 12 months, do you expect your income to be higher or lower than during the past year?*
>
> *Q1b: By about what percent do you expect your income to (increase/decrease) during the next 12 months?*
>
> *Q2a: During the next 12 months, do you think that prices in general will go up, or go down, or stay where they are now?*
>
> *Q2b: By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?*

2.1 Construction of Expectation Errors

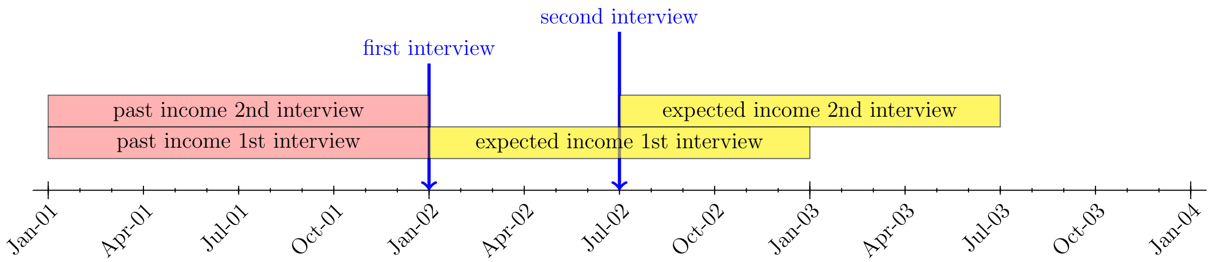
The fact that a subsample of the surveyed households is re-interviewed after 6 months allows us to confront income growth expectations with realized income changes. The basic idea is to compare expected income growth with ex post realized income growth. The challenge is, however, that there is only imperfect overlap between the periods for which households give expectations and for which they report realizations. For our baseline analysis we therefore employ imputation methods to increase this overlap. To ensure that our results are neither driven by the imputation method nor by the imperfect overlap, we also conduct two robustness checks: First, we conduct the analysis on directly reported data for a subsample of households. This analysis is completely unaffected by imputation. Second, we analyze the subsample where after imputation the overlap is perfect. To the best of our knowledge, there is no other existing survey which would allow the direct comparison of income expectations and realizations. Appendix B gives a detailed discussion of income expectation and realization data in other surveys.

The exact data structure is as follows. When reporting their income, households are asked to state their total household income in the previous *calendar year*. Expectations, on the other hand, refer to *the following 12 months*. This has two implications. First, households who are interviewed for the first time in the first half of a year (January to June) report their income twice for the same time period since their re-interview falls into the same calendar year as the first interview. Households interviewed for the first time in the second half of a year (July to December), on the other hand, are re-interviewed in the next calendar year and hence report income for two consecutive years. Only for those households do we therefore have a reported income growth realization. Figure 1 illustrates the timing problem, showing as an example the data reported by households interviewed for the first time in January 2002 (panel (a)) and July 2002 (panel (b)), respectively. The second implication of the data structure, however, is that even for households interviewed in the second half of the year, the overlap between the reported income realizations and the time period that refers to the expectations is not perfect. Figure 1(b) shows that the overlap between expected and realized income is only 6 months for a household interviewed for the first time in July. This overlap is further decreasing for August to December households.

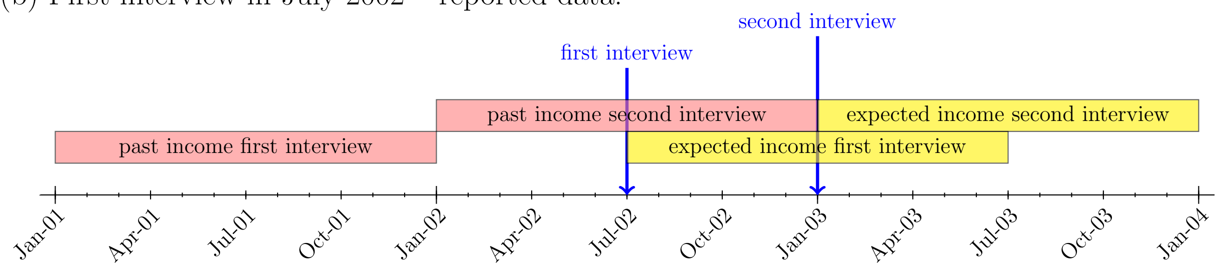
For our baseline analysis we exploit the fact that income growth reported by households interviewed in the second half of a year can be used to infer a relationship between this income growth in a particular year and the level of income as well as household characteristics in the year prior to that. We use this relationship to impute income growth realizations for the households interviewed in the first half of the year (see panel (c) of figure 1). Furthermore, to

Figure 1: Timing of Income Realizations versus Expectations

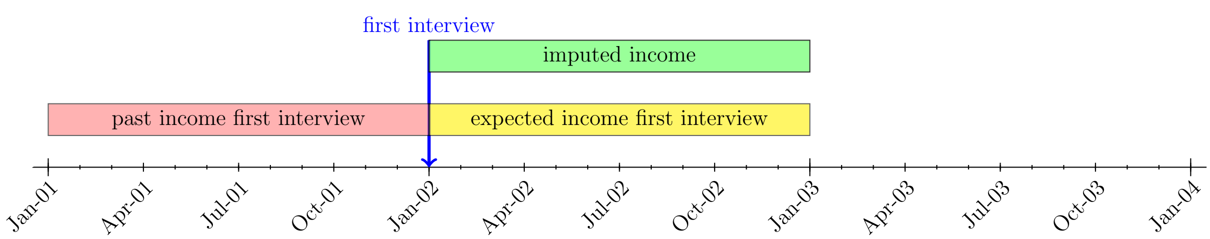
(a) First interview in January 2002 – reported data:



(b) First interview in July 2002 – reported data:



(c) First interview in January 2002 – imputed income:

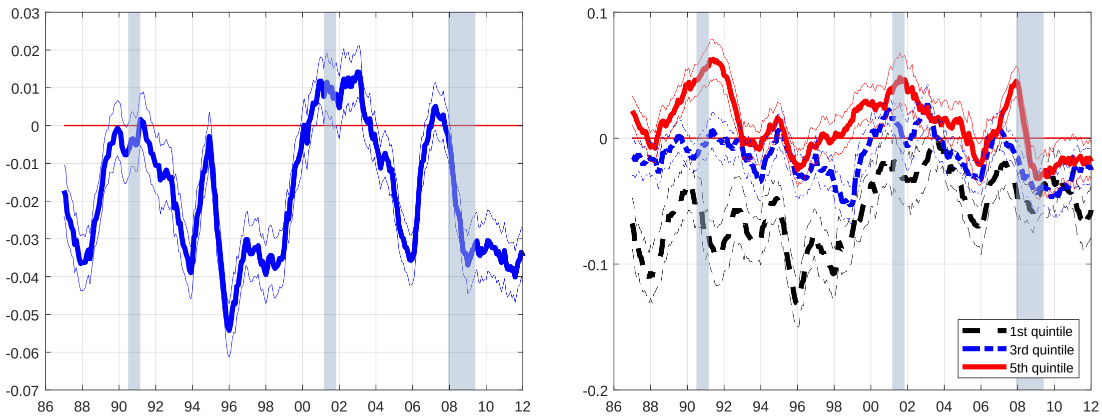


increase the overlap for households interviewed in the second half of the year, we impute their income growth using growth realizations of households interviewed in the following year. Imputation therefore both increases the number of observations and improves the timing overlap between expectations and realizations. We implement the imputation separately for each year. Our specification is therefore fully flexible regarding the effects of aggregate factors in the economy. A detailed description of the imputation procedure can be found in appendix A.2.

To ensure that our findings are not an artifact of the imputation method, we conduct the analysis also on non-imputed data for July households as there is the largest overlap for

Figure 2: Expectation Errors in Real Income Growth

(a) mean (b) mean by income quintile



Note: The figure plots the mean expectation errors in individual real income growth smoothed with 12-month moving average filter. 95% confidence intervals (bootstrapped) are included. Expectation errors are winsorized at 5% and 95%. Households are allocated to income quintiles based on the cross-sectional distribution of per-adult income in the year of the first interview. Data from the Michigan Surveys of Consumers and own calculations. Gray areas represent NBER recessions. On the y-axis, 0.01 corresponds to 1 percentage point.

directly reported data. Since we find similar results on this sample as we do on the full sample, we can be assured that our results are not driven by the imputation procedure. Moreover, we conduct another robustness check to ensure that the imperfect timing of expectations and realizations does not affect our results. We re-run our analysis on the subsample of January, the month for which the timing overlap is perfect once we have imputed income growth realizations. Since our results also hold on this subsample, we are confident the patterns we find are not driven by imperfect overlap of expectations and realizations either.

2.2 Analysis of Expectation Errors

The expectation error of household i is constructed as

$$\psi_{i,t} = \hat{g}_{i,t+1|t} - \tilde{g}_{i,t+1}, \tag{1}$$

i.e. it is equal to the difference between the household's expected growth rate in income $\hat{g}_{i,t+1|t}$ and its realized growth rate $\tilde{g}_{i,t+1}$, where $\tilde{g}_i$ is either the imputed realized growth or the directly reported realized growth rate. Under this definition of the forecast error, a household who was too optimistic about its future income growth has a positive error.

Figure 2 shows the average expectation error in real income growth over the sample period.[2] For the population as a whole, people tend to be too pessimistic about their income growth (the average forecast error is mostly negative, see panel (a)). However, there is considerable heterogeneity in the forecast error by household income. While the low-income group on average underestimates their income growth in all time periods, households in the high-income group are in fact too optimistic for prolonged periods of time. Panel (b) shows the average expectation errors for three different income groups over time. Throughout the whole time period, the expectation errors are the lowest for the lowest income group (1st quintile) and highest for the highest income group (5th quintile).

Since households in different income quintiles are likely to also differ along other characteristics, we control for other observables using the following OLS regression:

$$Z_i = \alpha + \beta X_i + \sum_{k=1}^{K} \gamma_k D_{ik} + \varepsilon_i, \tag{2}$$

where Z_i is the outcome variable of interest of household i (in this case the expectation error ψ_i), X_i is household demographics as well as dummies for the month in which this household was interviewed, and D_{ik} is dummy variable which takes the value 1 if household i belongs to income group k.[3] Table 1 shows the results of this regression. Even after controlling for other household characteristics, the effect of income in the first interview on expectation errors is highly significant and economically important. Looking at expectation errors in real income (column 1), households in the highest income quintile have on average an expectation error which is 3.5 percentage points more positive compared to households in the middle income group. At the same time, people in the lowest income group underestimate their income growth by 5.2 percentage points more than people in the middle income group.

Columns 2-4 repeat the analysis on different subsamples to ensure that the results are neither driven by imperfect overlap between the period of expectations and realizations nor by the imputation of realized changes. Columns 2 and 3 show the results when the sample is restricted to interviews in January or December only. For these months the overlap is perfect or almost perfect (11 out of 12 months), repectively. Since the results for these subsamples are very similar to the results for the full sample, we conclude that imperfect overlap does not generate our findings. Column 4 shows that the results also hold when the analysis is done on July interviews only using directly reported income changes instead of imputed

[2] In this section we focus our analysis on expectations about *real* income growth. However, the results we find are the same for *nominal* income expectations. Appendix C.1 shows the corresponding time series plots to figure 2 for nominal income expectations. Moreover, when we control for household characteristics we will also show the regression results for errors in nominal income. These results will turn out to be very similar, both quantitatively and qualitatively, to the results for real income expectations.

[3] Appendix C contains robustness checks to this specification.

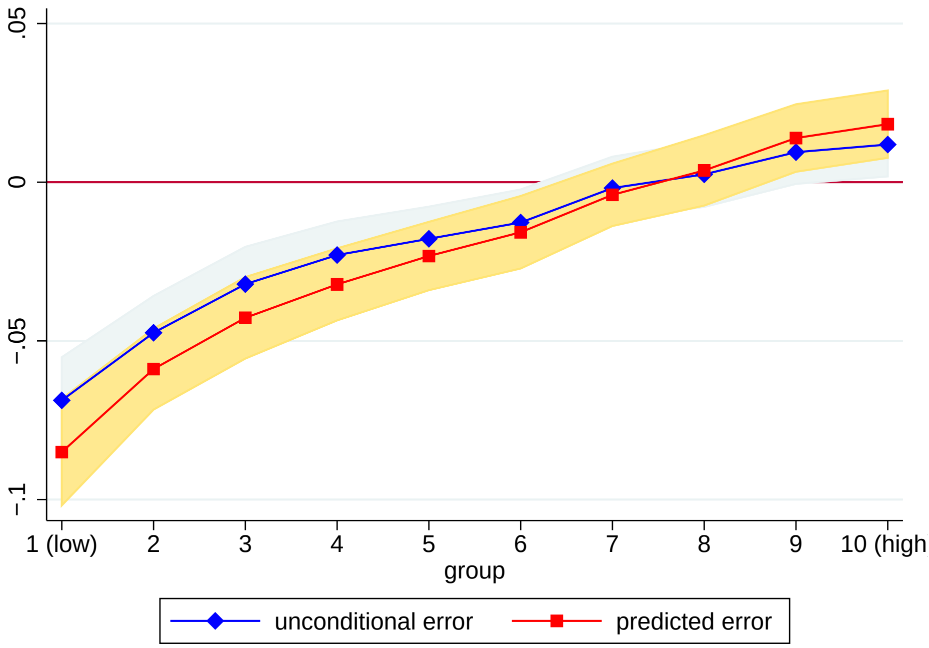
Table 1: OLS of Expectation Errors on Household Characteristics

	(1) real	(2) real	(3) real	(4) real	(5) nominal	(6) inflation
Income quintile						
1 (low)	−0.052***	−0.046**	−0.049*	−0.075***	−0.049***	0.004***
	(0.006)	(0.018)	(0.027)	(0.021)	(0.007)	(0.000)
2	−0.018***	−0.013	−0.025	−0.038*	−0.016***	0.002***
	(0.006)	(0.017)	(0.024)	(0.020)	(0.006)	(0.000)
4	0.019***	0.026*	0.030	0.025	0.018***	−0.002***
	(0.005)	(0.013)	(0.024)	(0.016)	(0.005)	(0.000)
5 (high)	0.035***	0.046***	0.040*	0.067***	0.032***	−0.004***
	(0.006)	(0.015)	(0.022)	(0.017)	(0.006)	(0.000)
Education						
no high school	0.014	0.015	0.015	0.000	0.019	0.002**
	(0.013)	(0.029)	(0.059)	(0.036)	(0.013)	(0.001)
college	−0.014***	−0.024**	−0.007	−0.032**	−0.017***	−0.003***
	(0.004)	(0.012)	(0.016)	(0.013)	(0.004)	(0.000)
Age						
age	−0.004***	−0.003	−0.007	−0.006	−0.004***	0.000***
	(0.001)	(0.003)	(0.006)	(0.004)	(0.002)	(0.000)
age × age	0.000**	0.000	0.000	0.000	0.000*	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Racial background						
black	0.019**	0.025	0.009	0.021	0.024***	0.002***
	(0.008)	(0.018)	(0.032)	(0.022)	(0.008)	(0.000)
hispanic	0.013	0.005	0.018	0.018	0.018*	0.003***
	(0.009)	(0.027)	(0.046)	(0.033)	(0.009)	(0.001)
Number of adults						
1	−0.025***	−0.004	−0.035	0.026	−0.025**	0.001***
	(0.009)	(0.026)	(0.039)	(0.042)	(0.010)	(0.001)
3 or more	0.020***	0.014	0.021	0.021	0.018**	−0.002***
	(0.007)	(0.018)	(0.030)	(0.022)	(0.007)	(0.000)
Other family characteristics						
female	−0.008*	−0.005	−0.007	−0.006	−0.002	0.005***
	(0.004)	(0.010)	(0.016)	(0.012)	(0.004)	(0.000)
not married	0.023**	0.004	0.030	−0.019	0.024**	0.000
	(0.009)	(0.024)	(0.034)	(0.040)	(0.009)	(0.000)
Region						
North Central	−0.022***	−0.023	−0.030	−0.020	−0.022***	−0.000
	(0.006)	(0.015)	(0.024)	(0.017)	(0.006)	(0.000)
North east	−0.020***	−0.021	−0.036	−0.005	−0.020***	0.001
	(0.006)	(0.017)	(0.027)	(0.018)	(0.006)	(0.000)
South	−0.018***	−0.014	−0.029	0.013	−0.017***	0.001**
	(0.006)	(0.016)	(0.024)	(0.016)	(0.006)	(0.000)
Constant	0.136**	0.097	0.170	0.132	0.131**	−0.016***
	(0.052)	(0.078)	(0.148)	(0.094)	(0.054)	(0.002)
Sample	MAIN	JAN	DEC	JULY	MAIN	INF
Imputed data?	yes	yes	yes	no	yes	no
Observations	58369	6973	2723	2805	58369	88017

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: Regression results from OLS of equation (2), where the dependent variable is the household expectation error in real income (columns 1-4), in nominal income (column 5) and in inflation (column 6). The regressions include month dummies. Standard errors account for the uncertainty induced by imputation using multiple imputation procedures based on Rubin (1987), Barnard and Rubin (1999) and Reiter (2007); without imputed data, heteroskedasticity-robust standard errors are computed.

Figure 3: Expectation Errors in Real Income by Income Group



Note: The figure shows the unconditional mean expectation error (blue line, diamonds) and predicted expectation error (red line, squares) in real income growth by income decile. Predicted expectation errors are based on regression results from table 1, column 1, except that income is split into income deciles instead of quintiles. Predicted values are computed for all other explanatory variables at the weighted sample mean. Bands refer to 95% confidence intervals (standard errors account for the uncertainty that is induced by the imputation using multiple imputation procedures based on Rubin (1987), Barnard and Rubin (1999) and Reiter (2007).). On the y-axis, 0.05 corresponds to 5 percentage points.

ones. The sample in this specification is hence not affected by any imputation. The fact that the results hold confirms that the findings are not driven by the imputation procedure. Moreover, using a completely different method and data set, D'Haultfoeuille et al. (2018) also find low-income households to be too pessimistic about their future income while high-income households turn out to be too optimistic (see their section 6.2). Even though their short sample length does not allow them to control for aggregate effects, it is striking that they come to very similar conclusions to ours.

While the coefficients in table 1 are informative about the errors in the respective income group relative to the middle income group, they cannot directly tell us whether a particular income group is too optimistic or too pessimistic. Figure 3 thus plots both the unconditional mean expectation error by income decile and the expectation error predicted by the OLS regression when all other regressors are at their sample mean. The figure shows that while low-income households underestimate their income growth, high-income households are too optimistic and overestimate their income growth. In terms of magnitudes, on average people in the lowest income quintile underestimate their income growth by 7 percentage points and people in the highest income quintile overestimate it by 2 percentage points. The systematic relationship between forecast error and income group is thus robust to controlling for other household characteristics. In fact, as seen in figure 3, controlling for other demographics increases the effect of income on expectation bias.

Are households only systematically biased with respect to their individual income expectations? Or are they also biased in their expectations about aggregate conditions? In addition to the regression results for real income expectations, table 1 also splits the results in expectation errors in nominal income (column 5) and expectation errors in inflation (column 6). While income quintiles also have a significant effect on errors in inflation expectations, column 5 shows that most of the effects on expectation errors in real income are driven by the effects on expectation errors in nominal income. This is also confirmed in figure 4 where unconditional and predicted expectation errors are plotted for expectations in nominal income and inflation. The pattern for nominal income is very similar to that of real income. The reason for this small difference is that errors in inflation expectations are almost an order of magnitude smaller than errors in individual income expectations. Moreover, note that inflation expectations are too high across the whole income distribution. While there is an economically small variation in the size of errors in inflation expectations, this variation is not strong enough to change the sign of the bias as we move along the income distribution. The small impact of inflation expectations relative to income expectations is in line with Bachmann et al. (2015) who find that consumers' spending attitudes are hardly affected by their inflation expectations.

Another aggregate variable that households in the Michigan Surveys of Consumers are asked about is unemployment. In particular, the question about unemployment expectations is the following:

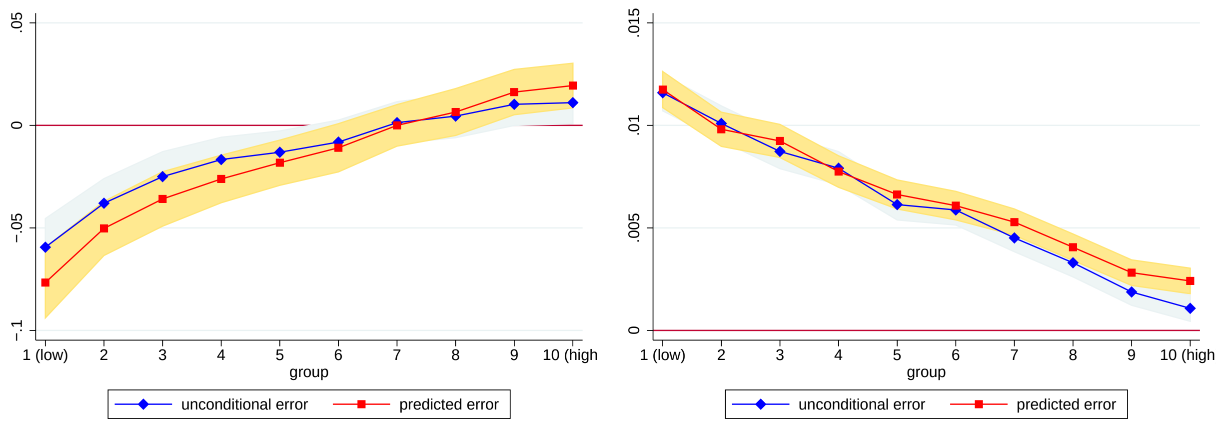
> *How about people out of work during the coming 12 months – do you think that there will be more unemployment than now, about the same, or less?*

We code an expected increase in unemployment as -1, no change as 0 and and expected decrease as 1. This categorical expectation can be compared to the realized change in the U.S. unemployment rate in the 12 months following the interview. We code a realized change within +/- 0.1% as "0: no change", an increase of more than 0.1% as "-1: increase in unemployment" and a decrease of more than 0.1% as "+1: decrease in unemployment".[4] Categorical expectation errors are then defined as "categorical expectation" – "categorical

[4]We also computed all the analyses for alternative assumptions about the band for "the same" (+/- 0.05%, +/- 0.20% and +/- 0.25%) and the results were robust to these specifications.

Figure 4: Expectation Errors by Income Group

(a) nominal income growth (b) inflation

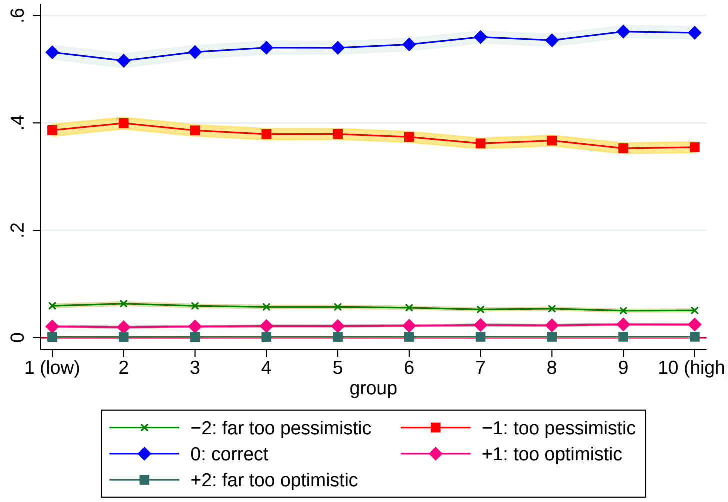


Note: The figure shows the unconditional mean expectation error (blue line, diamonds) and predicted expectation error (red line, squares) by income decile. Predicted expectation errors are based on regression results from table 1, column 5 and 6, except that income is split into income deciles instead of quintiles. Predicted values computed for all other explanatory variables at the weighted sample mean. Bands refer to 95% confidence intervals (for nominal income growth, standard errors account for the uncertainty that is induced by the imputation using multiple imputation procedures based on Rubin (1987), Barnard and Rubin (1999) and Reiter (2007); for inflation, heteroskedasticity-robust standard errors are computed). On the y-axis, 0.05 corresponds to 5 percentage points.

realization". The outcome categories for expectation errors range from "-2: far too pessimistic" to "+2: far too optimistic". We use an ordered logit regression to isolate the effect of individual income on errors in unemployment expectations (we keep the same control variables as in the analysis above). See appendix C.3 for the full regression results. Figure 5 shows the predicted likelihoods of each category for different income deciles, holding all other characteristics constant at their sample mean. The likelihood of a correct prediction is very stable around 55% to 58% for all income groups while the likelihood of being too pessimistic lies between 37% to 40%. At the same time, however, the likelihood of being too optimistic is very low for all income deciles. This indicates that – similarly to inflation expectations – people are too pessimistic across the whole income distribution. This finding of general pessimism in aggregate variables is in line with the results in Bhandari et al. (2019) who show that unemployment and inflation expectations are on average too pessimistic across various population groups (including income groups) relative to the Survey of Professional Forecasters.

The analyses in this section thus reveal two forms of bias in household expectations. First, errors in individual income expectations vary systematically with income: low-income households underestimate their income growth while high-income households overestimate their income growth. Second, households in all income groups are too pessimistic regarding

Figure 5: Unemployment Expectations: Predicted Likelihood of each Category by Subgroups



Note: The figure shows the predicted likelihoods of each outcome category of unemployment expectations (-2 (far too pessimistic) to +2 (far too optimistic)) by income decile. Predicted likelihoods are based on a ordered logit regression of categorical forecast errors in income deciles and other demographics as in previous regressions.

their forecasts of aggregate variables.

3 Expectation Formation: Overestimation of Persistence in Income Process

In this section we present a formulation for expectation formation that can generate the observed pattern in expectation errors: We argue that people overestimate the persistence of their income process. This explanation can be seen as an expression of people's failure to properly account for regression to the mean in their probabilistic judgments (Kahneman and Tversky, 1973; Kahneman, 2012). While we cannot claim that this is the only mechanism that can generate the observed patterns, we did consider various alternative explanations and found that none of them were able to account for the observed joint distribution of income and expectation errors. A detailed description of the mechanisms considered and why they are not fully consistent with the observed data can be found in appendix D.

3.1 Mechanism: Overpersistence Bias

Formally, overestimating the persistence of income can be described as follows (for proofs of all results in this section, see appendix E). Assume that income (net of age effects and the effects of other demographics) is generated by the process

$$\ln Y_{i,t} = \ln P_{i,t} + \ln T_{i,t}, \tag{3}$$

$$\ln P_{i,t} = \rho \ln P_{i,t-1} + \ln N_{i,t}, \tag{4}$$

where P_{it} is a persistent component and T_{it} is a transitory shock. Persistent income depends on past persistent income and on a shock N_{it}. Both shocks are independently and log-normally distributed with mean 1. Overestimating the persistence implies that the households believe their persistence parameter to be larger than it actually is:

$$1 > \hat{\rho} > \rho \tag{5}$$

Theorem *If the true income process is governed by equations* (3) *and* (4) *and the household overestimates the persistence of the process according to equation* (5)*,*

(a) $\exists! \bar{P}$:

$$\mathsf{E}\left[\hat{\mathsf{E}}_t[\ln(Y_{i,t+1})] - \ln(Y_{i,t+1}) | P_{i,t} > \bar{P}\right] > 0$$

and vice versa for $P_{it} < \bar{P}$*, where* $\hat{\mathsf{E}}_t[\ln(Y_{i,t+1})]$ *is the distorted expectation of* $Y_{i,t+1}$ *given information at time* t*.*

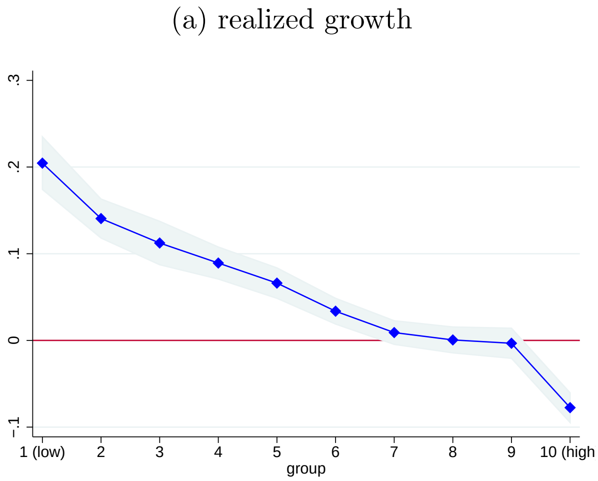
(b) *Let* $\Delta_{i,t} \equiv P_{i,t} - \bar{P}$*, then*

$$\frac{\partial \mathsf{E}\left[\hat{\mathsf{E}}_t[\ln(Y_{i,t+1})] - \ln(Y_{i,t+1}) | \Delta_{i,t}\right]}{\partial \Delta_{i,t}} > 0.$$

The proposition thus states that overestimating the persistence of the income process generates expectation errors in income growth that are (a) positive if the persistent income component is above a certain threshold (and negative if it is below this threshold) and (b) increasing in the distance from this threshold. Overpersistence can hence generate the pattern of systematic expectation errors observed in figure 3.

Intuitively, overestimating the persistence of the income process has the effect that people do not sufficiently account for mean reversion of income in the cross-section. This interpretation is supported by figure 6. Panel (a) shows that income is indeed mean-reverting by plotting the realized real income growth rates that are predicted for each income decile if all other household characteristics are at their sample mean. low-income households are predicted to experience a large income growth and the predicted growth is decreasing in income. high-income households, in fact, are predicted to have a negative income growth.

Figure 6: Realized Growth and Growth Expectations in Real Income by Income Group



Note: The figure shows the predicted realized growth (panel (a)) and growth expectations (panel (b)) in real income by income decile. Predicted values are based on OLS regression results from regressing individual realized growth rates or expectations on all regressors as in table 1. Detailed estimation results can be found in appendix C.4. Sample: For realized growth only directly reported income growth rates are used (first interviews in the second half of the year); for growth expectations all observations are used (with or without re-interview and all months). Predicted values computed for all other explanatory variables at the weighted sample mean. Bands refer to 95% confidence intervals (based on heteroskedasticity-robust standard errors). On the y-axis, 0.01 corresponds to 1 percentage point.

Panel (b) further plots the growth expectations that are predicted for each income decile, again holding all other characteristics constant at their sample mean. Growth expectations, like realized income growth, decrease with income. However, comparing the magnitudes we see that households fail to anticipate the magnitude of the mean reversion. We interpret this finding as evidence in favor of households overestimating the persistence of their income process.

The expectations under the overpersistence bias can also be expressed as a function of rational expectations and the history of past innovations:

Corollary *If the true income process is governed by equations* (3) *and* (4) *and the household overestimates the persistence of the process according to equation* (5)*, the distorted expectation at time* t *of income in period* $t = t+1$*,* $\hat{\mathsf{E}}_t[\ln Y_{i,t+1}] = \hat{\rho} \ln P_t$*, can be expressed as*

$$\hat{\mathsf{E}}_t[\ln Y_{i,t+1}] = \mathsf{E}_t[\ln Y_{i,t+1}] + (\hat{\rho} - \rho) \cdot \sum_{s=0}^{\infty} \rho^{s-1} \big(\mathsf{E}_{t-s}[\ln Y_{i,t-s+1}] - \mathsf{E}_{t-s-1}[\ln Y_{i,t-s+1}] \big) \tag{6}$$

where $\mathsf{E}_t[\ln Y_{i,t+1}] = \rho \ln P_t$ *is the rational expectation of income in period* $t+1$ *based on information available at time* t*.*

This implies that due to the overpersistence bias the distorted beliefs are equal to the sum of the rational expectation and a weighted sum of all innovations to past rational expectations. People under the overpersistence bias hence overreact to income shocks and the overreaction to a specific shock is persistent but decaying over time. This formulation of expectation formation is related to expectations formed by "Diagnostic Expectations" proposed in Gennaioli and Shleifer (2010) and Bordalo et al. (2018).[5] The difference is that in their setup the distortion would only be a function of the latest shock, $\hat{\mathsf{E}}_t[\ln Y_{i,t+1}] = \mathsf{E}_t[\ln Y_{i,t+1}] + \theta \cdot \big(\mathsf{E}_t[\ln Y_{i,t+1}] - \mathsf{E}_{t-1}[\ln Y_{i,t+1}]\big)$, where the parameter θ governs the magnitude of the bias due to diagnostic expectations. In contrast, with the overpersistence bias distortions accumulate over time. This persistence in distortions explains why empirically the level of income is systematically related to the forecast error households make.

3.2 Modeling and Quantifying Biased Beliefs

From the analyses in the previous sections we conclude that there are two forms of systematic bias in household income expectations: First, low-income households are too pessimistic about their income growth while high-income households are too optimistic. This pattern is consistent with people overestimating the persistence of their income process. Second, households across the whole income distribution are too pessimistic about aggregate conditions. We will now formulate how to parsimoniously incorporate these distortions in a model framework and quantify their magnitudes by matching the expectation errors in the model with those documented in the data.

We proceed in three steps. First, we assume a particular type of income process that is typically used in the quantitative literature (see, e.g., Berger and Vavra, 2015 and Storesletten et al., 2004) and parametrize this process using standard estimates from the literature. Second, we allow households to have wrong beliefs about the persistence of the process as well as to be too pessimistic about aggregate developments. Third, we calibrate these two belief parameters and show that this parsimonious representation is able to replicate the observed expectation errors across the income distribution.

[5] Note that mathematically, the overpersistence bias can be expressed in the general framework of Bordalo et al. (2018):

$$h^{\theta}(\ln \hat{P}_{i,t+1}) = h(\ln \hat{P}_{i,t+1} | \ln P_{i,t} = \ln \hat{P}_{i,t}) \cdot \left(\frac{h(\ln \hat{P}_{i,t+1} | \ln P_{i,t} = \ln \hat{P}_{i,t})}{h(\ln \hat{P}_{i,t+1} | \ln P_{i,t} = (\rho - 1) \ln \hat{P}_{i,t})} \right)^{\theta} \frac{1}{Z}$$

where $h^{\theta}(\ln \hat{P}_{i,t+1})$ is the distorted probability distribution, $\theta = \hat{\rho} - \rho$, $h(\ln \hat{P}_{i,t+1} | \ln P_{i,t} = \ln \hat{P}_{i,t})$ is the true probability distribution based on current information and $h(\ln \hat{P}_{i,t+1} | \ln P_{i,t} = (\rho - 1) \ln \hat{P}_{i,t})$ is a specific reference distribution, which in this case is a normal distribution with mean $(\rho - 1) \ln \hat{P}_{i,t}$ and variance $var(\ln N_{i,t})$. This is a different reference distribution compared to the one Bordalo et al. (2018) employ in their paper.

Underlying Income Process The exogenous income of a household is a combination of three mutually independent exogenous components: a persistent aggregate component Z_t, a persistent idiosyncratic component $P_{i,t}$ and a idiosyncratic transitory component $T_{i,t}$:

$$Y_{i,t} = Z_t \cdot P_{i,t} \cdot T_{i,t}. \tag{7}$$

Transitory shocks $T_{i,t}$ are iid log-normally distributed with

$$T_{i,t} \sim \log N\left(-\sigma_T^2/2, \sigma_T^2\right). \tag{8}$$

The idiosyncratic persistent component $P_{i,t}$ follows an AR(1) process in logs such that

$$\ln P_{i,t} = \rho \ln P_{i,t-1} + \epsilon_{i,t}^P, \qquad \epsilon_{i,t}^P \sim N(0, \sigma_P^2) \tag{9}$$

and the aggregate persistent component is a two-state Markov process

$$\mathbb{Z} = \begin{bmatrix} Z^h \\ Z^l \end{bmatrix}, \qquad \Pi_Z = \begin{bmatrix} \pi_{11} & 1-\pi_{11} \\ 1-\pi_{22} & \pi_{22} \end{bmatrix}, \tag{10}$$

where the high state refers to boom periods and the low state to recessions.

Incorporating Beliefs Motivated by our findings discussed above, we allow households to have biased beliefs about their income process. The overpersistence bias in expectations is implemented by allowing agents to believe that the persistence of the idiosyncratic component P is different from its true value. Formally, agents believe that their persistent income component evolves according to the following process:

$$\ln P_{i,t} = \hat{\rho} \ln P_{i,t-1} + \epsilon_{i,t}^P, \qquad \epsilon_{i,t}^P \sim N(0, \sigma_P^2), \tag{11}$$

where the persistence belief $\hat{\rho}$ is allowed to differ from the true persistence of the process ρ.

The pessimism in aggregate developments is implemented by allowing agents to believe that the level of the aggregate states will differ from the true levels by a factor μ:

$$\hat{Z}_{t+1} = \mu \mathsf{E} Z_{t+1} = \mu \Pi_Z(Z_t)\mathbb{Z}, \tag{12}$$

where $\Pi_Z(Z_t)$ is the row of Π_Z that corresponds to Z_t. To quantify the biases, we find both bias parameters – the overpersistence belief $\hat{\rho}$ and the pessimism parameter μ – by matching the empirically observed forecasting errors by income quintile with the ones generated in this model.

Matching Expectation Errors Before fitting the bias parameters, we need to parametrize the true income process. In the literature there is a debate about the true persistence of household income. Here in the main text we follow Storesletten et al. (2004) who estimate an income process with persistent and idiosyncratic shocks. In appendix F we show that this choice is not crucial: The overpersistence bias is able to match the observed forecast errors also for higher values of the persistence parameter, including the limit of a random walk. We transform Storesletten et al.'s (2004) income process to quarterly frequency and obtain the following parameters: The persistent income component has an autocorrelation parameter of $\rho = 0.9774$ with a standard deviation of $\sigma_P = 0.0424$. The transitory income shocks have a standard deviation of $\sigma_T = 0.1$. To determine the transition matrix for the aggregate component of income, we target the average duration of NBER recessions and booms in the post-war period (1945-2009).[6] On average in this period, booms lasted 58.4 months while recessions lasted 11.1 months. This leads to the probability of entering a recession of 6.85% and of leaving a recession of 36.04%. The levels of the boom and recession states have been chosen to reflect the average positive and the average negative deviation from trend in HP-filtered GDP. The resulting levels of booms and recessions are 1.0040 and 0.9790, respectively.[7]

We choose the overpersistence parameter $\hat{\rho}$ and the aggregate pessimism parameter μ to match the empirically observed expectation errors by income group. The parameters that match the errors are $\hat{\rho} = 0.9831$ (compared to the true persistence of $\rho = 0.9774$) and $\mu = 0.9778$. Table 2 shows that with these two parameters the model is able to match the expectation errors for all five income quintiles perfectly up to the second digit: The overpersistence belief generates the spread across the income distribution while the aggregate pessimism shifts down the expectations errors for all income groups.

Another benefit of the parsimony of this specification is that it makes the bias simple to implement in various settings. In the remainder of this paper, we focus on consumption-

[6] This specification leads to an asymmetric transition matrix. As a robustness check we have run all analyses (both the quantification of the biases as well as the solution of the complete model of consumption in the next section) also with a symmetric specification where we let the aggregate component Z_t follow an AR(1) process, parametrized as in Berger and Vavra (2015). Under this specification, all the results remain qualitatively identical and quantitatively very similar.

[7] The exact formula is

$$\text{avg\_dev} = \frac{1}{T_{pos}} \sum_{t=1}^{T} \hat{y}_t \cdot I(\hat{y}_t > 0) - \frac{1}{T_{neg}} \sum_{t=1}^{T} \hat{y}_t \cdot I(\hat{y}_t < 0) \tag{13}$$

where T_{pos} (T_{neg}) is the number of periods where $\hat{y}$ is *positive* (*negative*) in the sample and $\hat{y}_t$ is HP-filtered log(GDP). This difference between the good and the bad state combined with the fraction of time spent in booms and recessions (which results from the transition matrix) as well as the constraint that the mean of the overall process is 1 gives the levels of the two states.

Table 2: Mean Expectation Errors

	data	model
income quintile 1	-0.072	-0.069
income quintile 2	-0.037	-0.037
income quintile 3	-0.019	-0.021
income quintile 4	-0.000	-0.007
income quintile 5	0.016	0.021

Note: Data moments are the expectation errors predicted by equation (2) when all control variables apart from income are held constant at their sample mean.

saving implications. However, using this specification it would be straightforward to implement and study the overpersistence bias in other settings, for example in a model of asset pricing.

4 Implications of Biased Income Expectations

In this section we analyze how the distortions that we documented in income expectations affect consumption and saving decisions and investigate their aggregate implications. To do so we insert the representation of beliefs that we fitted in the previous section into a standard incomplete markets, heterogeneous agent model in the tradition of Bewley (1986) and Deaton (1991). Kaplan and Violante (2014) argue that it is crucial to include an illiquid asset into structural models to be able to match MPCs across the wealth distribution. To be able to meaningfully analyze the distribution of MPCs, we therefore include a durable good in our quantitative analysis. Our model setting is close to the one used by Berger and Vavra (2015). Apart from allowing for biased income expectations, the most important difference is in the treatment of the borrowing constraint. Whereas Berger and Vavra (2015) assume that agents can only save (no borrowing), we allow households to borrow up to a limit determined by their income state and durable holdings. This assumption is not only more realistic, but it also has important consequences. A significant fraction of U.S. households hold negative liquid assets. In order for the model to fit the data, borrowing is hence essential. However, fitting the distribution of how much people borrow, as opposed to only the fraction of households that borrow, is challenging for the class of models that we study. In section 4.2, we show that including the bias in income expectations as seen in the data allows the model to replicate the empirical distribution of borrowing. In section 4.3, we use the calibrated model to analyze how the overpersistence bias alters the behavior compared to an identically parameterized model under rational expectations. Finally, in section 4.4, we demonstrate the economic importance of the bias. We turn to a simplified calibration where we calibrate an exogenous borrowing constraint to fit the share of households with positive liquid assets. Since the rational model generates more borrowing, it requires a tighter borrowing constraint to fit this data moment. We show that this amplifies the effects of biased expectations, which leads to economically large differences in the distribution of MPCs and hence to large differences in the assessment of government stimulus policies.

4.1 Model Setup

We consider the following partial equilibrium framework. Households are infinitely lived and derive utility from two sources: a non-durable consumption good and a flow of services from a durable good. The stock of durable goods depreciates and is subject to non-convex adjustment costs. Households hence optimally adjust their durable holdings only infrequently. In addition to durable goods, households can also invest in a riskless liquid asset which they can also use to borrow. The only source of risk the households face is fluctuations in their exogenous income.

Households maximize their discounted life-time utility (to simplify notation we have dropped the subscript i which indicates the individual household)

$$\max_{\{c_t\}_{t=0}^{\infty},\{d_t\}_{t=0}^{\infty},\{s_t\}_{t=0}^{\infty}} \quad \sum_{t=0}^{\infty} \beta^t \ \mathsf{E}\big[U(c_t, d_t)\big], \tag{14}$$

subject to the following budget constraint

$$c_t + d_t + s_t + A(d_t, d_{t-1}) \leq Y_t + (1-\delta)d_{t-1} + R(s_{t-1}). \tag{15}$$

Households have available resources based on their income Y_t, the value of their depreciated durable stock $(1-\delta)d_{t-1}$, and the current value of the liquid asset holdings they chose in the previous period $R(s_{t-1})$. The current value of their liquid assets is determined as follows:

$$R(s_t) = [1 + r\,(s_t)]s_t \text{ where } r(s_t) = \begin{cases} r^l & \text{if } \ s_t > 0 \\ r^b & \text{if } \ -(\kappa_y P_t + \kappa_v d_t) \leq s_t \leq 0 \end{cases} \tag{16}$$

where $r^b > r^l$. Households can either save or borrow in liquid assets but have to pay a higher rate of interest for borrowing than they obtain when they are saving. The borrowing limit $(\kappa_y P_t + \kappa_v d_t)$ depends on their current persistent income (a loan-to-income constraint $\kappa_y P_t$) and the value of their durable stock (a loan-to-value constraint $\kappa_v d_t$). Our endogenous specification of the borrowing constraint departs from the practice of a fixed borrowing limit that is prevalent in the literature. We will show in section 4.4 that under the assumption of a fixed borrowing limit, the model with biased income expectations requires a less restrictive borrowing limit to fit the data than a rational model. This turns out to have significant consequences for the distribution of marginal propensities to consume and for the effectiveness of stimulus policies.

Households spend their available resources on non-durable consumption c_t, liquid assets s_t and the new durable stock d_t subject to adjustment costs $A(d_t, d_{t-1})$:

$$A(d_t, d_{t-1}) = \begin{cases} 0 & \text{if } d_t = (1-\delta)d_{t-1} \\ F^d(1-\delta)d_{t-1} & \text{otherwise.} \end{cases} \tag{17}$$

Equation (17) states that there are no adjustment costs if the household chooses to keep its depreciated durable stock, i.e. $d_t = (1-\delta)d_{t-1}$. On the other hand, if the household adjusts its durable stock, it has to pay adjustment costs equal to fraction F^d of the depreciated stock before the it is free to choose any new level of durable stock d_t.

Finally, the period utility function is

$$U(c,d) = \frac{\left[\left((1-\theta)c^{\frac{\xi-1}{\xi}} + \theta(\bar{d}+d)^{\frac{\xi-1}{\xi}}\right)^{\frac{\xi}{\xi-1}}\right]^{1-\gamma}}{1-\gamma}. \tag{18}$$

Note that every household obtains utility from a small free stock of durable $\bar{d}$. This captures the fact that even a very old car with almost zero resale value can be used as means of transport. This specification of the utility function hence enables the model to match the empirical distribution of durable stocks with its substantial share of low values.

The only source of risk in the model is income risk. We assume that income follows the process as described in the previous section (equations (7)-(10)) and that households have biased beliefs according to equations (11) and (12).

4.2 Matching the Model to the Data

The model is calibrated at quarterly frequency. We proceed in two steps. First, we set the parameters of the environment (interest rates, borrowing constraints, depreciation rate and adjustment costs) exogenously according to either our empirical estimates or results from the literature. Second, we calibrate the remaining preference parameters to match the empirical distributions of liquid assets and durable holdings. Note that the belief parameters are independent of the specification of the consumption model so that we can use the parameters obtained in the previous section. Table 3 reports the complete parametrization.

Exogenous Parameters of the Environment Households can both save and borrow in the liquid asset but earn a rate of return that depends on their balance. The interest rate for saving is set to the mean real interest rate on 3 month treasury bills in the post-war period

Table 3: Parameter Values

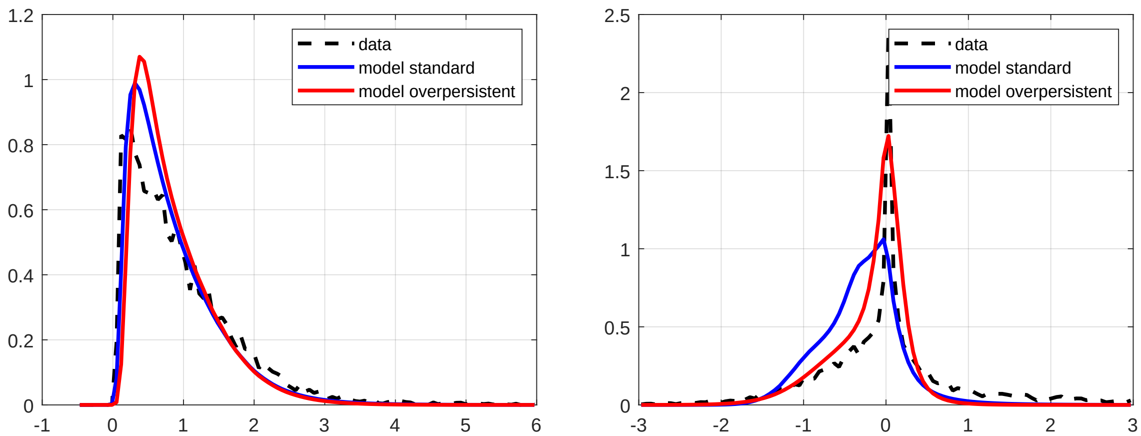
Parameter		Value
technology:		
interest rate (lending)	r^l	0.0016
interest rate (borrowing)	r^b	0.02
loan-to-income constraint	κ_y	0.56
loan-to-value constraint	κ_v	0.8
depreciation rate	δ	0.05
adjustment costs	F^d	0.3
income:		
persistence of idiosyncratic income process	ρ	0.9774
std. dev. of idiosyncratic persistent shocks	σ_P	0.0424
std. dev. of idiosyncratic transitory shocks	σ_T	0.1
high aggregate income state	Z^h	1.0040
low aggregate income state	Z^l	0.9790
prob. of entering recession	$1-\pi_{11}$	6.85%
prob. of leaving recession	$1-\pi_{22}$	36.04%
beliefs:		
persistence of income	$\hat{\rho}$	0.9831
aggregate pessimism	μ	0.9778
preferences:		
discount factor	β	0.9825
risk aversion	γ	1.5
weight of durable goods in utility	θ	0.075
elasticity of substitution in utility	ξ	3
free durable services	$\bar{d}$	0.5

(1948-2015). At quarterly frequency this value is equal to $r^l = 0.0016$. The interest rate for borrowing is set equal to $r^b = 0.02$ which reflects interest rates on credit cards and on car loans. Data on credit card rates is available since 1994 ("Commercial Bank Interest Rate on Credit Card Plans, All Accounts") and interest rates on car loans since 1972 ("Finance Rate on Consumer Installment Loans at Commercial Banks, New Autos 48 Month Loan"). The mean real interest rates at quarterly frequency for these two series are 0.0268 and 0.0127, respectively. Since households in the model borrow at the same rate against their income (which reflects credit card debt) and against durables (which resemble auto loans), we set the borrowing rate to 0.02, a value that is roughly in the middle of the two interest rates. Moreover, this value is well within the range of interest rates on car loans for new and used cars documented by Attanasio et al. (2008) for the Consumer Expenditure Survey.

To set the loan-to-income constraint, we turn to data from the Survey of Consumer Finances and compare the credit card limit of an individual household to its quarterly income.

Figure 7: Model Fit

(a) distribution of durable goods (b) distribution of liquid assets



Note: The figure depicts the distribution for (a) durable goods and (b) liquid savings. Data distributions (dash-dotted black line) are compared to the distributions implied by the model which allows for biased expectations (solid red line) and the model where expectations are assumed to be rational (solid blue line). The x-axis is normalised by the value of median quarterly income.

On average in the period 1992-2010, households have a borrowing limit that represents 56% of their quarterly income. We hence set $\kappa_y = 0.56$. Moreover, we further assume that households can borrow up to 80% against the value of their durable and set $\kappa_v = 0.8$. This is in line with Attanasio et al. (2008) who report that the average finance share for households buying cars is 0.78.

To determine the depreciation rate δ and the proportional adjustment costs F^d, we proceed as follows. The adjustment costs can be understood as the share of value a car loses just because it is sold to another person, i.e. the fraction of the purchase price which is not recovered if a car was resold immediately after the original purchase. We assume that this fraction is equal to 30% compared to the original value of the car and hence set $F^d = 0.3$. Furthermore, we assume that the resale value of a durable is negligible after 10 years. Given the adjustment costs F^d, this is the case for a quarterly depreciation rate of 5%. We therefore set $\delta = 0.05$.

Preference Parameters The remaining five parameters are the preference parameters which affect the trade-off between non-durable consumption and the durable good $(\theta, \xi, \bar{d})$, risk aversion (γ), and the discount factor (β). The values of these parameters are chosen to match the aggregate distribution of liquid assets and the stock of durable goods in the data.

The data distributions we target have been obtained from the Survey of Consumer Finances (SCF), waves 1992-2010. The data counterpart for liquid assets is the sum of checking accounts, savings accounts, stocks, bonds, and mutual funds minus outstanding credit card debt after the last payment and outstanding car loans. Durable goods are defined as the current value of all vehicles belonging to the household. To eliminate the effects of life-cycle savings, we focus on the sample of vehicle owners aged 25-55.

The optimal parameter values are found using a grid search procedure. The resulting values are the discount factor $\beta = 0.9825$, risk aversion $\gamma = 1.5$, weight of durable goods $\theta = 0.075$, elasticity of substitution between durables and non-durables $\xi = 3$, and free durable services $\bar{d} = 0.5$.

Model Fit of Asset Distributions (targeted) Figure 7 shows that the model is able to replicate key features of the distributions of both durable goods and liquid assets. The model achieves a very good fit for the distribution of durable goods in the economy. In terms of liquid assets, the model succeeds in replicating the mass of households with zero liquid assets. It is important to stress that each of the two distributions is an infinite dimensional object and the model has only five parameters to achieve a good fit. The model struggles to replicate the thick right tail of the liquid assets distribution. In the model agents hold liquid assets for transactionary (due to the adjustment costs in durables) and precautionary reasons. It does not, however, capture life-cycle motives for savings, nor does it include heterogeneity in preferences or heterogeneity in returns that households earn on their investments. Life-cycle savings motives have been shown to help generate wealth inequality (see, e.g., De Nardi and Fella (2017) for a survey). Moreover, recent evidence shows that empirically, heterogeneity in returns is pronounced and can explain the large concentration of wealth at the top (Fagereng et al., 2016; Bach et al., 2017). Hubmer et al. (2017) show that Bewley-type models like the one in this paper are not able to match the asset concentration at the top without adding heterogeneity in both preferences and returns. They also find that even with both of these sources of heterogeneity, the models are unable to match the wealth holdings at the very top. Since our focus here is not on the top end of the wealth distribution, we choose to abstract from these additional complexities.

Model Fit of Marginal Propensities to Consume (untargeted) Next, we scrutinize the fit of the model by comparing the simulated MPCs with their empirical counterparts from the literature. MPCs were not targeted when determining the preference parameters so that this comparison can serve as a test for the overall fit of the model. Because the durable good is calibrated to represent cars (not housing), the model generates a wide set of predictions that can be brought to the data. We report separately the marginal propensity to consume in nondurable consumption (MPC), the marginal propensity to spend on durables

(MPD), and the marginal propensity for total expenditures (MPE), where total expenditures combine nondurable consumption and durable expenditures but exclude adjustment costs.

The most relevant empirical estimates can be found in Johnson et al. (2006), Parker et al. (2013), and Misra and Surico (2014) for the reactions to the 2001 and 2008 stimulus payments in the U.S., as well as in Fagereng et al. (2018) who report the MPE from an ideal natural experiment of lottery winnings in Norway. The simulated marginal propensities to spend on the different goods have been constructed as the change in expenditures in reaction to a one-time, unanticipated transfer of 5% of median income. This size is comparable to the actual transfer people received in 2001 and 2008 in the U.S.. The technical details of the procedure to construct the MPC in the simulation are described in appendix G.2.

Figure 8 shows the cumulative response in nondurable consumption (panel (a)) and total expenditures (panel (b)). The model predicts an average MPC on impact in nondurable consumption of just below 10% and that 38% of the transfer is on average spent on durables, resulting in an MPE of 47% of the transfer being spent on impact. Over the course of the first year, almost 75% of the transfer is spent in total (25% is spent on nondurables). Over longer horizons, the contribution of nondurables increases.

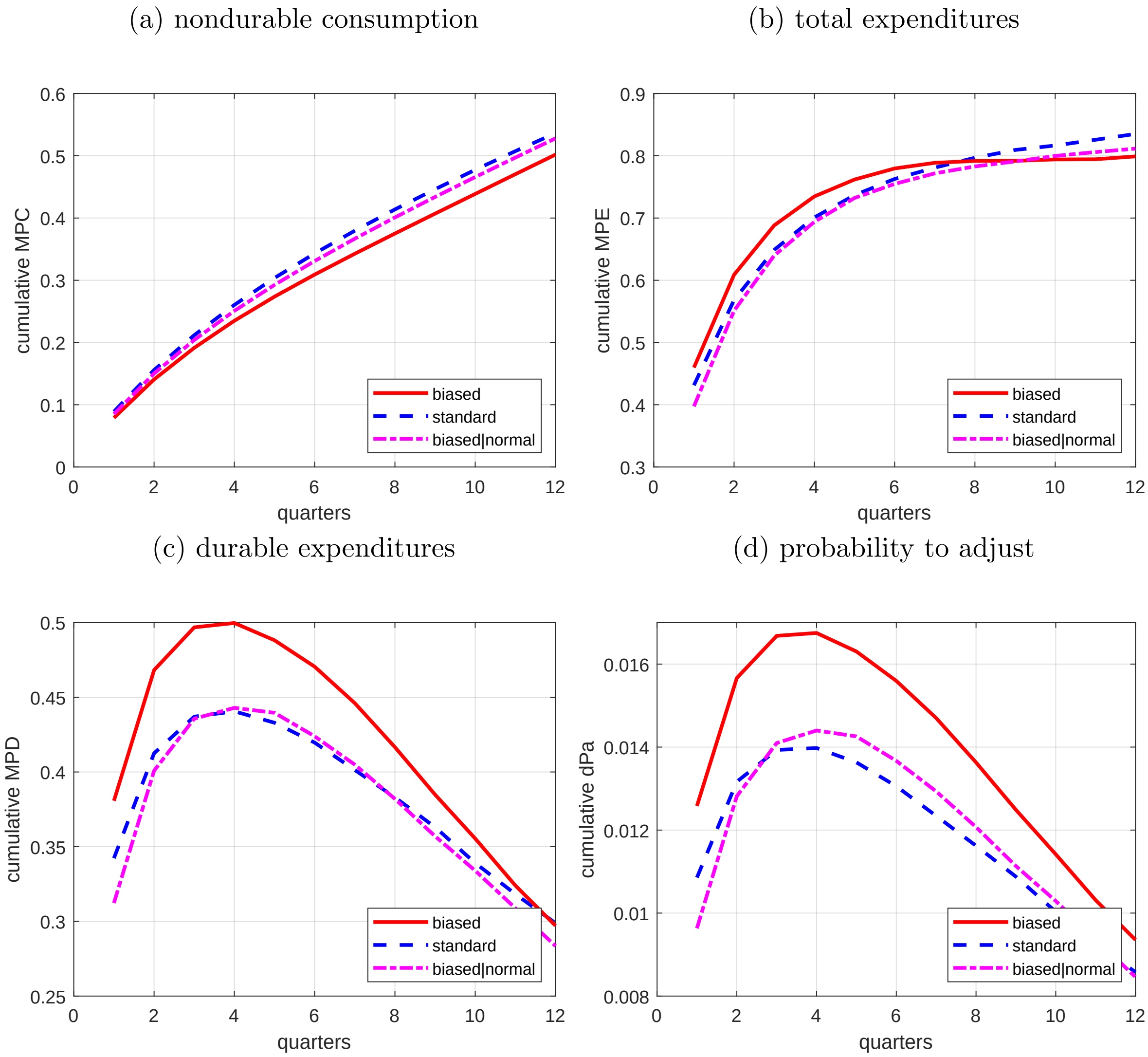
How do these numbers compare to empirical studies?[8] In the quarter of the transfer, Souleles (1999, table 5) finds an MPE of 0.34 or 0.64 (depending on the estimation method). For the same horizonn Parker et al. (2013, table 2) report an MPE of 0.516. The simulated MPE in the model of 0.47 lies well within one standard error of any of these estimates. At the 6-months horizon, Fagereng et al. (2018, table 4) report that 52% of the lottery winnings are spent, which is very close to the simulated counterpart of 60%.

How about the split between nondurables and durables? Parker et al. (2013, table 2) report MPCs of 0.079 and 0.121 for "*strictly nondurables*" and "*nondurable*" spending, respectively. Similarly, Souleles (1999) finds the MPC to be 0.045-0.093 on strictly nondurables. The model matches these estimates with an MPC of just below 10% for nondurables. Turning to durable expenditures, Souleles (1999) report an MPD of 0.294-0.537 for all durables (0.166-0.24 for vehicles). Parker et al. (2013, panel E, table 7) find an MPD of 0.527 for vehicles. In contrast, Fagereng et al. (2018) find only 3% of lottery winnings is spent on cars and boats. The simulated MPD of 0.38 in the model is again well within the range of these empirical estimates.

Moreover, consistent with the empirical findings reported by Misra and Surico (2014), the model generates large heterogeneity in responses: First, the vast majority of households

[8] To compare our results with empirical studies, we use point estimates reported in the literature. Needless to say that there is often large uncertainty around these estimates. For a recent overview of the empirical findings, see Carroll et al. (2017, table 1).

Figure 8: Reaction to an Unexpected Transfer



Note: The figure depicts how much of an unanticipated transfer households spend over time. Panel (a) depicts expenditures in nondurable consumption, panel (b) depicts total expenditure, panel (c) depicts durable expenditures, and panel (d) depicts the change in the probability to adjust the durable stock. All results are cumulative. The transfer size is equal to 5% of median quarterly household income.

(over 95%) do not adjust their durables, neither with nor without the transfer, which results in their MPD being 0. Second, there is a small group of households (just below 3%) who were adjusting even in the absence of the transfer. For these households, the average MPD is roughly 1/3. Finally, there is an even smaller group of households (just above 1%) who would not have adjusted their durable stock without the transfer, but decide to do so when they receive the transfer. The transfer thus makes them move the adjustment date forward. For these households, the MPD is much larger than 1, because the size of the durable purchase is an order of magnitude larger than the size of the transfer. Cumulatively, the effect on durable expenditures peaks at one year, suggesting that the households who were induced to buy a car when they got the transfer were close to buying one even in the absence of the transfer. This shows that both the intensive and the extensive margin of durable purchases are operating and important for investigating MPDs.

To summarize, we conclude that the model with biased income expectations not only captures well the targeted distributions of liquid assets and durable goods but is also able to capture well the untargeted patterns of MPCs documented in the literature. This is true for both the overall expenditures as well as for the split between expenditures on durable and nondurable goods.

4.3 Effects of Biased Income Expectations

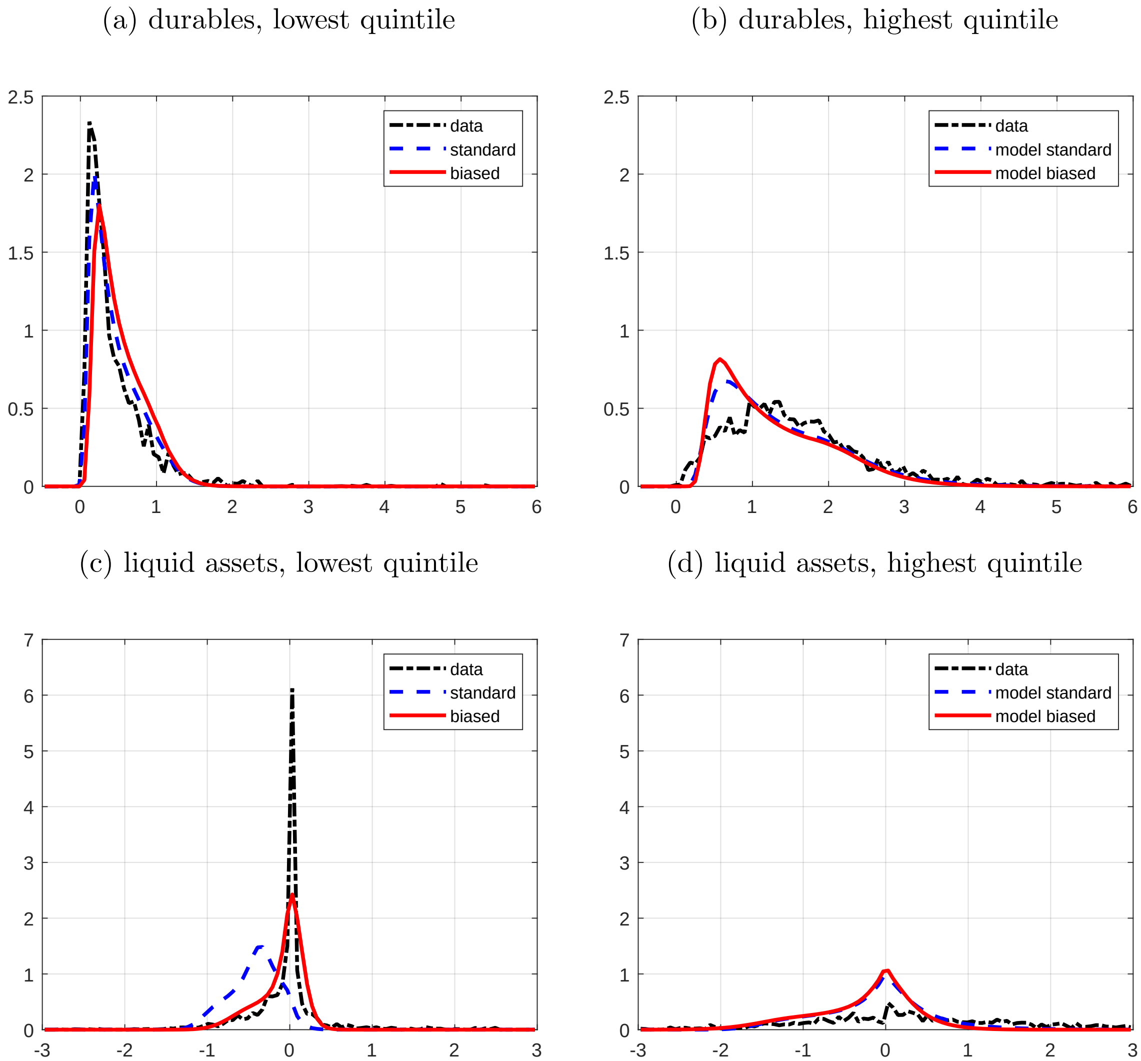
In this section we show how the beliefs about income expectations affect the behavior of households in different income groups. To do so we compare the implications of the calibrated model with biased expectations to the implications of the same model under rational expectations (i.e. same parametrization). This highlights the effect of biased income expectations holding everything else equal.

We demonstrate that the overpersistence bias in expectations allows the model to fit the joint distribution of income and liquid assets. Above all, incorporating biased expectations reduces the amount low-income households borrow, which is consistent with the data. Furthermore, we show how biased income expectations affect the consumption responses to unanticipated transfers. The overpersistence bias affects the MPC, MPD and MPE differentially across the income distribution. low-income households turn out to have a lower MPC in nondurables if they have biased expectations while the corresponding MPC of high-income households is hardly affected by the beliefs. The differences in MPCs across the income distribution are hence smaller than what would be predicted under rational expectations. Moreover, the overpersistence bias makes the extensive margin of durable purchases more responsive to the transfer. This increases the MPE of households with biased expectations relative to that of rational agents for all but the very income-poorest households.

4.3.1 Effects on Behavior Across Different Income Groups

Figure 9 shows the distribution of durable goods and liquid assets for households in the lowest and highest income quintiles. The model is able to match the cross-sectional variation in durable holdings (panels (a) and (b)). This is true for both the model that allows for the expectation bias and for the fully rational model. In terms of durable holdings, biased expectations hence do not change the distributions much compared to the distributions

Figure 9: Distribution of Assets across Income Groups



Note: The figure depicts the distribution of durable goods and liquid assets for different income quintiles. The panels show the data distribution (dash-dotted black line) against the model distribution when households have biased expectations (solid red line). For comparison, the distribution under rational expectations is also plotted (dashed blue line).

implied by rational expectations.

However, this is not true for the distribution of liquid assets. Figure 9, panels (c) and (d), shows the distribution for liquid assets for the two different income quintiles. While the distribution in the highest income group is not much affected by biased income expectations, the behavior of the lowest income group depends on what households believe about their future income. low-income households with biased beliefs are too pessimistic about their future income. They are therefore less willing to borrow even though their borrowing constraint is not binding. Figure 9(c) shows that this mechanism allows the model with biased income expectations to fit the empirical distribution of liquid assets in the lowest income group very well. It is important to note that with biased beliefs, low-income households choose not to borrow more even though they could. If people had rational expectations instead, the model would predict counterfactually large amounts of borrowing (mode of -0.5 versus 0 in the data).

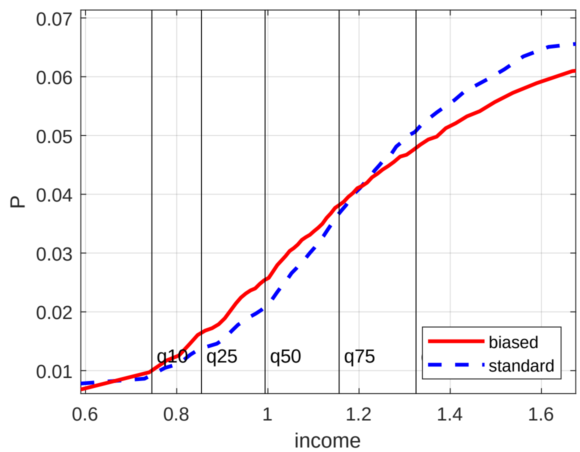
Figure 10 shows in more detail the heterogeneity of how the overpersistence bias alters the behavior. Panel (a) displays the probability of adjusting the durable stock for each percentile of the income distribution. It shows that the likelihood of adjusting the durable stock increases monotonically as income increases. However, allowing for biased expectations flattens this income gradient: Households in the bottom 80% of the income distribution adjust their durable stock more frequently than their rational expectation counterparts. Panels (b) to (d) detail the behavior given adjustment. Allowing for biased expectations very slightly reduces the size of the purchased durables for the whole income distribution except for the very lowest-income households. More striking, however, are the differences in consumption and savings at time of purchase: Biased expectations reduce the average amount of borrowing for lower income households and increase the amount of borrowing for high-income households. At the same time, lower income households consume less while high-income households consume more than their rational expectation counterparts. This effect on consumption and borrowing is the direct effect of biased expectations: Low-income households are too pessimistic about their future income and therefore want to save more (or borrow less). High-income households, in contrast, are too optimistic and are hence willing to spend more and borrow to finance these expenditures.

4.3.2 Implications for Marginal Propensity to Consume

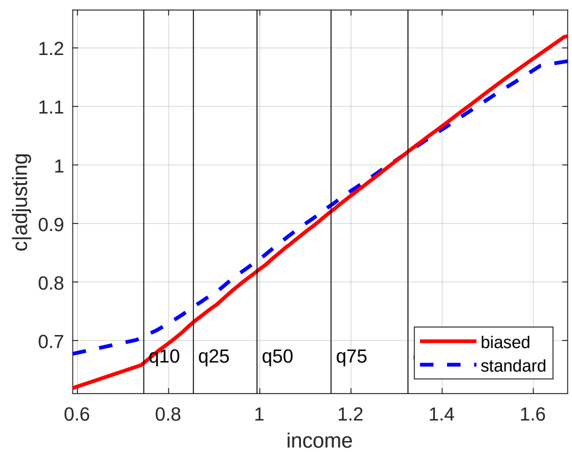
Turning to the effects of the bias on MPCs, figure 8, panel (a), shows that the average MPC in nondurable goods is lower for households with overpersistence bias compared to rational households. At the same time, however, durable expenditures are more responsive to transfers if households have biased beliefs (figure 8, panel (c)). The reason is that under biased beliefs more households are induced to move their adjustment date of durable stocks forward (panel (d)) while they spend less of the transfer conditional on adjustment. They thus react more on the extensive margin while reacting less on the intensive margin. Note that the differences in behavior are the result of two sources. First, biased beliefs imply that households have different expectations about their future income compared to rational agents. Second, they already had biased expectations in the past and hence made different consumption-savings decisions. They therefore have a different asset position than their rational expectations counterparts. Figure 8 shows that most of the differences in the durable

Figure 10: Income Gradient of Probability to Adjust and Behavior at the Time of Adjustment

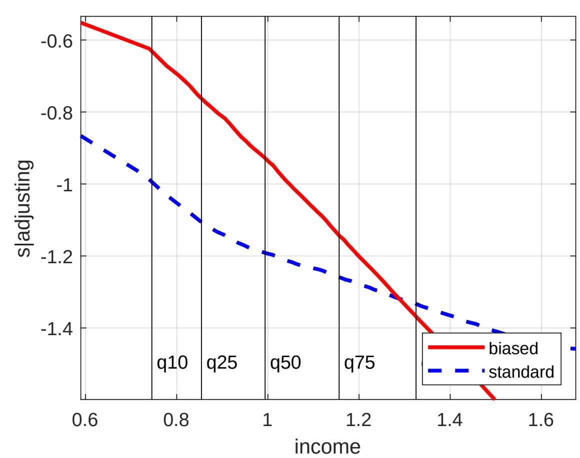
(a) probability of adjusting



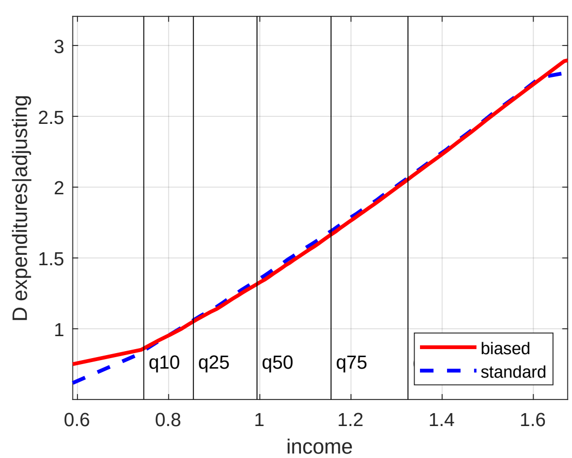
(b) C, conditional on adjusting



(c) s, conditional on adjusting



(d) D, conditional on adjusting



Note: The figure depicts the average behavior across the income distribution under different expectation scenarios: red line depicts the behavior under biased expectations, the dashed blue dashed line depicts the behavior under rational expectations and the magenta dash-dotted line shows what the behavior of the overpersistent population would be if they were given the liquid assets and durable stock of the rational agents. The figure displays the behavior within the 1st and 99th percentile of the income distribution, and the vertical lines denote the 10th, 25th, 50th, 75th, and 90th percentile, respectively.

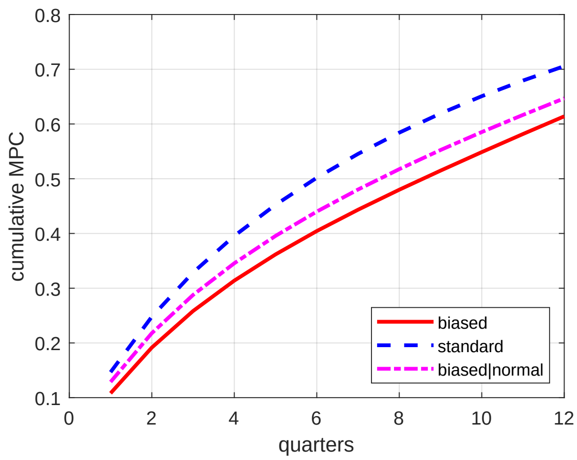
consumption response are due to the second effect. The dash-dotted magenta line depicts the response in durable expenditures if households have biased beliefs going forward but currently have the asset position of rational agents. We see that this response is much closer to the response in the rational model which indicates that biased beliefs mainly alter durable consumption responses through their effect on the asset position.

How do biased expectations affect the distribution of MPCs? Figure 11 depicts the differential effect of the bias on the MPC in nondurables for low and high-income households. Panel (a) shows that low-income households with biased expectations have an MPC in nondurables that is between 3-11 percentage points lower than the MPC of rational households, depending on the horizon. These differences are the result of the same two forces as explained above: First, low-income households with biased expectations are too pessimistic about their income going forward. This implies that they are more cautious about spending the transfer payment and more likely to save out of it. Second, they have a different asset position compared to their rational expectations counterparts. Since they have already been too pessimistic in the past, they are less likely to be close to the borrowing constraint. Figure 11 shows that both of these forces contribute to the reduction in the MPC of biased households and that the magnitude of the two effects is similar. Households in the highest income quintile, on the other hand, spend about the same fraction of the transfer payment on nondurables whether they have biased expectations or not (panel (b)). Figure 11, panels (c) and (d), displays the corresponding impulse response functions for total expenditures. In this case, low-income households have a similar MPE during the first 1.5 years after the transfer whether they have biased expectations or not. This is because the effect of differing expectations and differing asset position cancel each other out. For high-income households, on the other hand, both effects are positive. The overpersistence bias hence increases the MPE for the high-income group.

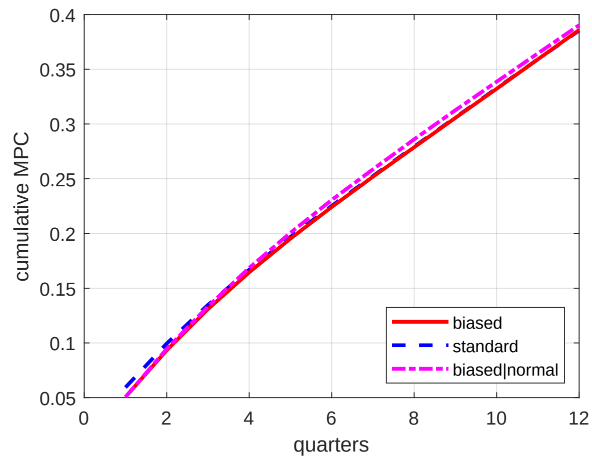
Figure 12 shows in more detail the heterogeneous effects of biased expectations across the income distribution. It depicts the MPCs, MPEs, MPDs on impact, and the change in propensity to adjust due to an unexpected transfer. Panel (a) shows that under both rational and biased expectations the MPC in nondurable consumption is falling in income. Under biased expectations this income gradient is similar across the whole income distribution. In contrast, under rational expectation, the MPC is much larger for the lowest-income households. This emphasizes that the bias has the most effect on the lowest-income households. Panel (b) shows that the MPE is increasing with income across the whole income distribution. This increasing slope is driven by durable expenditures (panel (c)). Panel (d) further shows that as a reaction to the transfer the likelihood of adjustment increases, in particular for the middle income groups. All else being equal, having biased income expectations increases the effect that the transfer has on the likelihood of adjusting for the bottom 75% of the income distribution. This translates into a higher MPD for these income groups. The average MPE is also higher for these income groups except for the lowest income group. For these households, the decrease in MPC is strong enough to overcompensate for the increase in MPD. For the lowest income group, even the MPE is thus lower under biased expectations than under rational expectations.

Figure 11: Cumulative MPC and MPE out of Unexpected Transfer by Income

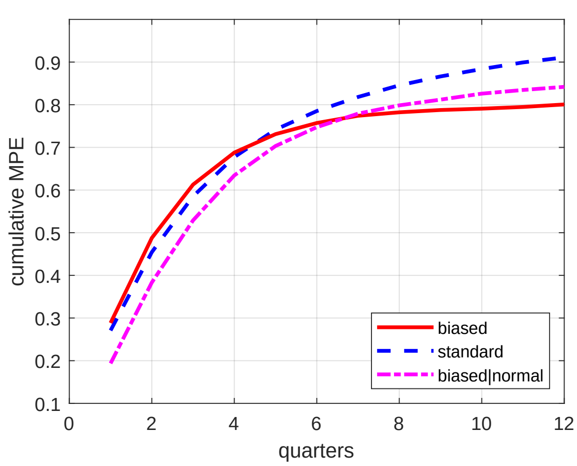
(a) MPC, lowest income quintile



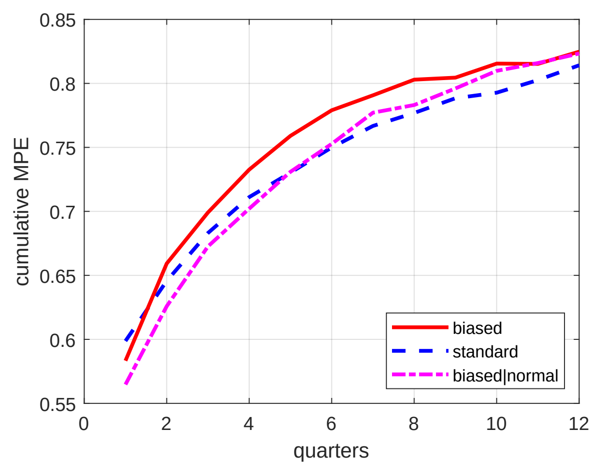
(b) MPC, highest income quintile



(c) MPE, lowest income quintile



(d) MPE, highest income quintile



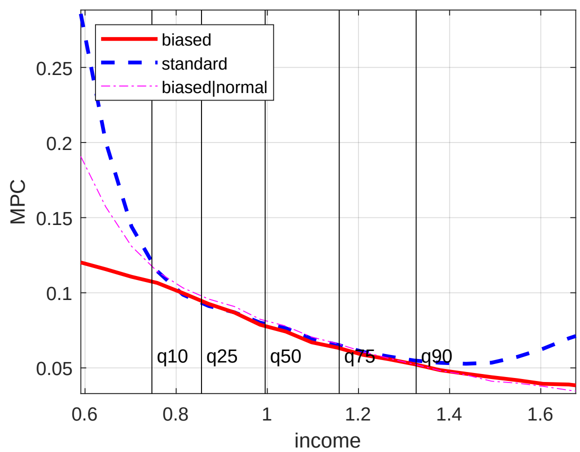
Note: The figure depicts the fraction of an unanticipated one-time transfer payment that is spent on non-durable consumption and total expenditures under different expectation scenarios: red line depicts the behavior under biased expectations, the dashed blue dashed line depicts the behavior under rational expectations and the dash-dotted magenta line shows what the behavior of the overpersistent population would be if they were given the liquid assets and durable stock of the rational agents. Panels (a) and (c) show the results for the lowest income quintile, panels (b) and (d) for the highest income quintile. The transfer size is equal to 5% of median quarterly income in the economy.

4.4 Aggregate Implications for Government Stimulus Programs

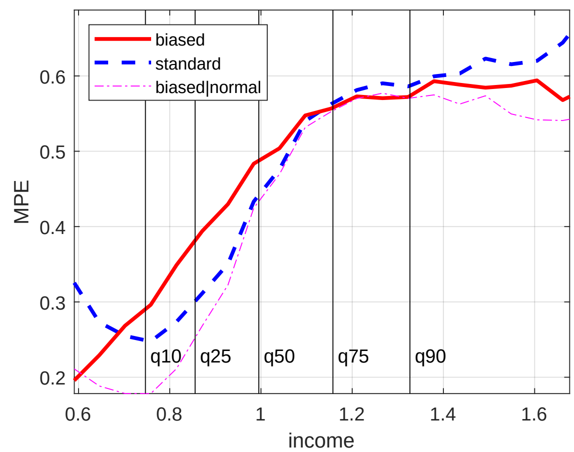
In the previous section we have analyzed the effects of biased expectations while holding all else equal, including preference parameters and the market environment. We have demonstrated that the calibrated model with biased expectations can generate the limited borrowing behavior of low-income households. However, in the fully rational counterpart to

Figure 12: Income Gradient of Marginal Propensities to Consume

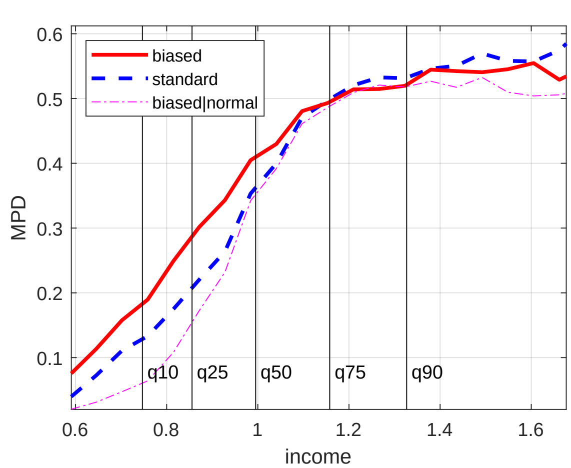
(a) nondurable consumption



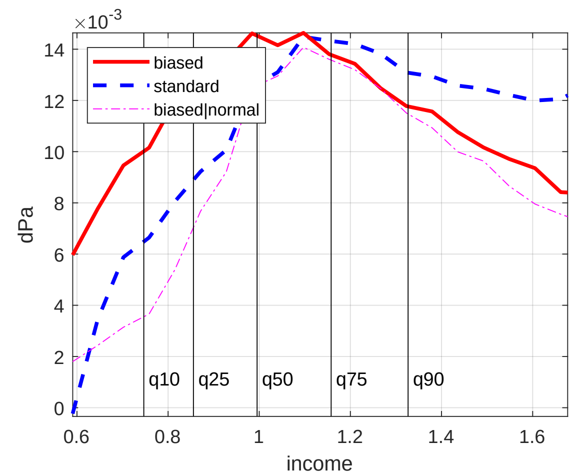
(b) total expenditures



(c) durable expenditures



(d) probability of adjustment



Note: The figure depicts the average MPC across the income distribution under different expectation scenarios: red line depicts the MPC under biased expectations, the dashed blue dashed line depicts the MPC under rational expectations and the dash-dotted magenta line shows what the MPC of the overpersistent population would be if they were given the liquid assets and durable stock of the rational agents. The figure displays the behavior within the 1st and 99th percentile of the income distribution, and the vertical lines denote the 10th, 25th, 50th, 75th, and 90th percentile, respectively.

this model, these households borrow too much compared to the data. In order to reduce this excessive borrowing one can make the borrowing behavior an explicit target for the calibration and calibrate an exogenous borrowing constraint to fit this data moment. In this section, we follow this approach for both the model with biased expectations and the model with rational expectations. We show that a model with biased income expectations requires less restrictive borrowing constraints than the rational model to fit the data. This has important implications for MPCs and hence for the effectiveness of fiscal stimulus programs. These government policies are a popular instrument during recessions to boost household consumption in order to stabilize the overall economy. In both recent recessions in 2001 and 2008, the U.S. government employed this strategy by giving households one-off cash transfers. We find that the rational model predicts such stimulus policies to be substantially more effective than what the model with biased income expectations predicts.

We make the following change to the model setup: We replace the endogenous borrowing limit $\kappa_y P_t + \kappa_v d_t$, which depended on a household's income and durable stock with a constant $\underline{s}$ that is the same for all households. Equation (16) hence becomes

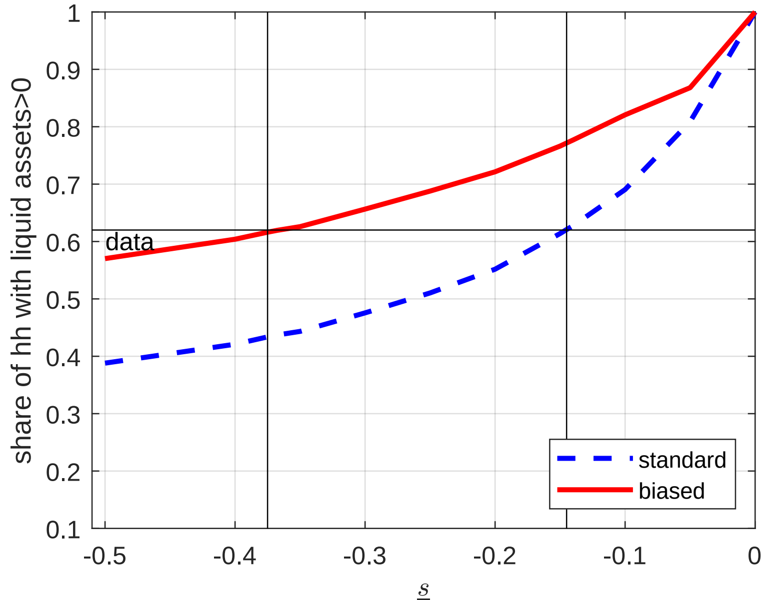
$$R(s_t) = [1 + r(s_t)]s_t \text{ where } r(s_t) = \begin{cases} r^l & \text{if } s_t > 0 \\ r^b & \text{if } \underline{s} \leq s_t \leq 0 \end{cases} \tag{19}$$

We leave all other parameters the same as in the main calibration and determine the level of $\underline{s}$ that is needed to fit the empirical share of households with positive liquid assets from the Survey of Consumer Finances (as before including the outstanding credit card balance and car loans). Figure 13 displays this share for varying levels of the borrowing limit for both the rational model and the model with biased income expectations. While in the biased model the required borrowing limit is –0.3675, the rational model needs a much tighter borrowing constraint of –0.145 to fit this data moment. With a median income of one, this difference corresponds to about 1/4 of median quarterly income.

This difference in borrowing limits amplifies the effects of expectations on the level and distribution of MPCs. Figure 14 shows that for all possible levels of the borrowing constraint, the rational model results in a higher aggregate MPC than the biased model. Moreover, the aggregate MPC increases as borrowing constraints are tightened. Taken together both effects imply that the rational model results in an aggregate MPC that is 50% higher compared to the MPC in the model with biased expectations: It is 0.18 in the rational model while the model with biased expectations leads to an MPC in nondurables of 0.12. To put this into perspective, the "Economic Stimulus Act" of 2008 provided about 100 billion U.S. dollars in tax relief to households (Shapiro and Slemrod, 2009; Parker et al., 2013). In this context, the rational model would predict that this stimulus package increases nondurable consumption by 18 billion U.S. dollars. The model with biased expectations, on the other hand, only predicts an increase of 12 billion U.S. dollars.

Moreover, the distribution of MPCs across the income distribution is affected by the different borrowing constraints. Figure 14, panel (b), displays the ratio between the average MPC of households in the lowest income quintile and the average MPC in the highest income quintile. The biased model predicts this relative MPC to be 2.2. This value is well within

Figure 13: Share of Households with Non-Negative Liquid Assets by Borrowing Constraint



Note: The figure depicts the share of households with non-negative liquid assets for model specifications with varying borrowing constraints $\underline{s}$. The solid red line refers to the model with biased income expectations; the dashed blue line refers to the rational model. The horizontal line depicts the empirical value computed from the Survey of Consumer Finances (at 0.62), the vertical lines (at $\underline{s}$ =–0.3675 and $\underline{s}$ =–0.145) mark the borrowing constraint required in either model to match the data.

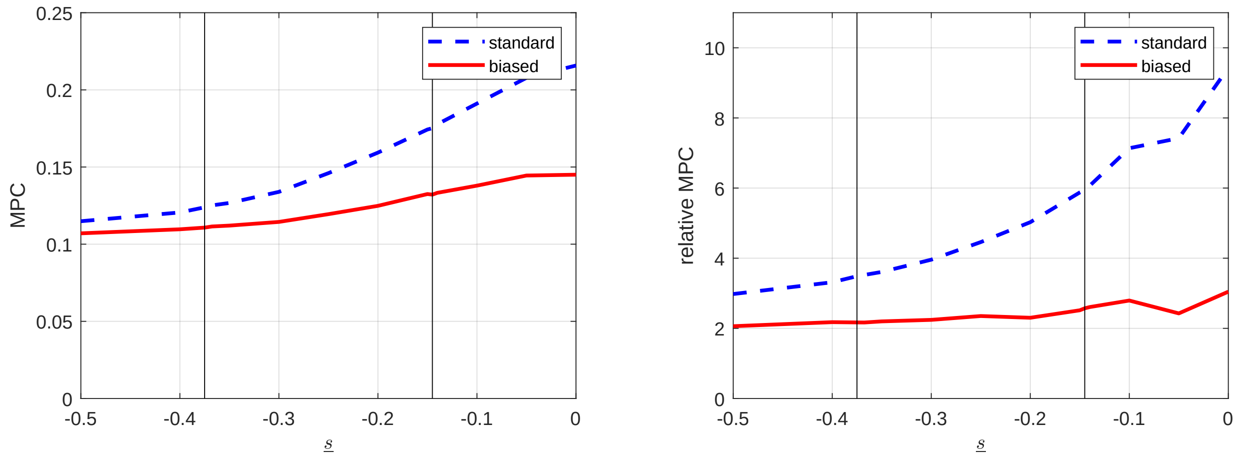
the range of empirical estimates: Johnson et al. (2006) and Parker et al. (2013) obtain point estimates of this MPC ratio of 2.33-2.99 and 1.16 for the stimulus payments in the U.S. in 2001 and 2008, respectively.[9] In contrast, the rational model predicts that low-income households spend almost six times as much as high-income households out of the transfer. In the previous section we showed that all else being equal the bias decreases the MPC in nondurables for the lowest income households. The large relative MPC here demonstrates that the tighter required borrowing constraint in the rational model further amplifies this effect on the MPC of low-income households.

Figure 14, panels (c) and (d), displays the corresponding results for total expenditures. While the level of the aggregate MPE is comparable in the rational and biased models (0.37 vs 0.34), the distribution of MPEs remains very different in the two models. The rational model predicts that the MPE of low-income households is about the same as that of high-income households (i.e. a relative MPE of 1). In contrast, in the model with biased income expectations low-income households spend only 70% of what high-income households spend out of the transfer.

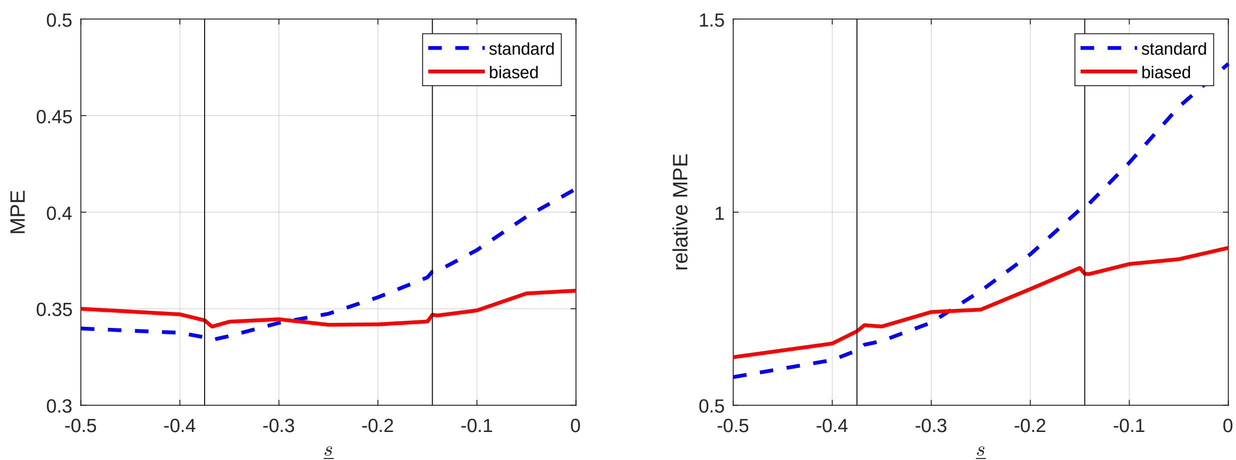
[9]Johnson et al. (2006) define income groups as: low < \$34K, high > \$69K. Parker et al. (2013) define income groups as: low < \$32K, high > \$75K.

Figure 14: MPC and MPE for Different Levels of the Borrowing Constraint

(a) aggregate MPC (b) relative MPC



(c) aggregate MPE (d) relative MPE

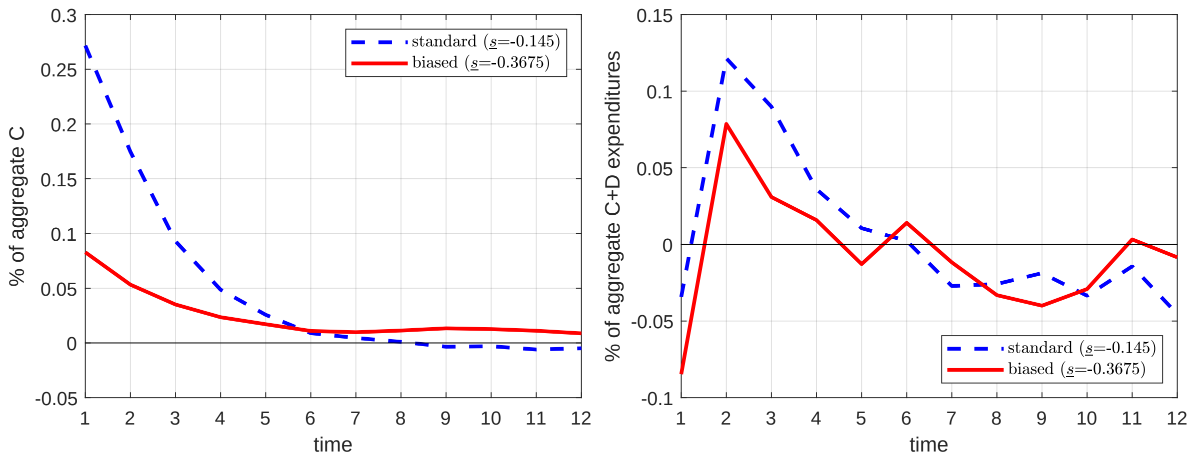


Note: The figure depicts the aggregate and relative MPC and MPE for model specifications with varying borrowing constraints $\underline{s}$. Relative MPC (relative MPE) is the ratio of the MPC (MPE) of the lowest income quintile over that of the highest income quintile. The solid red line refers to the model with biased income expectations; the dashed blue line refers to the rational model. The vertical lines $\underline{s}$ =–0.3675 and $\underline{s}$ =–0.145 mark the borrowing limit required to match the data generated by the rational and biased model, respectively.

The difference in MPC (and MPE) between high and low-income households is important for the effectiveness of government stimulus policies. Stimulus payments have to be financed in some way, which is often done through taxes. Since high-income households typically pay higher taxes than low-income households, stimulus payments are a form of redistribution. How much aggregate consumption increases due to this transfer therefore depends on the ratio between the MPC (and MPE) of low-income households and high-income households.

Figure 15: Aggregate Effects of a Redistributive Policy

(a) nondurable consumption (b) total expenditures



Note: The figure depicts the aggregate impulse-response function of nondurable consumption and total expenditures to a redistributive policy: Households below the median income receive a transfer while households above the median income pay for the transfer. The figure shows the results for the biased model (solid red line) and the rational model (dashed blue line). Magnitudes are expressed as a percentage increase in nondurable consumption or total expenditures, respectively, relative to the level without the policy.

To illustrate the importance of the distribution of marginal propensities across income, we compute the reactions to a theoretical redistributive stimulus policy with a balanced budget. We assume that all households with income below the median income receive a transfer (or tax rebate) of 5% o the median household income. This transfer is financed by levying a lump sum tax of the same magnitude on all households above the median income. Figure 15 shows the resulting aggregate impulse response functions. The model with overpersistence bias predicts that this policy increases nondurable consumption on impact by 8%. In contrast, according to the rational model we would expect this policy to increase nondurable consumption by 27%, that is almost 3.5 times the effect in the biased model. In terms of total expenditures we see an almost equally large discrepancy between the two models: On impact both models predict a fall in total expenditures. This fall is more pronounced in the model with biased expectations than in the rational model (–8% vs –3%). In the subsequent quarter the model with biased expectations predicts that total expenditures to increase by 7% while the rational model expects an increase in total expenditures of 12%. The rational model thus predicts this policy to be more effective than what the model with biased expectations predicts. This is true both for nondurable consumption and for total expenditures.

To summarize, we find that the rational model requires a tighter borrowing constraint than the biased model to fit the data. This tighter borrowing limit amplifies the differences between the biased and rational models. The rational model generates a larger MPC and MPE for low-income households relative to high-income households than the model that accounts for the overpersistence bias. The rational model therefore predicts stimulus payments to be more effective than what the model with biased expectations predicts.

5 Conclusion

In this paper we investigate the role of income expectations on the consumption behavior of households. We document a systematic bias in income expectations, show how it can be formally incorporated into the process of expectation formation and investigate its implications for consumption-saving decisions in a quantitative model.

Using household level data from the Michigan Surveys of Consumers, we find that households with high income today tend to overestimate their future income and those with low income underestimate their future income. We argue that this feature of expectation bias can be explained by households overestimating the persistence of their income process. This overpersistence belief is consistent with the observation that people fail to sufficiently appreciate regression to mean. This observation is not new to behavioral economics and psychology (Kahneman and Tversky, 1973; and Kahneman, 2012, chapter 17). However, to the best of our knowledge this paper is the first to quantify the extent of the bias in income expectations and investigate its implications for consumption decisions using a quantitative model.

We proceed by exploring an economy where households exhibit the same expectation biases as we observe in the data. The model we build is an otherwise standard partial equilibrium consumption model with a durable asset subject to adjustment costs. Income expectation biases of the magnitude seen in the data significantly affect the distribution of liquid assets in the cross section. Low-income households with biased beliefs are too pessimistic about their future income and are hence unwilling to borrow to smooth consumption. In contrast, households with high-income turn out to have similar portfolios of durable goods and liquid savings whether they have biased income expectations or not. This prediction of the model with biased beliefs is in line with the distribution of liquid assets in the data.

The paper further showed that if instead we calibrate the exogenous borrowing constraint in a rational model, the rational model needs a tighter borrowing limit to fit the data than the model with biased expectations. This tighter borrowing limit amplifies the effects of biased beliefs. In particular, the model with biased expectations leads to a substantially lower relative MPC of low-income households to that of high-income households. If stimulus payments are financed through taxes (which are predominantly paid by high-income households), stimulus payments are a form of redistribution. How effective these programs are hence depends on the distribution of MPCs across the income distribution. The paper showed that the differences in the distribution of MPCs translate into economically meaningful differences in the assessment of fiscal stimulus policies: According to the biased model stimulus payments are substantially less effective than according to the rational model.

We believe that our empirical finding opens an avenue for further research in two main areas. First, while the available data from the Michigan Surveys of Consumers, allows us to document patterns in income expectation biases, the data set has an important limitation: It has only a very short panel dimension. This limitation makes it impossible to follow the same households and their expectations over time. Using the Michigan Surveys of Consumers we are therefore unable to investigate in detail the process of expectation formation and expectation updating. Other existing panel surveys do not include enough information to analyze expectation biases in individual income expectations. To learn more about how income expectations are formed, it thus seems very important to collect new data both on income expectations and on the corresponding realizations in a panel survey.

Second, our analysis shows that there are substantial movements in income expectation errors at the business cycle frequency. This suggests a role for income expectation errors for macroeconomic business cycle analysis. In the present paper we have focused on the cross-sectional patterns of expectation errors. In future work it would be interesting to study these business cycle movements in expectation errors and analyze the effects that household income expectations have for the amplification of other types of macroeconomic shocks.

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A Further Details about the Empirical Analyses

A.1 Sample Selection

The Michigan Surveys of Consumers interview around 500 households per month of which around one third are re-interviewed after 6 months. The time period that includes precise income information (previously income was only surveyed as bins) is July 1986 - December 2013. Overall, there are observations on 153,241 households (with or without re-interviews). We restrict the sample in the following way: (a) We only select households where the respondent is at most 65 years of age (excludes 30,701 observations). (b) We exclude observations with missing information on demographics (7,605 observations). (c) We exclude observations where the income is lower than the average unemployment benefits in that year (15,525 observations). (d) For households with a re-interview we exclude households where the respondent changes between interviews (as identified by the demographics such as gender, age, education, marriage status, and racial background, excludes 2,901 observations). Moreover, we exclude households where the number of adults changes between interviews (excludes 3,182 observations). This restriction is made since we are analyzing per adult income in the household, so that changes in the number of adults in the household will reflect changes in this measure of income that might not be anticipated by respondents when they are asked about their income growth expectations.

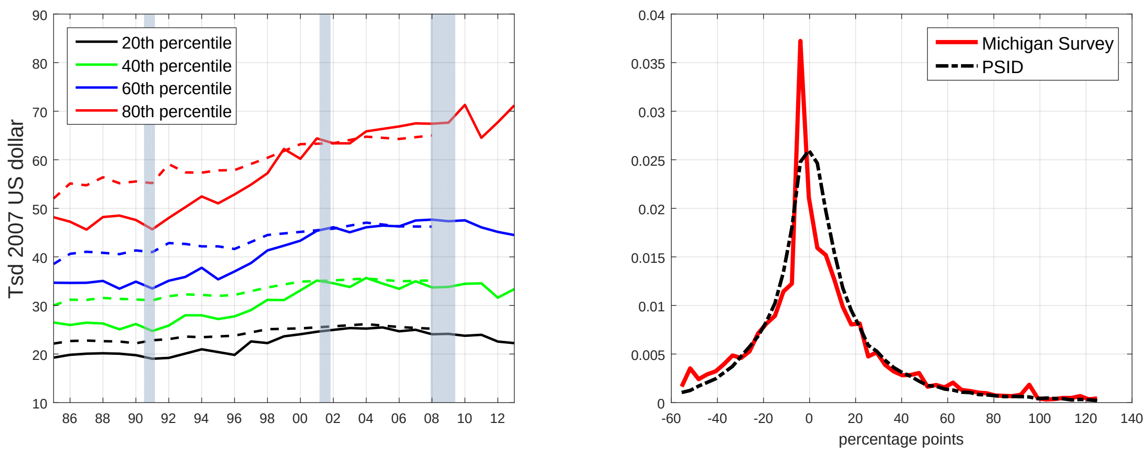
Overall, this leaves a sample of 88,017 households for which we have full information on demographics as well as inflation expectations (sample INF). 17,500 of these households are both first interviewed in the second half of a year and have a re-interview (sample H2RE). This is the sample for which we have information on realized income growth. Out of sample INF, 41,742 households also provide income expectations and are first interviewed in the first half a year (sample H1), 44,010 provide income expectations and are first interviewed in the second half a year (sample H2).

Figure 16 shows how the income information in our sample compares to the income information in the Panel Study of Income Dynamics (PSID). The PSID is a panel survey that has been running since 1968 which has been widely used to analyze income dynamics. Plot (a) shows that in the first part of the sample, real per capita income in the Michigan Surveys is slightly lower than in the PSID. Since the late 1990s, however, the levels of income in both surveys are very similar. Note that we are not using the levels of income in our analysis. Instead, individual income growth rates are the center of our investigation. Plot (b) displays the distribution of these growth rates in the Michigan Surveys and in the PSID. The distribution of income growth is very similar in both surveys. The only difference is that in the Michigan Surveys more households report zero change in nominal income (around 15% of weighted observations, compared to 2% in the PSID). To ensure that our results are not driven by these observations, we conduct a robustness check of our main analysis where we exclude all households that report zero income change (see appendix C.2.5). Our results hold and in fact become stronger once these observations are excluded.

Figure 17 displays the distribution of expectations in real income growth and table 4 lists its descriptive statistics. This distribution arguably has some extreme observations. In the main analysis we hence winsorize expectations and forecast errors at the 5% level, i.e. we set the top and bottom 5% of observations to the 95th and 5th percentile of the distribu-

Figure 16: Comparison with Income Panel Study of Income Dynamics

(a) percentiles (b) distribution of income growth



Note: The figure plots a comparison of reported income in the Michigan Surveys and in the Panel Study of Income Dynamics (PSID). Plot (a) shows the percentiles of per capita real income over time: Solid lines refer to the Michigan Survey's distribution of income, dashed lines to the corresponding percentiles in the PSID. Plot (b) shows the distribution of real income growth rates in the Michigan Surveys and in the PSID. Since the PSID changed to biannual surveys in 1997, the income growth rates have been constructed from PSID data for 1986-1996 only.

tion, respectively. To ensure that our results are not driven by the choice of winsorization threshold, we repeat the analysis for varying levels of winsorization (1%, 10%, and 25%). The results of this robustness check are shown in appendix C.2.3. All the results remain, only the magnitudes of the effects become smaller as we remove high and low expectations more and more aggressively.

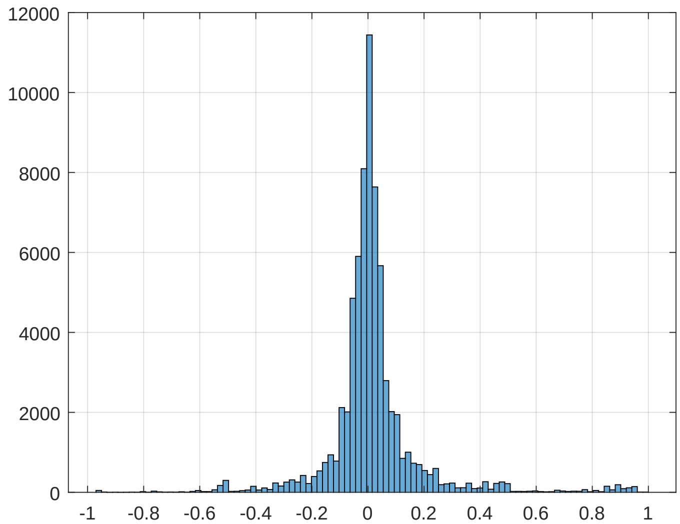
Table 4: Descriptive Statistics of Real Income Growth Expectations

mean	std	min	p1	p5	median	p95	p99	max
0.018	0.173	-0.967	-0.505	-0.190	0	0.262	0.857	2.1

A.2 Details about the Imputation Procedure

To increase the overlap of expectations and realizations, we impute income growth realizations using the information of households with similar household characteristics who report their income growth for the relevant period. In the example of figure 1, households interviewed for the first time between July 2002 and December 2002 report both their income in 2001 as well as their income in 2002. We can hence use their income in 2001 as well as all available household characteristics to predict their income growth 2001-2002. We then use this relationship to impute income growth 2001-2002 for all households interviewed for the first time in January 2002 to June 2002. The equation that we use to impute income growth

Figure 17: Distribution of Real Income Expectations



Note: The figure plots the histogram of individual real income growth expectations. For graphical reasons a total of 27 observations (0.04% of all observations) have been removed since they are larger than +100%.

realizations is the following:

$$g_{i,t+1} = \alpha + \beta X_{i,t} + \varepsilon_{i,t} \tag{20}$$

where $g_{i,t+1}$ is the growth rate in income of individual i from year t to year $t+1$ and $X_{i,t}$ includes a quadratic term in $\log(income_{i,t})$, a quadratic term in age, as well as indicators for education, gender, ethnic background, marriage status, number of adults, region, income growth expectations, inflation expectations, and household weight in the survey. The imputation procedure is implemented as multiple imputations algorithm using the predictive mean matching method with the five nearest neighbors and 25 imputations. The imputation procedure is done separately for each survey year, using the observations from sample H2RE which report income changes for the respective year.

Figure 1(c) shows that for January households the overlap between expectation and imputed realization is now perfect. For February to June this overlap decreases but is still larger than the maximum overlap we obtain for July to December households on directly reported data. Moreover, for January to June households we do not need any re-interview so that we can use all observations in the data, not only the ones with a re-interview. This greatly increases the sample size: We are able to obtain income growth realizations (and thus forecast errors) for the whole sample H1.

Furthermore, we can also increase the overlap for July to December households by imputing income changes for the following year. In the example of figure 1 we use the information provided by households interviewed for the first time in July to December 2003 to impute income growth 2002-2003 for the households first interviewed in July to December 2002. This increases the overlap between their expectations and imputed realizations. The largest overlap is 11 months for December households, which is close to perfect. Note that for this step we base the imputation on the income that households reported in their second interview.

Unlike in the case of the sample H1, we are hence only able to impute income changes for households who have a re-interview. Combined with the imputed sample H1 this generates the main sample of forecast errors of 58,369 observations (sample MAIN). Table 5 shows the distribution of imputed individual income growth rates in this sample compared to the directly reported income growth rates in sample H2RE. The distribution of the imputed data is very close to the distribution of the original data.

Table 5: Distribution of Real Reported Income Changes and Imputed Values

	mean	p5	p25	p50	p75	p95
directly reported	0.034	-0.378	-0.097	-0.015	0.133	0.572
imputed	0.032	-0.365	-0.103	-0.016	0.130	0.577

Note: The table compares the distribution of imputed individual growth rates in real income in sample MAIN with the growth rates in directly reported income in sample H2RE.

The main analyses reported in this paper are conducted on the sample MAIN where realized income growth has been imputed to maximize both the timing overlap and the number of observations. However, we have conducted robustness checks on the following subsamples: JAN (households with an interview in January, income growth imputed, overlap perfect: 6,973 observations); DEC (households with the first interview in December, income growth imputed, overlap close to perfect: 2,723 observations); JULY (households with an interview in July, directly reported income growth, maximum overlap for directly reported data: 2,805 observations). Whenever imputed income growth is used, standard errors account for the additional uncertainty using multiple imputation procedures and standard errors based on Rubin (1987), Barnard and Rubin (1999), and Reiter (2007).

B Data Available in other Surveys

In this section we present the information about income expectations and realizations available in other household surveys and describe the challenges they pose for the analysis of rationality or biases of household income expectations. Compared to these other surveys, the Michigan Survey of Consumers in our opinion provides the best available data and allows the analysis of income expectations over a very long period of time.

B.1 Italian Survey of Income and Wealth (SHIW), Bank of Italy

The SHIW is a biannual panel household survey conducted by the Bank of Italy that has been running since 1977. Unfortunately, there is no overlap at all between income expectations and realizations.

Every other year the survey interviews the members of the participating households. It asks the following question about income expectations (Bank of Italy, 2018):

> *B41 (ASPRED) This year, in 2017, do you expect your household's total income to rise more than prices, less than prices, or about the same as prices?*

For realizations, the survey asks in detail about different components of the income of each household member (see sections B1-B6 in the questionnaire). However, all these questions refer to income in the calender year *prior* to the interview, while the expectation question refers to a change over the *next* calendar. Due to the biannual interview frequency that implies that there is no overlap at all between the expectations and the realizations (in addition to expectations being only qualitative). It is therefore not possible to use the SHIW to investigate rationality or biases in income expectations.

B.2 Survey of Consumer Expectations (SCE), Federal Reserve Bank of New York

The SCE is a survey that interviews a representative, rolling panel of U.S. households about their economic expectations, including their income expectations. The survey started in 2013 and each household stays in the panel for at most 12 months. Unfortunately, income realizations are only elicited in bins which precludes the computation of income growth realizations.

In the core survey, the respondent is asked the following questions (Federal Reserve Bank of New York, 2018b):

> *Q25v2 Next we would like to ask you about your overall household income going forward. By household we mean everyone who usually lives in your primary residence (including yourself), excluding roommates and renters. Over the next 12 months, what do you expect will happen to the total income of all members of your household (including you), from all sources before taxes and deductions? Over the next 12 months, I expect my total household income to...*
>
> - *increase by 0% or more*
> - *decrease by 0% or more*

Q25v2part2 By about what percent do you expect your total household income to [increase/decrease as in Q25v2]? Please give your best guess.

Q47 Which category represents the total combined pre-tax income of all members of your household (including you) during the past 12 months?
Less than \$10,000
\$10,000 to \$19,999
\$20,000 to \$29,999
\$30,000 to \$39,999
\$40,000 to \$49,999
\$50,000 to \$59,999
\$60,000 to \$74,999
\$75,000 to \$99,999
\$100,000 to \$149,999
\$150,000 to \$199,999
\$200,000 or more

The problem is that the realization of household income is only reported in bins so that realized changes in income cannot be computed.

The survey also asks additional questions about the respondents' labor earnings in their current job in their labor market survey (Federal Reserve Bank of New York, 2018a). This survey is repeated every 4 months. The exact wording of the question is as follows:

L3 How much do you make before taxes and other deductions at your [main/current] job, on an annual basis? Please include any bonuses, overtime pay, tips or commissions.
... dollars per year

This question is answered in levels, not in bins. It asks the respondents to report the income they would have if they stayed a full year in the current job that they currently have. It does not ask about the earnings they actually had during the last year. If people change jobs or move in and out of unemployment, these two objects can be very different. Question L3 thus refers to a different object than the expectation question Q25v2 (the expectation is about the income the household expects to earn in the next 12 months from any job they might work at during that period). Moreover, Q25 refers to total household income from all sources for all household members while L3 asks about labor earnings of the respondent only. Without further assumptions it is thus not possible to use question L3 as a realization for expectations in question Q25. Since March 2015 the survey has added another expectation question about annual earnings:

OO2e2 What do you believe your annual earnings will be in 4 months?
... dollars per year

This question will be comparable to question L3 to analyze 4-month ahead expectations. Currently this question is only available for 2015/2016 so it is difficult to control for aggregate time effects. However, this source of data seems promising as more waves become available.

D'Haultfoeuille et al. (2018) develop and exploit a new method of testing for rationality in this short sample and come to strikingly similar conclusions to the ones in this paper (even though the limited sample period does not allow them to control for aggregate effects).

B.3 Longitudinal Internet Studies for the Social Sciences (LISS), CentERdata

LISS is a panel survey that has been following a representative sample of Dutch households since October 2007. Unfortunately, only qualitative income expectations are solicited.

The survey asks the households to give categorical expectations about their "financial situation", not explicitly income expectations. In detail, the questions asked are the following (CentERdata, 2018):

> *ci261 Do you expect your financial situation to get better or worse over the coming 12 months?*
>
> - *will get much better*
> - *will get slightly better*
> - *will remain more or less the same*
> - *will get a bit worse*
> - *will get a lot worse*

> *ci243 Can you indicate, on a scale from 0 to 10, whether your financial situation has gotten better or worse compared to one year ago? 0 means that your financial situation has gotten much worse compared to one year ago 10 means that it has gotten much better.*

These questions are certainly related to income expectations. However, their categorical nature and the fact that they mix income expectations into the general phrase of "financial situation" (which also subsumes other financial components such as expenditures, wealth developments, inheritances, etc) prohibit the direct analysis of income expectations.

B.4 Eurosystem's Household Finance and Consumption Survey (HFCS), European Central Bank

The HFCS collects data from household surveys in the euro area. As of now there are two waves of this survey. Unfortunately, there is no overlap between income expectations and realizations

Most participating countries have a repeated cross-section design which does not allow connecting realizations with expectations. Moreover, even for the few participating countries with a panel component (Belgium, Germany, Spain, Italy, Cyprus, Malta, and the Netherlands, see Household Finance and Consumption Network, 2017) there is no overlap between the expectations and realizations since the survey is conducted every 3 years but expectations are asked only for one year ahead. In detail, the question about income expectations is the following Household Finance and Consumption Network (2012):

7.13 HG0800 Over the next year, do you expect your (household's) total income to go up more than prices, less than prices, or about the same as prices?

- *More than prices*
- *Less than prices*
- *About the same as prices*

Income realizations are recorded as follows (as an example we show here the employee income component):

7.01A PG0100 Did you receive any sort of employee income during (last 12 months / last calendar year)?

7.01B PG0110 What was the total gross amount over (the last 12 months / last calendar year)? Please include income from regular wages or salaries, as well as any overtime pay, tips, bonuses, profit sharing benefits (unless part of the pension arrangements).

Thus, there is no overlap at all between the expectations ("over the next year") and the realizations since income realizations are asked 3 years later for "the last 12 months / last calendar year"[10]. Even if we were willing to work with the categorical expectations, the 3-year rhythm of the survey makes it therefore impossible to match realizations to the expectations.

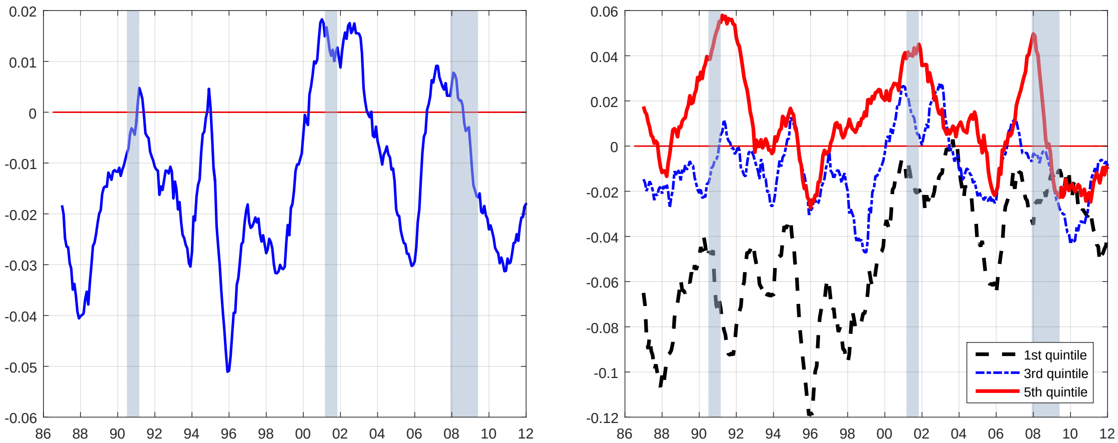
[10]Note that the phrasing of last 12 months vs last calendar year differs between participating countries.

C Additional Empirical Results and Robustness Checks

C.1 Time Series Plots of Errors in Nominal Income

Figure 18: Expectation Errors in Nominal Income Growth

(a) mean (b) mean by income quintile



Note: The figure plots the 12-month moving average of mean expectation errors in individual nominal income growth. Expectation errors are winsorized at 5% and 95%. Data from the Michigan Surveys of Consumers and own calculations. Gray areas represent NBER recessions. On the y-axis, 0.01 corresponds to 1 percentage point.

C.2 Robustness Checks

This appendix contains robustness checks to the specification in the main text. The first robustness check is to include interaction terms of income quintiles with age bins and education dummies. Most of these interaction terms are not significant and the relationship between expectation errors and income quintiles is robust to this change: It remains statistically and economically significant and of very similar magnitude as in the main specification. In a second robustness check we control for cohort effects, in one specification instead of age and in another specification instead of time effects (and include dummies for the month of the interview to control for seasonal effects). Our results are virtually unchanged by these alternative controls. The third robustness check is to limit our analysis only to the period 2000 and later. Our results are qualitatively the same as in the main specification. The magnitudes of the effects are smaller but still economically and statistically significant. The fourth robustness check varies the thresholds for winsorization to exclude that our findings are driven by outliers. All results remain for all levels of winsorization, merely the magnitudes become smaller as we remove high and low expectations more and more aggressively. The last robustness check excludes observations with zero reported income change (as the fraction of those households seems slightly inflated compared to the PSID). Also here we find that all our results hold so that the households with zero reported income change are not driving our results.

C.2.1 Interaction with Age and Education

Table 6: OLS of Forecast Error on Observables, Interaction with Education and Age

	real	real	nominal	nominal
1st	−0.051***	−0.057***	−0.047***	−0.054***
	(0.007)	(0.010)	(0.007)	(0.010)
2nd	−0.017***	−0.021**	−0.016***	−0.018*
	(0.006)	(0.010)	(0.006)	(0.010)
4th	0.019***	0.027***	0.017***	0.025***
	(0.005)	(0.009)	(0.005)	(0.009)
5th	0.035***	0.047***	0.032***	0.043***
	(0.006)	(0.010)	(0.006)	(0.011)
no high school	0.013	0.023	0.019	0.030
	(0.014)	(0.027)	(0.014)	(0.028)
college	−0.014***	−0.008	−0.017***	−0.010
	(0.004)	(0.008)	(0.004)	(0.008)
age $<$ 35	0.026***	0.021**	0.026***	0.021**
	(0.005)	(0.010)	(0.005)	(0.010)
50 $\leq$ age $<$ 65	−0.013***	−0.015	−0.014***	−0.015
	(0.004)	(0.009)	(0.004)	(0.009)
1st × no high school		−0.019		−0.021
		(0.030)		(0.030)
2nd × no high school		−0.008		−0.011
		(0.034)		(0.035)
4th × no high school		0.015		0.013
		(0.037)		(0.038)
5th × no high school		0.020		0.021
		(0.045)		(0.046)
1st × college		0.005		0.003
		(0.013)		(0.013)
2nd × college		0.001		−0.000
		(0.012)		(0.013)
4th × college		−0.013		−0.011
		(0.011)		(0.011)
5th × college		−0.021*		−0.021*
		(0.012)		(0.012)
1st × age $<$ 35		0.012		0.014
		(0.015)		(0.015)
2nd × age $<$ 35		0.007		0.007
		(0.014)		(0.014)
4th × age $<$ 35		−0.004		−0.005
		(0.012)		(0.012)
5th × age $<$ 35		0.007		0.008
		(0.013)		(0.014)
1st × 50 $\leq$ age $<$ 65		0.010		0.010
		(0.015)		(0.015)
2nd × 50 $\leq$ age $<$ 65		0.005		0.003
		(0.014)		(0.014)
4th × 50 $\leq$ age $<$ 65		−0.003		−0.004
		(0.012)		(0.012)
5th × 50 $\leq$ age $<$ 65		−0.001		−0.001
		(0.012)		(0.012)
Month dummies	57498	57498	57498	57498

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows the results of the multiple imputations OLS regression of equation (2) (dependent variable is an error in either real or nominal income growth at the household level) with additional interaction terms of income quintiles with education and age groups. Additional regressors (coefficients not shown) are a constant, racial background, number of adults in the household, gender, marriage status as well as region and month dummies. Standard errors take into account the uncertainty induced by the imputation procedure.

C.2.2 Controlling for Cohort Effects

Table 7: OLS of Expectation Errors on Household Characteristics, Controlling for Cohort and Rime Effects

	(1) real	(2) real	(3) real	(4) real	(5) nominal	(6) inflation
Income quintile						
1 (low)	−0.051***	−0.046**	−0.047*	−0.077***	−0.048***	0.004***
	(0.006)	(0.018)	(0.027)	(0.021)	(0.007)	(0.000)
2	−0.017***	−0.013	−0.024	−0.039**	−0.016***	0.002***
	(0.006)	(0.017)	(0.024)	(0.020)	(0.006)	(0.000)
4	0.019***	0.026*	0.028	0.021	0.017***	−0.002***
	(0.005)	(0.013)	(0.024)	(0.016)	(0.005)	(0.000)
5 (high)	0.034***	0.045***	0.039*	0.064***	0.031***	−0.004***
	(0.006)	(0.015)	(0.022)	(0.017)	(0.006)	(0.000)
Education						
no high school	0.013	0.013	0.018	−0.002	0.019	0.002***
	(0.013)	(0.029)	(0.060)	(0.036)	(0.014)	(0.001)
college	−0.014***	−0.024**	−0.007	−0.036***	−0.017***	−0.002***
	(0.004)	(0.012)	(0.016)	(0.013)	(0.004)	(0.000)
Racial background						
black	0.019**	0.024	0.007	0.021	0.023***	0.002***
	(0.008)	(0.018)	(0.033)	(0.022)	(0.008)	(0.000)
hispanic	0.012	0.005	0.017	0.017	0.017*	0.003***
	(0.009)	(0.027)	(0.046)	(0.033)	(0.009)	(0.001)
Number of adults						
1	−0.025**	−0.003	−0.036	0.019	−0.025**	0.001**
	(0.009)	(0.026)	(0.039)	(0.042)	(0.010)	(0.001)
3 or more	0.018***	0.012	0.017	0.021	0.016**	−0.002***
	(0.007)	(0.018)	(0.029)	(0.022)	(0.007)	(0.000)
Other family characteristics						
female	−0.008*	−0.005	−0.007	−0.008	−0.002	0.005***
	(0.004)	(0.010)	(0.016)	(0.012)	(0.004)	(0.000)
not married	0.023**	0.003	0.033	−0.011	0.024**	0.000
	(0.009)	(0.024)	(0.035)	(0.041)	(0.009)	(0.000)
Region						
North Central	−0.022***	−0.023	−0.031	−0.021	−0.023***	−0.000
	(0.006)	(0.016)	(0.024)	(0.017)	(0.006)	(0.000)
North east	−0.020***	−0.021	−0.037	−0.005	−0.020***	0.001
	(0.006)	(0.017)	(0.027)	(0.018)	(0.006)	(0.000)
South	−0.018***	−0.014	−0.029	0.013	−0.017***	0.001**
	(0.006)	(0.016)	(0.024)	(0.016)	(0.006)	(0.000)
Constant	0.010	0.013	−0.051	0.114	0.000	−0.017***
	(0.052)	(0.084)	(0.111)	(0.093)	(0.054)	(0.002)
Sample	MAIN	JAN	DEC	JULY	MAIN	INF
Observations	58369	6973	2723	2805	58369	88017

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows results of the multiple imputations OLS regression of equation (2), where the dependent variable is the household expectation error in real income (columns 1-4), in nominal income (column 5) and in inflation (columns 6). The regressions include cohort dummies and month dummies as additional controls. Standard errors take into accountthe uncertainty induced by the imputation procedure into account whenever imputed data is used; without imputed data heteroskedasticity-robust standard errors are computed.

Table 8: OLS of Expectation Errors on Household Characteristics, Controlling for Age and Cohort Effects

	(1) real	(2) real	(3) real	(4) real	(5) nominal	(6) inflation
Income Quintile						
1 (low)	−0.052***	−0.047**	−0.049*	−0.078***	−0.048***	0.004***
	(0.006)	(0.018)	(0.027)	(0.021)	(0.007)	(0.000)
2	−0.017***	−0.011	−0.024	−0.038*	−0.015**	0.002***
	(0.006)	(0.017)	(0.024)	(0.020)	(0.006)	(0.000)
4	0.019***	0.026*	0.029	0.022	0.018***	−0.002***
	(0.005)	(0.013)	(0.024)	(0.016)	(0.005)	(0.000)
5 (high)	0.035***	0.045***	0.041*	0.065***	0.032***	−0.004***
	(0.006)	(0.015)	(0.022)	(0.017)	(0.006)	(0.000)
Education						
no high school	0.014	0.013	0.021	0.008	0.020	0.002***
	(0.013)	(0.029)	(0.059)	(0.036)	(0.014)	(0.001)
college	−0.014***	−0.024**	−0.007	−0.033**	−0.017***	−0.002***
	(0.004)	(0.012)	(0.016)	(0.013)	(0.004)	(0.000)
Age						
age	−0.003*	−0.000	−0.006	−0.006	−0.003	0.001***
	(0.002)	(0.004)	(0.007)	(0.005)	(0.002)	(0.000)
age × age	0.000	0.000	0.000	0.000*	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Racial background						
black	0.019**	0.024	0.008	0.019	0.023***	0.003***
	(0.008)	(0.018)	(0.033)	(0.022)	(0.008)	(0.001)
hispanic	0.013	0.006	0.017	0.014	0.018*	0.003***
	(0.009)	(0.027)	(0.046)	(0.034)	(0.009)	(0.001)
Number of adults						
1	−0.025**	−0.002	−0.037	0.024	−0.024**	0.002***
	(0.009)	(0.026)	(0.040)	(0.043)	(0.010)	(0.001)
3 or more	0.019***	0.012	0.018	0.027	0.017**	−0.002***
	(0.007)	(0.018)	(0.030)	(0.022)	(0.007)	(0.000)
Other family characteristics						
female	−0.008*	−0.006	−0.006	−0.010	−0.003	0.005***
	(0.004)	(0.010)	(0.016)	(0.012)	(0.004)	(0.000)
not married	0.023**	0.002	0.032	−0.017	0.023**	−0.000
	(0.009)	(0.024)	(0.036)	(0.042)	(0.009)	(0.001)
Region						
North Central	−0.022***	−0.023	−0.032	−0.023	−0.023***	−0.000
	(0.006)	(0.016)	(0.024)	(0.018)	(0.006)	(0.000)
Northeast	−0.020***	−0.021	−0.037	−0.007	−0.021***	0.001*
	(0.006)	(0.017)	(0.026)	(0.018)	(0.006)	(0.000)
South	−0.018***	−0.014	−0.029	0.012	−0.017***	0.001*
	(0.006)	(0.016)	(0.023)	(0.016)	(0.006)	(0.000)
Constant	0.085**	0.020	0.078	0.080	0.039	−0.062***
	(0.038)	(0.108)	(0.185)	(0.125)	(0.040)	(0.002)
Sample	MAIN	JAN	DEC	JULY	MAIN	INF
Observations	58369	6973	2723	2805	58369	88017

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows results of the multiple imputations OLS regression of equation (2), where the dependent variable is the household expectation error in real income (columns 1-4), in nominal income (column 5), and in inflation (columns 6). The regressions include cohort dummies and indicators for the month of the year of the interview as additional controls. Standard errors take the uncertainty induced by the imputation procedure into account whenever imputed data is used; without imputed data heteroskedasticity-robust standard errors are computed.

C.2.3 Subsample year 2000 and later

Table 9: OLS of Expectation Errors on Household Characteristics, Sample Year 2000 and Later

	(1) real	(2) real	(3) real	(4) real	(5) nominal	(6) inflation
Income quintile						
1 (low)	−0.031***	−0.026	−0.028	−0.013	−0.026***	0.005***
	(0.008)	(0.022)	(0.036)	(0.029)	(0.009)	(0.001)
2	−0.010	−0.007	−0.024	−0.010	−0.007	0.002***
	(0.007)	(0.022)	(0.033)	(0.026)	(0.008)	(0.001)
4	0.014**	0.017	0.017	0.038	0.013*	−0.002***
	(0.006)	(0.018)	(0.034)	(0.025)	(0.007)	(0.001)
5 (high)	0.025***	0.029	0.027	0.072***	0.020**	−0.005***
	(0.008)	(0.024)	(0.033)	(0.025)	(0.008)	(0.001)
Education						
no high school	−0.002	−0.023	0.032	0.015	0.000	0.000
	(0.021)	(0.051)	(0.094)	(0.038)	(0.021)	(0.001)
college	−0.011*	−0.021	−0.008	−0.016	−0.014**	−0.003***
	(0.006)	(0.015)	(0.021)	(0.019)	(0.006)	(0.000)
Age						
age	−0.004*	−0.003	−0.007	0.003	−0.004*	0.000***
	(0.002)	(0.004)	(0.009)	(0.007)	(0.002)	(0.000)
age × age	0.000	0.000	0.000	−0.000	0.000	−0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Racial background						
black	0.025**	0.045	0.002	0.028	0.026**	0.000
	(0.011)	(0.027)	(0.047)	(0.032)	(0.011)	(0.001)
hispanic	0.030***	0.021	0.024	−0.016	0.030***	0.000
	(0.011)	(0.035)	(0.061)	(0.046)	(0.012)	(0.001)
Number of adults						
1	−0.005	0.019	−0.038	−0.009	−0.004	0.001
	(0.012)	(0.034)	(0.049)	(0.057)	(0.012)	(0.001)
3 or more	0.017**	0.002	0.030	−0.010	0.015*	−0.002***
	(0.008)	(0.025)	(0.041)	(0.028)	(0.008)	(0.001)
Other family characteristics						
female	−0.009*	−0.004	−0.009	−0.002	−0.005	0.005***
	(0.005)	(0.013)	(0.020)	(0.016)	(0.005)	(0.000)
not married	0.008	−0.015	0.040	0.015	0.009	0.001*
	(0.011)	(0.031)	(0.043)	(0.054)	(0.012)	(0.001)
Region						
North Central	−0.019**	−0.018	−0.034	−0.003	−0.018**	0.000
	(0.009)	(0.021)	(0.030)	(0.024)	(0.009)	(0.000)
North East	−0.011	−0.014	−0.019	0.007	−0.011	0.001**
	(0.008)	(0.023)	(0.033)	(0.025)	(0.008)	(0.001)
South	−0.012	−0.013	−0.016	0.013	−0.010	0.002***
	(0.008)	(0.021)	(0.031)	(0.022)	(0.008)	(0.000)
Constant	0.120**	0.095	0.240	−0.064	0.107**	−0.018***
	(0.051)	(0.100)	(0.199)	(0.148)	(0.053)	(0.003)
Sample	MAIN	JAN	DEC	JULY	MAIN	INF
Observations	27279	3315	1252	1262	27279	40434

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows the results of the multiple imputations OLS regression of equation (2), where the dependent variable is the household expectation error in real income (columns 1-4), in nominal income (column 5), and in inflation (columns 6). The regressions include month dummies as additional controls and use only observations for sample of year 2000 and later. Standard errors take the uncertainty induced by the imputation procedure into account whenever imputed data is used; without imputed data heteroskedasticity-robust standard errors are computed.

C.2.4 Winsorization at Different Thresholds

Table 10: OLS of Expectation Errors on Household Characteristics - Varying Winsorization Thresholds

	(1) real	(2) real	(3) real	(4) real
Income quintile				
1 (low)	−0.052***	−0.070***	−0.040***	−0.019***
	(0.006)	(0.009)	(0.005)	(0.003)
2	−0.018***	−0.022***	−0.014***	−0.007***
	(0.006)	(0.008)	(0.004)	(0.002)
4	0.019***	0.022***	0.016***	0.009***
	(0.005)	(0.006)	(0.004)	(0.002)
5 (high)	0.035***	0.041***	0.029***	0.016***
	(0.006)	(0.008)	(0.005)	(0.002)
Education				
no high school	0.014	0.016	0.010	0.004
	(0.013)	(0.017)	(0.011)	(0.005)
college	−0.014***	−0.019***	−0.010***	−0.004**
	(0.004)	(0.005)	(0.003)	(0.002)
Age				
age	−0.004***	−0.005**	−0.004***	−0.002***
	(0.001)	(0.002)	(0.001)	(0.001)
age × age	0.000**	0.000	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Racial background				
black	0.019**	0.020*	0.017***	0.009***
	(0.008)	(0.010)	(0.006)	(0.003)
hispanic	0.013	0.015	0.010	0.005
	(0.009)	(0.012)	(0.007)	(0.004)
Number of adults				
1	−0.025***	−0.029**	−0.020***	−0.011***
	(0.009)	(0.012)	(0.007)	(0.004)
3 or more	0.020***	0.018*	0.017***	0.009***
	(0.007)	(0.010)	(0.006)	(0.003)
Other family characteristics				
female	−0.008*	−0.008	−0.007**	−0.004***
	(0.004)	(0.006)	(0.003)	(0.002)
not married	0.023**	0.027**	0.018**	0.009**
	(0.009)	(0.012)	(0.007)	(0.004)
Region				
North Central	−0.022***	−0.026***	−0.017***	−0.009***
	(0.006)	(0.007)	(0.005)	(0.003)
North East	−0.020***	−0.025***	−0.016***	−0.008***
	(0.006)	(0.007)	(0.005)	(0.003)
South	−0.018***	−0.022***	−0.014***	−0.007**
	(0.006)	(0.008)	(0.005)	(0.002)
Constant	0.136**	0.136*	0.123***	0.078***
	(0.052)	(0.071)	(0.041)	(0.020)
Winsorization	WIN 5	WIN 1	WIN 10	WIN 25
Observations	58369	58369	58369	58369

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows regressions results of OLS of equation (2) in the paper, where the dependent variable is the household expectation error in real income, winsorized at different thresholds (column 1: at 5% and 95% (the benchmark), column 2: 1% and 99%, column 3: 10% and 90%, column 4: 25% and 75%). The regressions included month dummies as additional controls. Standard errors take the uncertainty induced by the imputation procedure into account.

C.2.5 Exclude Observations with Zero Reported Income change

Table 11: OLS of Expectation Errors on Household Characteristics, July only, Observations with Zero Reported Income Change Excluded

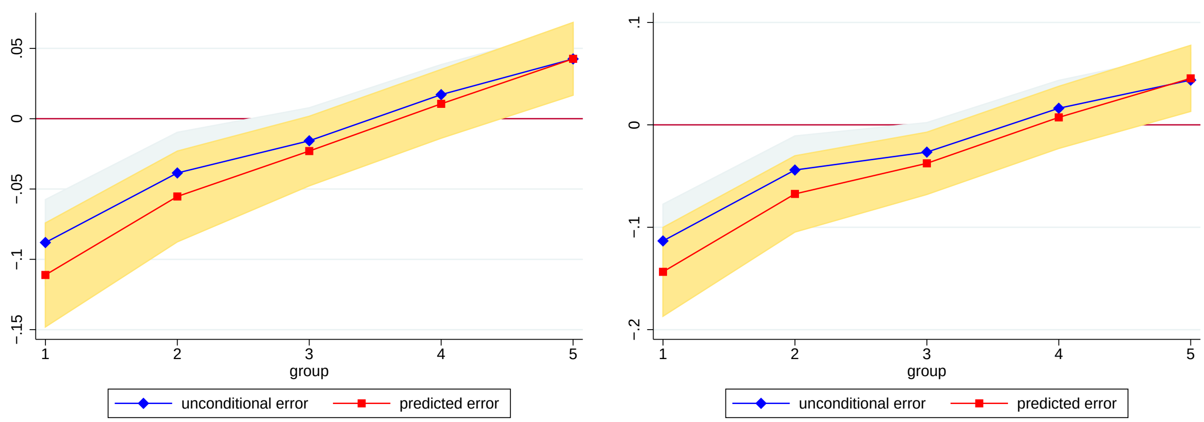
	(1) real	(2) real
Income Quintile		
1 (low)	−0.075***	−0.091***
	(0.021)	(0.025)
2	−0.038*	−0.040*
	(0.020)	(0.024)
4	0.025	0.032
	(0.016)	(0.020)
5 (high)	0.067***	0.083***
	(0.017)	(0.021)
Education		
educ=1	0.000	0.012
	(0.036)	(0.044)
educ=3	−0.032**	−0.047***
	(0.013)	(0.016)
Age		
age	−0.006	−0.008
	(0.004)	(0.005)
age × age	0.000	0.000*
	(0.000)	(0.000)
Racial background		
black	0.021	0.023
	(0.022)	(0.025)
hispanic	0.018	0.022
	(0.033)	(0.038)
Number of adults		
1	0.026	0.031
	(0.042)	(0.047)
3 or more	0.021	0.028
	(0.022)	(0.027)
Other family characteristics		
female	−0.006	0.004
	(0.012)	(0.014)
not married	−0.019	−0.028
	(0.040)	(0.045)
Region		
North Central	−0.020	−0.021
	(0.017)	(0.021)
Northeast	−0.005	−0.006
	(0.018)	(0.022)
South	0.013	0.017
	(0.016)	(0.020)
Constant	0.132	0.163
	(0.094)	(0.110)
Sample	JULY	JULY
Observations	2805	2244

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows results of the OLS regression of equation (2), where the dependent variable is the household expectation error in real income growth. Column 1 repeats the estimation on the full JULY sample (from table 1), column 2 excludes observations which report no change in nominal income. The regressions include month dummies as additional controls. Standard errors are heteroskedasticity-robust.

Figure 19: Expectation Errors in Real Income by Income Quintile, July Sample, With and Without Observations that Report Zero Income Change

(a) all households (b) exclude no change



Note: The figure shows the unconditional mean expectation error (blue line, diamonds) and predicted expectation error (red line, squares) by income quintile. Predicted expectation errors are based on regression results from table 11. Predicted values computed for all other explanatory variables at the weighted sample mean. Bands refer to 95% confidence intervals (based on heteroskedasticity-robust standard errors). On the y-axis, 0.01 corresponds to 1 percentage point.

C.3 Regression Tables for Errors in Aggregate Unemployment Expectation

Table 12: Ordered Logit / Ordered Probit of Unemployment Expectations

	(1) ologit	(2) oprobit
Income Quintile		
1st	−0.086***	−0.046***
	(0.023)	(0.013)
2nd	−0.032	−0.018
	(0.022)	(0.012)
4th	0.064***	0.036***
	(0.021)	(0.012)
5th	0.119***	0.069***
	(0.022)	(0.012)
Education		
no high school	−0.042	−0.017
	(0.039)	(0.022)
college	0.084***	0.048***
	(0.015)	(0.008)
Age		
age	−0.054***	−0.031***
	(0.005)	(0.003)
age × age	0.001***	0.000***
	(0.000)	(0.000)
Racial background		
black	−0.160***	−0.074***
	(0.029)	(0.016)
hispanic	0.078**	0.051***
	(0.035)	(0.020)
Number of adults		
1	−0.050	−0.025
	(0.030)	(0.017)
3 or more	0.083***	0.048***
	(0.024)	(0.014)
Other family characteristics		
female	−0.133***	−0.084***
	(0.014)	(0.008)
not married	−0.038	−0.024
	(0.028)	(0.016)
Region		
North Central	0.002	−0.002
	(0.020)	(0.011)
Northeast	−0.074***	−0.041***
	(0.022)	(0.012)
South	0.042**	0.023**
	(0.019)	(0.011)
Month dummies	yes	yes
Observations	96332	96332

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows the results of the ordered logit and ordered probit regression of categorical errors in individual expectations about aggregate unemployment development. The ordered categories are as follows: -2: far too pessimistic, -1: too pessimistic, 0: correct expectation, +1: too optimistic, +2: far too optimistic. Standard errors are heteroskedasticity-robust.

C.4 Regression Tables for Actual and Expected Income Growth

Table 13: OLS of Growth Expectations on Observables

	(1) actual growth (real)	(2) actual growth (nominal)	(3) expected growth (real)	(4) expected growth (nominal)
Income quintile				
1st	0.124***	0.128***	0.017***	0.022***
	(0.011)	(0.011)	(0.002)	(0.002)
2nd	0.052***	0.054***	0.006***	0.009***
	(0.009)	(0.010)	(0.002)	(0.002)
4th	−0.044***	−0.045***	−0.001	−0.003**
	(0.007)	(0.008)	(0.002)	(0.002)
5th	−0.086***	−0.089***	0.003	−0.001
	(0.009)	(0.009)	(0.002)	(0.002)
Education				
no high school	−0.065***	−0.067***	−0.023***	−0.019***
	(0.017)	(0.017)	(0.003)	(0.003)
college	0.074***	0.076***	0.022***	0.019***
	(0.007)	(0.007)	(0.001)	(0.001)
Age				
age	0.007***	0.007***	−0.003***	−0.003***
	(0.002)	(0.002)	(0.000)	(0.000)
age × age	−0.000***	−0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Racial background				
black	−0.052***	−0.054***	0.011***	0.016***
	(0.011)	(0.011)	(0.002)	(0.002)
hispanic	−0.034***	−0.035***	−0.005	0.002
	(0.013)	(0.013)	(0.003)	(0.003)
Number of adults				
1	0.077***	0.078***	0.001	0.003
	(0.020)	(0.021)	(0.003)	(0.003)
3 or more	−0.050***	−0.052***	0.003	0.001
	(0.010)	(0.011)	(0.002)	(0.002)
Other family characteristics				
female	−0.024***	−0.025***	−0.020***	−0.013***
	(0.006)	(0.006)	(0.001)	(0.001)
not married	−0.066***	−0.067***	0.010***	0.009***
	(0.018)	(0.019)	(0.003)	(0.003)
Region				
North Central	0.001	0.001	−0.018***	−0.018***
	(0.009)	(0.009)	(0.002)	(0.002)
North East	0.013	0.014	−0.011***	−0.011***
	(0.010)	(0.010)	(0.002)	(0.002)
South	0.005	0.006	−0.009***	−0.008***
	(0.009)	(0.009)	(0.002)	(0.002)
Constant	−0.082*	−0.065	0.125***	0.160***
	(0.045)	(0.047)	(0.013)	(0.013)
Observations	18181	18181	89079	93764
R^2	0.039	0.040	0.046	0.047

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: The table shows the results of the OLS regression of equation (2) where the dependent variable is either actual income growth (columns 1 and 2) or expected growth (columns 3 an 4) in real or nominal income at the household level. Estimation for actual income growth performed on all households with re-interview; the regression includes year dummies as additional controls. Estimation of expected growth performed on full sample of households (with or without re-interview (first interview if there are two interviews), all interview months); the regression includes month dummies as additional controls. Standard errors are heteroskedasticity-robust.

D Alternative Mechanisms

In this section we go through alternative mechanisms that could potentially generate the same pattern of expectation errors. We argue that none of them are consistent with the empirical results.

Learning One potential explanation could be that people need to learn about their income potential over time, so that young households could be expected to make larger errors than older households. While in the regressions in the main text we already control for age effects, it might still be the case that expectation errors vary systematically with age. Figure 20 shows the unconditional as well as the predicted expectation errors for different age groups (holding all other characteristics, including income, at their sample mean). Panel (a) shows that the unconditional mean error is hump-shaped in age. However, once all other characteristics are controlled for, expectation errors are in fact decreasing with age, indicating that people become more and more pessimistic with age. It is not the case that expectations would improve as households age. Moreover, panel (b) shows that there is no clear pattern in inflation expectations with regard to age. Based on this result we conclude that people do not seem to learn about their income potential over time.

Inability to Distinguish between Persistent and Transitory Shocks In the income process typically considered in the literature there are two types of idiosyncratic shocks which differ in their persistence. The first type of shock is persistent. The other type is completely transitory. Could an inability to distinguish between the two shocks generate the pattern of expectation errors that we observe in the data? If households cannot tell the shocks apart and observe only overall income, they have to rely on some form of filtering to form beliefs about the current state. From linear projection theory we know that Kalman filtering is (conditionally) unbiased and optimal for linear systems and normal shocks. Hence there cannot be a systematic error conditional on past income developments if people form their beliefs optimally.

A sketch of a formal proof is the following. Consider a simple state space model

$$x_t = \rho x_{t-1} + \eta_t \tag{21}$$

$$y_t = x_t + \mu_t \tag{22}$$

where η and μ are iid zero mean normal shocks with known finite variances. The forecasting error conditional on being in a particular quantile Q is $\mathsf{E}\big[y_{t+1} - y_{t+1|t} | y_t \in Q\big]$.

Suppose that t periods ago, the true state x_0 was known. It is then possible to write y_{t+1} as a function of starting state x_0, all previous η's and μ_{t+1}:

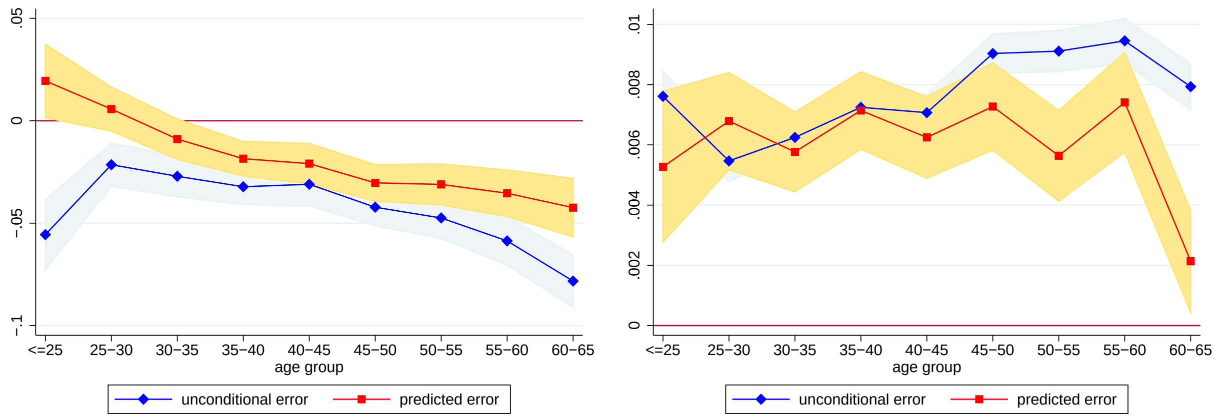
$$y_{t+1} = \eta_{t+1} + \mu_{t+1} + \rho\eta_t + \ldots + \rho^{t-1}\eta_1 + \rho^t x_0 \tag{23}$$

Similarly, $y_{t+1|t}$ can be written as a similar sum. However, now the noise terms μ also play a role because of imperfect information. It can be shown that

$$y_{t+1} - y_{t+1|t} = \eta_{t+1} + \mu_{t+1} + \rho\left[(1-K)\eta_t + K\mu_t\right] \tag{24}$$

Figure 20: Expectation Errors in Real Income by Age Group

(a) real income growth (b) inflation



Note: The figure shows the unconditional mean expectation error (blue line, diamonds) and predicted expectation error (red line, squares) by income decile. Predicted expectation errors are based on regression results from table 1, columns 1 and 6, except that age is split into 5-year age groups instead of the quadratic term in age. Predicted values computed for all other explanatory variables at the weighted sample mean. Bands refer to 95% confidence intervals (for real income growth, standard errors take the uncertainty induced by the imputation procedure into account; for inflation heteroskedasticity-robust standard errors are computed). On the y-axis, 0.01 corresponds to 1 percentage point.

where we assumed that the kalman gain K does not change over time.[11] The conditional forecasting error behaves similar to

$$\mathsf{E}\left[y_{t+1} - y_{t+1|t} \middle| y_t\right] \approx \mathsf{E}\left[\eta_t - \mu_t \middle| \eta_t + \mu_t + \sum_{\tau=1}^{t-1} \rho^{t+1-\tau} \eta_\tau\right] \tag{25}$$

However, $\eta_t - \mu_t$ is independent of $\eta_t + \mu_t$ and because the shocks are not serially correlated, $\sum_{\tau=1}^{t-1} \rho^{t+1-\tau}\eta_\tau$ does not overturn the fact that the term in the expectations is independent of the condition. Hence the conditional forecasting error is equal to the unconditional error, which is equal to zero.

Extrapolation from Recent Experience One explanation why current income can predict expectations about future income growth could be that people overweigh their recent experience. This would imply that households with a recent increase in income – which is correlated with being in a higher income group, all else being equal – would expect another increase in the future.[12] We test for this explanation by regressing the growth expectations in the second interview on past expectations and recent experience (as well as on the other control variables we included in previous regressions). Table 14 shows that past expectations explain a large portion of current expectations, which means there is persistence in expectations on the individual level. The coefficient on recent experience, on the other hand, turns

[11]This approximation is better the bigger t is at a exponential rate.

[12]The relationship between expected income change and realized income change has been found to play a role in the analysis of Das and van Soest (1999).

Table 14: Effect of Recent Experience on Growth Expectations

	(1) real	(2) real	(3) nominal	(4) nominal
Past expectation	0.372***	0.374***	0.373***	0.374***
	(0.016)	(0.016)	(0.016)	(0.016)
Past realized growth		−0.021***		−0.022***
		(0.004)		(0.004)
Income quintile				
1st	0.004	0.007	0.007	0.009**
	(0.004)	(0.004)	(0.004)	(0.004)
2nd	0.002	0.003	0.004	0.005
	(0.004)	(0.004)	(0.004)	(0.004)
4th	−0.005	−0.006*	−0.005	−0.006*
	(0.004)	(0.004)	(0.003)	(0.003)
5th	−0.008**	−0.010**	−0.008**	−0.010**
	(0.004)	(0.004)	(0.004)	(0.004)
Constant	0.061***	0.059***	0.070***	0.068***
	(0.022)	(0.022)	(0.022)	(0.021)
Observations	15931	15931	17210	17210
R^2	0.185	0.187	0.182	0.184

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

Note: OLS estimation of individual growth expectations in second interview as a function of past expectations and recent experience; estimation on sample 2HP (households with first interview in the second half of year and reinterview). Additional (unreported) control variables the same as in previous regressions: education, age, age^2, racial background, number of adults, gender, marriage status, region, and time dummies. Standard errors are heteroskedasticity-robust.

out to be significantly negative. This shows that households do not extrapolate from their recent experience. In fact, they seem to anticipate that there is mean reversion in their income process. Note, however, that the magnitude of this anticipated reversion is economically small. We can hence exclude extrapolation from recent experience as an explanation of the systematic expectation errors by income groups.

Systematically Wrong Expectations about Aggregates Another explanation for the observed pattern in expectation errors could be that households have biased expectations about aggregate conditions that vary systematically with their relative position in the income distribution. However, as seen in the analyses in the main text, household expectations about aggregate variables – such as inflation and the unemployment rate – are too pessimistic across the whole income distribution. Moreover, the magnitude of this bias does not vary much with income groups. Expectation errors in aggregate variables thus cannot explain the shift from overpessimism to overoptimism we observe as we move along the income distribution.

Measurement Error Since the empirical results are based on survey data, we want to ensure that measurement error in reported variables is not the cause of the observed patterns.

To do this we simulate an income process with persistent and transitory shocks as in the main text[13] and allow for four types of measurement errors: Errors in either the reported income level or the reported expectation in income growth, and each of these errors can either be an additive error or a multiplicative error. In detail, the information reported in the survey is assumed to have the following form:

$$\check{Y}_{it} = Y_{it} \cdot \xi^y_{it} + \varepsilon^y_{it} \tag{26}$$

$$\check{E}[g_{it}] = \frac{E[Y_{it+1}]}{Y_{it}} \cdot \xi^g_{it} + \varepsilon^g_{it} \tag{27}$$

$$\check{g}_{it} = \frac{\check{Y}_{it+1}}{\check{Y}_{it}} \tag{28}$$

where $\check{Y}_{it}$ and $\check{E}[g_{it}]$ are the reported income and reported growth expectations, respectively. $\check{g}_{it}$ is the realized income growth obtained from the reported income level. The additive measurement errors are normally distributed, the multiplicative errors log-normally:

$$\varepsilon^y_{it} \sim N(0, \sigma^y_\varepsilon) \tag{29}$$

$$\varepsilon^g_{it} \sim N(0, \sigma^g_\varepsilon) \tag{30}$$

$$\xi^y_{it} \sim \log N(-0.5(\sigma^y_\xi)^2, \sigma^y_\xi) \tag{31}$$

$$\xi^g_{it} \sim \log N(-0.5(\sigma^g_\xi)^2, \sigma^g_\xi) \tag{32}$$

We proceed by computing the observed forecast errors:

$$\check{\psi}_{it} = \check{E}[g]_{it} - \check{g}_{it} \tag{33}$$

We regress these errors by OLS on indicators for income quintiles, which are in turn determined based on reported income:

$$\check{\psi}_{it} = \alpha + \beta_1 \check{D}^1_{it} + \beta_2 \check{D}^2_{it} + \beta_4 \check{D}^4_{it} + \check{D}^5_{it} + \epsilon_{it} \tag{34}$$

Tables 15-18 show the resulting predicted forecast errors for increasing magnitudes of measurement errors in each of the four cases. The tables also show the distribution of measurement errors by income quintile and compare the magnitudes to the average income or growth rate in the respective income quintile.

Table 15 and table 16 show the results for measurement errors in the reported level of income. The considered magnitudes of these errors range from a standard deviation of 5% to 30% compared to the standard deviation of persistent income shocks. This translates into substantial measurement errors which are up to about 40% and 26% of mean income in the lowest income quintile for additive and multiplicative errors, respectively. As regards the forecast errors that the OLS regression would predict, the tables show that the signs of these errors are broadly in line with the empirical findings. Quantitatively, however, even for large variances of measurement errors, the forecast errors are an order of magnitude smaller than what is found in the survey data. Table 17 and table 18 show that even for large measurement errors in reported expectations, there is no systematic effect on forecast errors.

[13] The income process is the same as employed in the main text. The difference is that we abstract from aggregate shocks and simulate the process directly on annual frequency.

We hence conclude that measurement errors in reported level income might contribute to the observed pattern, but they can at most explain a small fraction of the effects. Measurement errors in reported growth expectations do not contribute to predicted forecast errors.

Interpretation of Survey Answers as Median or Mode One potential concern about the way the Michigan Surveys of Consumers phrases the expectation question is that it asks households about their expected income growth. But it does not explicitly specify whether households are supposed to supply their mean expected income growth, the median or even the mode. In the analysis in the main text we interpret their answers as the mean expected income growth.

However, even if households answered with the median or the mode, this could not explain our systematic expectation errors. The reason is that the median and the mode of realized income growth rates are significantly lower than the mean for *both* low and high-income households. Hence, if households answered with the median or mode of their expectations then both income groups would show up as too pessimistic in our analysis. This mechanism is therefore not able to explain why high-income households are too optimistic – it is not able to generate a change in the sign of the forecast errors.

Other Mechanism Brunnermeier and Parker (2005) describe a setting where agents find it optimal to have too optimistic expectations. Alternatively, it might be possible that in order to attempt high risk-high reward projects, one needs to underestimate the chances of failure. The overoptimism of high-income households could then arise as a result of survival bias. However, neither of these mechanisms can explain why low-income households are on average too pessimistic in their expectations. As regards the low-income agents, if there is ambiguity about the true income process, they might find it optimal to form expectations under a worst-case belief (Gilboa and Schmeidler, 1989; Epstein and Schneider, 2003). However, this mechanism cannot explain the overoptimism of high-income households.

Table 15: Effects of Additive Measurement Errors in Reported Income Levels

$\sigma_{\varepsilon^y}/\sigma_P$	Predicted Forecast Errors Income Quintile			Distribution of Measurement Errors 1st income quintile					3rd income quintile					5th income quintile				
	1st	3rd	5th	mean(Y)	min	5%	95%	max	mean(Y)	min	5%	95%	max	mean(Y)	min	5%	95%	max
0.05	-0.000	0.000	0.000	0.50	-0.03	-0.01	0.01	0.03	0.97	-0.04	-0.01	0.01	0.03	2.00	-0.03	-0.01	0.01	0.03
0.10	-0.002	0.000	0.000	0.50	-0.06	-0.02	0.02	0.06	0.97	-0.07	-0.02	0.02	0.06	2.00	-0.06	-0.02	0.02	0.07
0.15	-0.005	0.001	0.000	0.50	-0.10	-0.03	0.03	0.09	0.97	-0.11	-0.03	0.03	0.10	2.00	-0.09	-0.03	0.03	0.10
0.20	-0.009	0.001	0.001	0.50	-0.13	-0.04	0.04	0.12	0.97	-0.14	-0.04	0.04	0.13	2.00	-0.12	-0.04	0.04	0.13
0.25	-0.013	0.001	0.001	0.50	-0.17	-0.05	0.05	0.16	0.97	-0.18	-0.05	0.05	0.17	2.00	-0.15	-0.05	0.05	0.16
0.30	-0.019	0.002	0.001	0.50	-0.20	-0.06	0.05	0.18	0.97	-0.21	-0.06	0.06	0.20	2.00	-0.18	-0.06	0.06	0.20

Note: The table shows the effects of additive measurement errors in reported income levels. Column 1 shows the variation of the measurement error relative to the variation in persistent income shocks. Columns 2-4 show the the predicted forecast errors that result from running the main regression on simulated data. The remaining columns show the distribution of measurement errors for the different income quintiles and compare them to the mean income in the respective income quintile.

Table 16: Effects of Multiplicative Measurement Errors in Reported Income Levels

σ_{ξ^y}/σ_P	Predicted Forecast Errors Income Quintile			Distribution of Measurement Errors 1st Income Quintile					3rd Income Quintile					5th Income Quintile				
	1st	3rd	5th	mean(Y)	min	5%	95%	max	mean(Y)	min	5%	95%	max	mean(Y)	min	5%	95%	max
0.05	-0.000	0.000	0.000	0.50	-0.02	-0.01	0.00	0.02	0.97	-0.03	-0.01	0.01	0.04	2.00	-0.17	-0.02	0.02	0.19
0.10	-0.001	-0.000	0.000	0.50	-0.04	-0.01	0.01	0.04	0.97	-0.06	-0.02	0.02	0.06	2.00	-0.34	-0.04	0.04	0.38
0.15	-0.001	-0.000	0.001	0.50	-0.06	-0.02	0.01	0.05	0.97	-0.10	-0.03	0.03	0.09	2.00	-0.50	-0.06	0.06	0.58
0.20	-0.003	-0.000	0.001	0.50	-0.08	-0.02	0.02	0.07	0.97	-0.14	-0.04	0.04	0.12	2.00	-0.66	-0.08	0.08	0.78
0.25	-0.004	-0.001	0.002	0.50	-0.11	-0.03	0.02	0.09	0.97	-0.17	-0.05	0.05	0.15	2.00	-0.82	-0.10	0.10	0.97
0.30	-0.006	-0.001	0.002	0.50	-0.13	-0.03	0.03	0.10	0.97	-0.22	-0.06	0.06	0.18	2.00	-0.98	-0.11	0.12	1.18

Note: The table shows the effects of multiplicative measurement errors in reported income levels. Column 1 shows the variation of the measurement error relative to the variation in persistent income shocks. Columns 2-4 show the the predicted forecast errors that result from running the main regression on simulated data. The remaining columns show the distribution of measurement errors for the different income quintiles and compare them to the mean income in the respective income quintile.

Table 17: Effects of Additive Measurement Errors in Reported Growth Rate Expectations

$\frac{\sigma^2_{\varepsilon g}}{var(g)}$	Predicted Forecast Errors			Distribution of Measurement Errors														
	income quintile			1st income quintile					3rd income quintile					5th income quintile				
	1st	3rd	5th	mean(g)	min	5%	95%	max	mean(g)	min	5%	95%	max	mean(g)	min	5%	95%	max
0.01	0.000	0.000	0.000	1.30	-0.26	-0.07	0.07	0.22	1.06	-0.22	-0.07	0.07	0.22	0.87	-0.22	-0.07	0.07	0.23
0.02	0.000	0.000	0.000	1.30	-0.36	-0.10	0.10	0.31	1.06	-0.31	-0.10	0.10	0.31	0.87	-0.32	-0.10	0.10	0.33
0.03	0.000	0.000	0.000	1.30	-0.44	-0.12	0.12	0.37	1.06	-0.38	-0.12	0.12	0.38	0.87	-0.39	-0.12	0.12	0.40
0.04	0.000	0.000	0.000	1.30	-0.51	-0.14	0.14	0.43	1.06	-0.44	-0.14	0.14	0.43	0.87	-0.45	-0.14	0.14	0.46
0.05	0.000	0.000	0.000	1.30	-0.57	-0.15	0.15	0.48	1.06	-0.50	-0.15	0.15	0.49	0.87	-0.50	-0.15	0.15	0.52

Note: The table shows the effects of additive measurement errors in expected income growth. Column 1 shows the variation of the measurement error relative to the variation in income growth. Columns 2-4 show the the predicted forecast errors that result from running the main regression on simulated data. The remaining columns show the distribution of measurement errors for the different income quintiles and compare them to the mean growth rate in the respective income quintile.

Table 18: Effects of Multiplicative Measurement Errors in Reported Growth Rate Expectations

$\frac{var(\xi^g)}{var(g)}$	Predicted Forecast Errors			Distribution of Measurement Errors														
	Income Quintile			1st income quintile					3rd income quintile					5th income quintile				
	1st	3rd	5th	mean(g)	min	5%	95%	max	mean(g)	min	5%	95%	max	mean(g)	min	5%	95%	max
0.01	0.000	0.000	0.000	1.30	-0.43	-0.09	0.09	0.55	1.06	-0.33	-0.07	0.08	0.42	0.87	-0.35	-0.06	0.06	0.34
0.02	0.000	0.000	0.000	1.30	-0.59	-0.12	0.13	0.80	1.06	-0.44	-0.10	0.11	0.62	0.87	-0.48	-0.08	0.09	0.49
0.03	0.000	0.000	0.000	1.30	-0.71	-0.15	0.16	1.00	1.06	-0.53	-0.12	0.13	0.78	0.87	-0.58	-0.10	0.11	0.62
0.04	0.000	0.000	0.000	1.30	-0.81	-0.17	0.19	1.18	1.06	-0.60	-0.14	0.15	0.93	0.87	-0.65	-0.12	0.13	0.73
0.05	0.000	0.000	0.000	1.30	-0.90	-0.19	0.21	1.34	1.06	-0.65	-0.16	0.17	1.06	0.87	-0.72	-0.13	0.14	0.83

Note: The table shows the effects of multiplicative measurement errors in expected income growth. Column 1 shows the variation of the measurement error relative to the variation in income growth. Columns 2-4 show the the predicted forecast errors that result from running the main regression on simulated data. The remaining columns show the distribution of measurement errors for the different income quintiles and compare them to the mean growth rate in the respective income quintile.

E Proof of Results in Section 3.1

E.1 Theorem

Income (net of age effects and the effects of other demographics) follows the process

$$Y_{it} = P_{it} \cdot T_{it} \tag{35}$$
$$P_{it} = P_{it-1}^{\rho} \cdot N_{it} \tag{36}$$

where P_{it} is a persistent component and T_{it} a transitory shock. Persistent income depends on past persistent income and a persistent shock N_{it}. Both shocks are independently and log-normally distributed with mean 1.

We assume that $1 > \hat{\rho} = \rho + \varepsilon > \rho$, so that all relevant moments exist and are finite. The expected income next period in this case is equal to $\mathsf{E}[Y_{it+1}] = \mathsf{E}[P_{it+1} \cdot T_{it+1}] = \mathsf{E}[P_{it}^{\hat{\rho}} \cdot N_{it+1} \cdot T_{it+1}] = P_{it}^{\hat{\rho}}$. Therefore the expected growth rate in income is $\mathsf{E}\left[\frac{\Delta Y_{it+1}}{Y_{it}}\right] = \frac{P_{it}^{\hat{\rho}} - Y_{it}}{Y_{it}}$ and the actual growth rate is equal to $\frac{\Delta Y_{it+1}}{Y_{it}} = \frac{P_{it}^{\rho} \cdot N_{it+1} \cdot T_{it+1} - Y_{it}}{Y_{it}}$. The expectation error can hence be calculated as:

$$\begin{aligned}
\psi_{it} &= E\left[\frac{\Delta Y_{it+1}}{Y_{it}}\right] - \frac{\Delta Y_{it+1}}{Y_{it}} \\
&= \frac{P_{it}^{\hat{\rho}} - Y_{it}}{Y_{it}} - \frac{P_{it}^{\rho} \cdot N_{it+1} \cdot T_{it+1} - Y_{it}}{Y_{it}} = \frac{P_{it}^{\hat{\rho}} - P_{it}^{\rho} \cdot N_{it+1} \cdot T_{it+1}}{Y_{it}} \\
&= \frac{P_{it}^{\rho+\varepsilon} - P_{it}^{\rho} \cdot N_{it+1} \cdot T_{it+1}}{Y_{it}} = \frac{P_{it}^{\rho}}{Y_{it}} \left(P_{it}^{\varepsilon} - N_{it+1} T_{it+1}\right) \\
&= \frac{P_{it}^{\rho-1}}{T_{it}} \left(P_{it}^{\varepsilon} - N_{it+1} T_{it+1}\right)
\end{aligned} \tag{37}$$

The *average* expectation error is then equal to $\mathsf{E}[\psi_{it}] = \frac{P_{it}^{\rho-1}}{T_{it}}\left[P_{it}^{\varepsilon} - 1\right]$. P_{it} can be re-written as a combination of its mean of $\mathsf{E}P = 1 + \bar{P}$ and the deviation from the mean p_{it}: $P_{it} = 1 + \bar{P} + p_{it}$. The term $\bar{P}$ is the log-normal mean correction term.

Using this notation, the expected error becomes

$$\mathsf{E}[\psi_{it}] = \frac{\left(1 + \bar{P} + p_{it}\right)^{\rho-1}}{T_{it}} \left[\left(1 + \bar{P} + p_{it}\right)^{\varepsilon} - 1\right] \tag{38}$$

For a large enough current P_{it} (namely $p_{it} > -\bar{P}$), the term in the brackets is positive. This means that agents with income above this threshold on average overpredict their future income growth.

How does the expected error change with current P_{it}? $\frac{\partial \mathsf{E}\psi_{it}}{\partial P_{it}}$ has the same sign as $\frac{\partial F(z)}{\partial z}$

where $F(z) = z^{\rho+\varepsilon-1} - z^{\rho-1}$. We have

$$\begin{aligned} F(z)' &= z^{\rho-1}[(\rho+\varepsilon-1)z^{\varepsilon} - (\rho-1)] \\ &\approx (\rho+\varepsilon-1)\left[z^{\varepsilon} - \frac{\rho-1}{\rho-1+\varepsilon}\right] \\ &= -(1-\rho-\varepsilon)\left[z^{\varepsilon} - \frac{1-\rho}{1-\rho-\varepsilon}\right] \end{aligned} \tag{39}$$

This expression is *positive* as long as $z^{\varepsilon} < \frac{1-\rho}{1-\rho-\varepsilon}$, i.e. as long as $z < \left(\frac{1-\rho}{1-\rho-\varepsilon}\right)^{1/\varepsilon}$. Because $\rho \gg \varepsilon$ and ε is close to zero, the expectation error is increasing in P_{it} until very very large values of the current P_{it}. In the model calibration, we have $\rho = 0.9774$, $\varepsilon = 0.0057$, which translates into a threshold of $z \approx 1.4e22$.

E.2 Corollary

If the true income process is governed by equations (3) and (4) and the household overestimates the persistence of the process according to equation (5), the distorted expectation of the next period's income is

$$\begin{aligned} E_t^{\theta}[\ln Y_{i,t+1}] &= \hat{\rho} \ln P_{i,t} \\ &= (\rho+\theta)\ln P_{i,t} \\ &= E_t[\ln Y_{i,t+1}] + \theta \cdot \sum_{s=0}^{\infty} \rho^s \ln N_{i,t-s} \\ &= E_t[\ln Y_{i,t+1}] + \theta \cdot \sum_{s=0}^{\infty} \rho^s \big(\ln P_{i,t-s} - E_{t-s-1}[\ln P_{i,t-s}]\big) \\ &= E_t[\ln Y_{i,t+1}] + \theta \cdot \sum_{s=0}^{\infty} \rho^{s-1} \big(\rho \ln P_{i,t-s} - \rho E_{t-s-1}[\ln P_{i,t-s}]\big) \\ &= E_t[\ln P_{i,t+1}] + \theta \cdot \sum_{s=0}^{\infty} \rho^{s-1} \big(E_{t-s}[\ln P_{i,t-s+1}] - E_{t-s-1}[\ln P_{i,t-s+1}]\big) \\ &= E_t[\ln Y_{i,t+1}] + \theta \cdot \sum_{s=0}^{\infty} \rho^{s-1} \big(E_{t-s}[\ln Y_{i,t-s+1}] - E_{t-s-1}[\ln Y_{i,t-s+1}]\big) \end{aligned}$$

F Overpersistence Bias for Alternative Income Process Parametrization

In the main text we use an income process parametrized according to Storesletten et al. (2004) as a true underlying process. In this section we show that the expectation formation under overpersistence bias is able to match the empirically observed forecasting errors also for alternative specifications of the true underlying process. In particular, we show that the results are robust to increasing the persistence of the process and show how even the limit of random walk can be accommodated in our framework.

F.1 AR(1)

In this section, we keep the income process as a persistent AR(1) process with transitory shocks. We vary the persistence of the process and show that the overpersistence bias is able to match the patterns in the forecast error data very well even for very persistent processes.

Table 19: Mean Expectation Errors

	Data	Model				
ρ - true persistence		0.9774	0.9828	0.9882	0.9936	0.9990
$\hat{\rho}$ - persistence beliefs		0.9831	0.9867	0.9905	0.9945	0.9991
μ - aggregate beliefs		0.9777	0.9777	0.9777	0.9776	0.9774
income quintile 1	-0.0716	-0.0689	-0.0688	-0.0684	-0.0672	-0.0665
income quintile 2	-0.0372	-0.0374	-0.0374	-0.0382	-0.0396	-0.0396
income quintile 3	-0.0193	-0.0208	-0.0209	-0.0211	-0.0223	-0.0229
income quintile 4	-0.0003	-0.0065	-0.0065	-0.0057	-0.0046	-0.0052
income quintile 5	0.0158	0.0208	0.0209	0.0208	0.0210	0.0216

Note: The results in this table show that the overpersistence bias can match the mean forecasting errors by income quintiles for varying values of the underlying persistence parameter.

This observation is documented in table 19. The first line shows the assumed persistence parameter of the underlying process (increasing from column to column). The second and third lines show the two bias parameters that are needed to match the forecast errors. The last 5 lines show that for all assumed persistence parameters, the overpersistence bias is able to match the empirically observed forecast errors very well.

F.2 Random Walk

In the limit case, the AR(1) becomes a random walk. In this section we show that a similar mechanism functions even in this setting. Here we assume that people do not observe the persistent and transitory component separately and have wrong beliefs about the relative volatility of the persistent component. This mechanism preserves the underlying intuition that people believe that shocks are more persistent than they truly are.

The agents receive income y_{it}, which is the combination of aggregate Z_t and idiosyncratic permanent P_{it} and transitory ε_{it}.

$$y_{it} = Z_t P_{it} \varepsilon_{it}, \tag{40}$$
$$P_{it} = P_{it-1} \eta_{it}, \tag{41}$$

where

$$\begin{bmatrix} \varepsilon \\ \eta \end{bmatrix} \sim \log \mathcal{N}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_\varepsilon^2 & 0 \\ 0 & \sigma_\eta^2 \end{bmatrix} \right) \tag{42}$$

People only observe y_{it}, not P_{it} and ε_{it} separately, so they use a Kalman filter to make forecasts about their future income. Following the same argument as in the main text, the households are allowed to make systematic mistakes when forecasting the aggregate component: $Z_{t+1|t} = \mu \mathsf{E}[Z_{t+1}]$. Because the aggregate bias does not change the dispersion of forecasting errors in the cross-section, we assume that $Z_t = 1$ for simplicity. Combined, the next period forecast is (dropping the individual index i):

$$y_{t+1|t} = \mu P_{t|t}, \tag{43}$$

where $P_{t|t}$ is the inferred permanent state based on the information set at time t. The resulting forecasting error in income growth is

$$\begin{aligned} error_t &= \log\left(\frac{\mu P_{t|t}}{P_t \varepsilon_t}\right) - \log\left(\frac{P_t \eta_{t+1} \varepsilon_{t+1}}{P_t \varepsilon_t}\right) \\ &= \log(\mu) + \log(P_{t|t}) - \log(P_t) - \log(\eta_{t+1}) - \log(\varepsilon_{t+1}) \end{aligned}$$

$\log(\eta_{t+1})$ and $\log(\varepsilon_{t+1})$ are on average zero, so the bias has to come from μ and the discrepancy between the believed and the actual state of the permanent income component.

The bias is implemented in the following way. The agents have wrong beliefs about σ_ε^2 and σ_η^2. This affects the Kalman gain, and changes how much of recent surprises in the observed y_t is believed to be caused by P as opposed to ε. We also assume that people are not wrong about the total variance $\sigma_\varepsilon^2 + \sigma_\eta^2$, so that people are correct about the one step ahead conditional volatility of y. In other words, people believe that

$$\hat{\sigma}_\eta = \gamma_1 \sigma_\eta$$
$$\hat{\sigma}_\varepsilon = \gamma_2 \sigma_\varepsilon$$

such that

$$\gamma_1^2 \sigma_\eta^2 + \gamma_2^2 \sigma_\varepsilon^2 = \sigma_\eta^2 + \sigma_\varepsilon^2.$$

We simulate the income and forecast errors of 50,000 households over 50 years for 3 different parametrizations of the variances employed in the literature.[14] The results are captured in table 20. We show that this mechanism is able to match the empirical forecast errors for all three parametrizations of the random walk income process.

Note that qualitatively the mechanism always generates the correct direction of forecast-

[14]Carroll et al. (2017) and Debacker et al. (2013) estimate the process on total household income which is the object of interest in our paper. Guvenen et al. (2016), on the other hand, only report estimates for total male labor earnings.

Table 20: Mean Expectation Errors

	Data	Model		
		Carroll et al. (2017)	Debacker et al. (2013)	Guvenen et al. (2016)
σ_ε		0.1000	0.3520	0.4940
σ_η		0.1000	0.0849	0.1560
γ_1		1.9990	1.5869	1.3693
μ		0.9778	0.9777	0.9777
income quintile 1	-0.0720	-0.0653	-0.0669	-0.0671
income quintile 2	-0.0370	-0.0448	-0.0399	-0.0396
income quintile 3	-0.0190	-0.0211	-0.0232	-0.0239
income quintile 4	-0.0000	-0.0013	-0.0031	-0.0020
income quintile 5	0.0160	0.0203	0.0211	0.0206

Note: The results in this table show that the overpersistence bias can match the mean forecasting errors by income quintiles even for the limit case of a random walk (for three different calibrations of the income process from the literature).

ing errors. In order to match the errors also quantitatively, there must be enough volatility in the transitory shocks relative to the permanent shocks. The reason is that the bias falsely attributes parts of the realized transitory shocks to permanent shocks. For this to be able to generate large forecasting errors, sufficiently large transitory shocks are required to give enough scope for misallocation.

G Consumption Model: Numerical Implementation

G.1 Solution Algorithm

The model is solved using a value function iteration algorithm with Howard's Improvement. The solution of the rational agent's problem is standard. The policy functions of the agent with biased beliefs are obtained in two steps. First, the problem is solved using the grid and transition matrices as if the biased beliefs were correct. After the solution converges, we do one more iteration of the value function iteration algorithm, now using the grid corresponding to the true data generating process, keeping the transition matrices and the continuation values $\mathsf{E}V'$ from the biased agent solution.

Including the discretization of the aggregate and idiosyncratic income components, we solve the baseline model using the following grids:

- 210 grid points for liquid assets, unevenly spaced (step size gets smaller around zero) between around negative 11 and positive 12
- 120 grid points for durable assets, unevenly spaced (step size increasing with the level of durable assets) between 0 and 12
- 15 states for the persistent idiosyncratic component P, levels and transition matrices generated using the Rouwenhorst method
- 11 states for the idiosyncratic transitory component T, levels and probabilities generated using the Gauss-Hermite Quadrature
- 2 states for the aggregate component Z, calibrated so the model delivers the same time spent in booms and recessions as the U.S. economy.

The presence of the durable adjustment costs implies that the household has to decide whether to incur these costs and choose the optimal level of durable assets or let the durable good depreciate. In theory, in each step of the value function iteration, the values for both action and inaction have to be updated. Solving for the optimal action given adjustment is particularly costly, because it involves two-dimensional optimization. However, in practice it is not necessary to update both value functions at all grid points. If one keeps track of the boundary of the inaction region, both values only need to be updated in the neighborhood of the boundary. This step can lower the solution time considerably for well-chosen grids, as the inaction region will occupy a large fraction of the state space.

G.2 Simulation

We obtain the distributions by simulating a panel of 150,000 households for 1,500 periods (discarding the first 200 periods). Using the remaining 1,300 periods, which include both booms and recessions as captured by the income component Z, we pool all the agents over all periods to construct the ergodic distributions.

To construct MPCs we run the following experiment. From the simulated series after discarding the burn-in period, we randomly select 300 points in time (so we correctly account for the effect of aggregate conditions) and use them as new starting points for new simulations. At these 300 starting points, we give every household a lump sum cash transfer and then we re-simulate the economy for one period. The MPCs are computed by comparing the behavior of households in the simulation with the transfer to the same households from the original simulation, averaged over all 150,000 households and 300 simulations. This experiment uses all the memory that is available to us (256 GB). In order to compute the impulse response functions, we are forced to limit the number of households to 30,000 and simulate for 12 periods.

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