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Abstract

We propose a new approach to identify the strength of the precautionary motive and the extent of self-insurance in response to earnings risk based on Euler equation estimates. To address endogeneity problems, we use Norwegian administrative data and instrument consumption and earnings volatility with the variance of firm-specific shocks. The instrument is valid because firms pass some of their productivity shocks onto wages; moreover, for most workers firm shocks are hard to avoid. Our estimates suggest a coefficient of relative prudence of 2, in a very plausible range.

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1 Introduction

We propose a new approach to identify the strength of the precautionary motive and the extent of self-insurance in response to earnings risk based on empirical Euler equation estimates. As is well known (see e.g. Carroll, 1992), households who face income risk and have a precautionary motive for saving accumulate wealth to cushion against rainy days and sustain future consumption. One way to test for precautionary saving is to estimate a consumption Euler equation, regressing consumption growth on the volatility of future consumption growth:[1]

$$\Delta \ln c_{it} = \alpha V_{it}^{c} + \beta' X_{it} + \zeta_{it}, \tag{1}$$

where c_{it} is individual i 's consumption, V_{it}^{c} consumption growth volatility conditional on information at the beginning of the period, X_{it}' a vector of demographic controls and ζ_{it} a consumption growth innovation. Under CRRA preferences, α equals 1/2 the coefficient of relative prudence as defined by Kimball (1990) and thus identifies the strength of the precautionary motive for saving.

2 Problems with and solutions to the Euler equation approach

Dynan (1992) was one of the first to use (1) to identify the strenght of the precautionary motive using data from the Consumer Expenditure Survey. The main problem is that V_{it}^{c} is unobserved. Dynan solves it by estimating:

$$\Delta \ln c_{it} = \alpha \left(\Delta \ln c_{it}\right)^2 + \beta' X_{it} + \zeta_{it}, \tag{2}$$

and instrumenting realized volatility in consumption growth (the term $(\Delta \ln c_{it})^2$) with a set of socio-demographic variables that are known at time $t-1$ and presumably explain volatility (such as education, occupation, etc.). She estimates a very small value of α, suggesting a limited role for precautionary saving. The empirical problem with this approach is that the selected instruments either lack power or may be good predictors of changes in the chosen pattern of consumption (i.e., they violate the exclusion restriction).[2]

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[1] An alternative approach is to estimate reduced form savings equations or wealth equations using measures of earnings volatility, as in Guiso et al. (1992).

[2] One solution to the problem of weak instruments, first proposed by Bertola et al. (2005), is to instrument the realized variability of consumption growth with a measure of the subjective variance of future earnings available in the Italian Survey of Households Income and Wealth. This approach results in an estimate of

An alternative approach is to proxy the unobserved conditional variance of consumption growth (a sufficient statistic for all sources of risk faced) with income risk, which for most people is the most relevant risk faced over the life cycle. The strength of this proxy depends on the degree of self-insurance. Suppose that consumption risk V^c originates from two independent sources, the first related to labor income risk, V^y, and the second, V^η, reflecting other sources of consumption risk arising for instance from shocks to consumption needs:

$$V^c_{it} = \theta V^y_{it} + V^\eta_{it} \tag{3}$$

The parameter $0 \leq \theta \leq 1$ maps income risk into consumption risk. A value of $\theta < 1$ implies partial self-insurance of labor income risk, either through accumulation of precautionary assets or other sources of insurance, such as family risk sharing or formal access to credit or insurance markets. We are interested in identifying both the strength of the precautionary motive α as well as the extent of insurance against labor income risk θ. The latter is critical to judge the adequacy of precautionary savings.

Using income risk as a proxy for the unobserved V^c_{it} leads to the estimation of a modified Euler equation:

$$\Delta \ln c_{it} = \alpha \widetilde{V^y_{it}} + \beta' X_{it} + u_{it}, \tag{4}$$

where $\widetilde{V^y_{it}}$ is a measure of the *observed* residual variance of earnings faced by individual i at time t (obtained from estimation of a statistical process for earnings in longitudinal data). Since from (3) consumption volatility reflects the underlying volatility of individual earnings, the latter is a natural candidate to proxy for the former; it is idiosyncratic and can be measured. However, because a non-negligible part of measured earnings volatility (as discussed in Fagereng et al., 2016) may reflect choice rather than risk, it may fail the exogeneity requirement: it is an error-ridden measure of true earnings risk. To see this, suppose that (residual) wage variance is:

$$\widetilde{V^y_{it}} = H_{it} + \rho_f F_{it} \tag{5}$$

where F is the variance of shocks to the firm the individual works for, ρ_f the (square) of the pass-through of firms shocks to workers' wages reflecting partial insurance within the firm, and H the residual, non-firm related, earnings variance (e.g., the unobserved component of human capital). However, assume that only a fraction ρ_h of H is truly risk, while the rest is

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the prudence parameter of around 2, suggesting a strong precautionary motive. While useful, the problem with this approach is that subjective probability distributions of future earnings are usually unavailable in survey data. Furthermore, little is known on how much of the earnings risk that people face is actually insured.

variation in wages that reflects individual choice (or even statistical noise), rather than risk. Hence:

$$V_{it}^{y} = \rho_h H_{it} + \rho_f F_{it}, \tag{6}$$

implying that measured earnings risk is $\widetilde{V_{it}^{y}} = V_{it}^{y} + \varepsilon_{it}$, the sum of true risk and a measurement error $\varepsilon_{it} = (1 - \rho_h) H_{it}$. An OLS regression of Δc_{it} on $\widetilde{V_{it}^{y}}$ as in (4) thus yields:

$$p \lim \widehat{\alpha} = \alpha\theta \frac{\rho_h V_H + \rho_f^2 V_F}{V_H + \rho_f^2 V_F}$$

where $V_H = var(H)$, $V_F = var(F)$ (see Appendix). This is a downward biased estimate of α for two reasons: i) it ignores that some earnings volatility may reflect choice or noise (the factor ρ_h); and ii) it mixes precautionary motive and self-insurance (the factor θ).[3]

Identification of the strength of the precautionary motive and of the self-insurance of earnings risk requires separate identification of the two parameters α and θ; it also requires solving the error-in-variable problem induced by the choice/noise issue. Our proposed solution is to follow Fagereng et al.'s (2016) methodology, match data on consumers with data on their employers, and use the firm-specific variance of value added shocks (F_{it} in the notation of equation 6) as an instrument for $\widetilde{V_{it}^{y}}$ in equation (4), and as an instrument for realized consumption volatility in equation (2). The instrument is valid because, as we document below, firms pass some of their productivity shocks onto wages (i.e., there is only partial insurance within the firm). Moreover, for most workers firm-related shocks cannot be manipulated and are hard to avoid - that is they are a genuine source of risk.[4] It can be shown that, under the maintained assumptions, the resulting IV estimation of (4) provides a consistent estimate of $\alpha\theta$, while IV estimation of (2) provides a consistent estimate of α (see Appendix). Hence, comparison of estimates from the two models allows separate identificaton of α and θ.

3 Data

We use nearly 20 years of longitudinal administrative data on income and assets covering the whole Norwegian population. Data are thus attrition-free except for mortality and migration. A full description of the data is provided in Fagereng et al. (2016). Here we summarize their main features. All data, including assets values and income from capital and labor, are obtained from tax administrative records implying that measurement error is likely contained. Firm data also come from administrative records (balance sheets). Employed

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[3] Banks et al. (2001) interact the residual earnings variance with a measure of θ (the squared wealth/income ratio), and hence their estimate is free from the second problem.

[4] Note that if only because of self-insurance, it is natural to expect firm volatility to be a more powerful instrument for residual earnings volatility than for realized consumption volatility.

workers can be matched with their employer and with measures of the firm performance for all years they are observed in employment. Because we use firm performance volatility as an instrument for earnings volatility we limit our sample to individuals employed in private firms.

3.1 Measuring consumption

The Norwegian administrative data do not provide us with a direct measure of consumption. Instead, we follow Fagereng and Halvorsen (2015) and impute it using the budget identity: $c_{it} = (y^d_{it} - \Delta a_{it})/n_{it}$, where y^d_{it} is the sum of all income sources (including capital income) net of taxes, and a_{it} is liquid assets (since information on housing wealth is incomplete). We deflate consumption by the OECD equivalence scale $n = (1 + 0.7(A - 1) + 0.5K)$, where A is the number of adults and K the number of children (aged less than 18) in the household. This measure adjusts for capital gains and losses by use of broad domestic and foreign stock market indices, but likely suffers from some measurement error. Examples are extreme observations that may occur in household-year observations where the household has been involved in a real estate transaction, extreme returns from financial markets or when the household is a business owner or a farmer. Excluding such observations and using the crude adjustment for capital gains and losses alleviate the problem of measurement error. However, issues related to the yearly nature of our data, such as intra-year trading in stocks, and to housing transactions and marriage/divorce dynamics, remain. For this reason, we focus on a sample where exclude extreme values of consumption growth.[5]

4 Methodology

We measure firm j performance with its value added, VA_{jt}, and assume its log evolves according to the process

$$\begin{aligned} \ln VA_{jt} &= \mathbf{X}'_{jt}\varphi + Q_{jt} + f^T_{jt} \\ Q_{jt} &= Q_{jt-1} + f^P_{jt} \end{aligned}$$

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[5] We choose an asymmetric trimming, excluding the bottom 2.5% and top 1% of observations because our measure of consumption is total expenditures, including durable purchases. Hence, occasionally one sees big increases in expenditures. To further limit imputation error we retain only households with consumption levels above a minimum threshold (around USD 10,000 following the government guidelines for social financial support).

where $\mathbf{X}_{jt}$ is a vector of observables that captures the predictable component of firm's performance. The stochastic component is the residual $Q_{jt} + f_{jt}^T$, the sum of a random walk component Q_{jt} with permanent shock f_{jt}^P and a transitory shock component f_{jt}^T.

We model the earnings y_{ijt} (in logs) of worker i in firm j as a linear function of a vector of workers' observed characteristics, $\mathbf{Z}_{ijt}$, and an idiosyncratic unexplained residual ω_{ijt}. The latter is the sum of an individual random walk and a transitory component, plus a component that depends on the firm shocks (transitory and permanent) with transmission coefficients λ^T and λ^P, reflecting partial wage insurance within the firm.[6] Hence:

$$\begin{aligned} \ln y_{ijt} &= \mathbf{Z}'_{ijt}\gamma + \omega_{ijt} \\ &= \mathbf{Z}'_{ijt}\gamma + v_{it} + \lambda^P f_{jt}^P + \lambda^T f_{jt}^T \end{aligned}$$

where v_{it} is an individual unobserved component (the sum of a random walk permanent component and an i.i.d. transitory shock). The term v_{it} may in part be predictable by the consumer (though not by the econometrician) and not constitute a source of earnings risk. The firm component instead qualifies as earnings risk. We assume the two components are independent. Hence, if earnings risk $\widetilde{V_{it}^y}$ is measured by the variance of ω_{ijt} it will reflect both true risk and "noise". For firm-related shocks to matter, λ^T and λ^P must be economically and statistically significant: i.e., firms must pass over to the workers some of the shocks to their performance and not offer them full wage insurance.

Following Guiso et al. (2005) methodology, Fagereng et al. (2016) use Norwegian data and obtain estimates of $\lambda^P$and λ^T of 0.071 and 0.018, respectively, both strongly statistically significant. Thus, both transitory and permanent shocks to firm performance are partly passed over to the worker but the pass-through is much stronger for permanent shocks, consistent with intuition. We replicate this methodology here.

To have a reasonably long series of earnings volatility measures, we compute the overall variance of unexplained workers earnings growth over T periods using rolling averages: $\widetilde{V_{it}^y} = \frac{\sum_{s=0}^{T-1}\omega_{ijt-s}^2}{T}$ (and set $T = 5$). We use this measure when estimating the Euler equation (4). Our instruments are the variances of the unexplained firm value added growth - both permanent and transitory - computed over the same T periods:

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[6] These processes fit the data quite well (see Fagereng et al. (2016)).

$$F_{jt}^{P} = \frac{\sum_{s=0}^{T-1} g_{jt-s}(g_{jt-s-1} + g_{jt-s} + g_{jt-s+1})}{T}$$

$$F_{jt}^{T} = \frac{\sum_{s=0}^{T-1} g_{jt-s} g_{jt-s+1}}{T}$$

where $g_{jt} = \Delta(\ln VA_{jt} - \mathbf{X}'_{jt}\varphi)$.

5 Results

Table 1 shows the results of the IV estimates of the Euler equations (4) and (2). To eliminate outliers, we trim the variances of firm shocks at the 1st and 99th percentile. Our estimation sample contains about 327,000 observations. As additional controls we include a set of year fixed effects (to account for changes in interest rates), a quadratic in age, the change in the number of children and years of schooling.

Table 1: IV estimates of the effect of wage and consumption risk on the growth of consumption

	$\Delta \ln c_{it}$	
Endogenous:	$\widetilde{V}_{yit}$	$\widetilde{V}_{cit}$
IV:	0.650***	1.008***
	(0.233)	(0.310)
F-stat 1st stage	294.854	7.853
Kleibergen-Paap underid p-value	0.000	0.001
Hansen J-test p-value	0.029	0.396
Observations	327,518	327,518

Notes: The table reports IV estimates (see Table A1 in the Appendix for full first stage regressions) of the marginal effect of wage and consumption risk on the growth of consumption, using two instruments - the variance of transitory and permanent shocks to firm's value added. All regressions include year fixed effects, a quadratic in age, the change in the number of children, and years of schooling. F-stat for the power of the instruments is shown at the bottom of the table. Clustered standard errors are in brackets. Coefficient significance: *** at 1 % or less; ** at 5 %; * at 10 %.

The first column shows the estimates of the earnings-variance Euler equation (eq. (4)). The effect of earnings volatility is estimated to be 0.65, and is highly statistically significant. This is joint evidence of a precautionary savings motive and of consumers' inability to fully self-insure wage risk. The F test from the first stage (value 294.9) reveals that the instruments are quite powerful. Table A1 in the Appendix shows the full first stage regression. The second column shows the estimate of the consumption-variance Euler equation (eq. (2)). The IV estimate is now 1.01, significant at the 1% level and larger than the estimate in the first column. As anticipated, the power of the instruments is lower when estimating this Euler equation than the one in the first column, though the test (value 7.8) is not far from conventional levels denoting non-weak instruments. In fact, in the first stage regression both instruments have predictive power on observed consumption volatility, but much more the variance of persistent shocks to the firm than that of the transitory ones (see Appendix). This is reasonable as the former are more easily self-insured than the latter.

From the estimates reported in the second column we infer a degree of prudence - measuring the strength of the precautionary motive - of around 2, which is reasonable. Using jointly the estimates reported in the first and second column, we infer a value of $\theta = 0.64$ - i.e. little less than 2/3 of the earnings risk results in undesired fluctuations in consumption, while consumers manage to self-insure the remaining 1/3.

Finally, we can use our estimates to assess the precautionary savings response to an increase in earnings risk when the latter originates from a change in the role of the firm as an insurance provider. Suppose that, following a trend documented by Benabou and Tirole (2016), firms offer more high-powered wage contracts and start sharing permanent shocks equally with their workers. That, is the value of λ^P increases from 0.07 to 0.5. Holding constant the self insurance parameter at 0.64, we calculate that consumption growth would be higher by 0.45 percentage points. If the firm shares equally also transitory shocks, the consumption profile would increase at a much faster rate of 0.8 percentage points.

6 Conclusion

Building on a credible instrument for consumption risk, we develop a strategy that allows to identify simultaneously the strength of the precautionary motive and the degree of self-insurance of labor income risk. At the same time, it provides a framework for studying the precautionary savings response of structural changes in wage insurance provided by the firm. We find a strong precautionary motive, a partial ability to self-insure labor income risk and a large precautionary savings response to firm adoption of high powered wage contracts.

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Appendix

In this appendix we first prove the inconsistency of OLS estimates of Euler equation (2) and then the consistency of the IV estimate using as instruments the variances of the firm permanent and transitory shocks. Lastly we provide summary statistics of the estimation sample as well as first stages of the IV regressions.

A Bias of OLS and consistency of IV estimates of the two Euler equations

Euler equation (1) (omitting the other controls and suppressing the i and t indexes) is

$$\Delta c = \alpha V_c + \zeta$$

where α is the parameter of interest, V_c is the conditional variance of consumption growth, and ζ is the consumption innovation.

Consumption risk is related to income risk plus other types of risk that don't depend on labor market:

$$V_c = \theta V_y + V_\eta$$

where $\theta < 1$ means there is some (self-)insurance.

There are two "measurement" error problems. The first is that we observe consumption volatility and wage volatility, not consumption risk and wage risk. In particular:

$$\widetilde{V}_c = V_c + \xi$$

where $\widetilde{V}_c = (\Delta c)^2$, $V_c = E\left((\Delta c)^2\right)$ and ξ is the innovation in the consumption variance. Moreover, the (residual) wage variance is:

$$\widetilde{V}_y = H + \rho_f F$$

But part of the H variability is not risk, but choice, so wage risk is really:

$$V_y = \rho_h H + \rho_f F$$

What people typically use is $\widetilde{V}_y = V_y + \varepsilon$, where $\varepsilon = (1 - \rho_h) H$.

An OLS regression of Δc on $\widetilde{V}_c$ (Euler equation (2)) has a classical measurement error problem:

$$\begin{aligned}
\frac{cov\left(\Delta c, \widetilde{V}_c\right)}{var\left(\widetilde{V}_c\right)} &= \frac{cov\left(\alpha\widetilde{V}_c + \zeta - \alpha\xi, \widetilde{V}_c\right)}{var\left(\widetilde{V}_c\right)} \\
&= \alpha - \alpha\frac{cov\left(\xi, \widetilde{V}_c\right)}{var\left(\widetilde{V}_c\right)} \\
&= \alpha\frac{var\left(V_c\right)}{var\left(\widetilde{V}_c\right)} \\
&< \alpha
\end{aligned}$$

An OLS regression of Δc on $\widetilde{V}_y$ (Euler equation (2)) yields :

$$\begin{aligned}
\frac{cov\left(\Delta c, \widetilde{V}_y\right)}{var\left(\widetilde{V}_y\right)} &= \frac{cov\left(\alpha V_c + \zeta, H + \rho_f F\right)}{var\left(H + \rho_f F\right)} \\
&= \frac{cov\left(\alpha\left(\theta V_y + V_\eta\right) + \zeta, H + \rho_f F\right)}{var\left(H + \rho_f F\right)} \\
&= \frac{cov\left(\alpha\left(\theta\left(\rho_v H + \rho_f F\right) + V_\eta\right) + \zeta, H + \rho_f F\right)}{var\left(H + \rho_f F\right)} \\
&= \frac{cov\left(\alpha\theta\rho_v H + \alpha\theta\rho_f F + \alpha V_\eta + \zeta, H + \rho_f F\right)}{var\left(H + \rho_f F\right)} \\
&= \alpha\theta\frac{\rho_h V_H + \rho_f^2 V_F}{V_H + \rho_f^2 V_F} \\
&< \alpha\theta
\end{aligned}$$

which does not identify α both because of the measurement error and because of the presence of self-insurance.

The IV regression of Euler equation (2) that uses the firm variance as an instrument fixes the measurement error problem but not the sufficient statistics problem:

$$
\begin{aligned}
\frac{cov\left(\Delta c, F\right)}{cov\left(\widetilde{V}_y, F\right)} &= \frac{cov\left(\alpha V_c + \zeta, F\right)}{cov\left(H + \rho_f F, F\right)} \\
&= \frac{cov\left(\alpha\left(\theta V_y + V_\eta\right) + \zeta, F\right)}{cov\left(H + \rho_f F, F\right)} \\
&= \frac{cov\left(\alpha\left(\theta\left(\rho_h H + \rho_f F\right) + V_\eta\right) + \zeta, F\right)}{cov\left(H + \rho_f F, F\right)} \\
&= \frac{cov\left(\alpha\theta\rho_h H + \alpha\theta\rho_f F + \alpha V_\eta + \zeta, F\right)}{cov\left(H + \rho_f F, F\right)} \\
&= \frac{\alpha\theta\rho_f V_F}{\rho_f V_F} \\
&= \alpha\theta
\end{aligned}
$$

The IV on Euler equation (2) that uses the firm-related variances as instruments for realized consumption volatility corrects the bias and identifies α:

$$
\begin{aligned}
\frac{cov\left(\Delta c, F\right)}{cov\left(\widetilde{V}_c, F\right)} &= \frac{cov\left(\alpha V_c + \zeta, F\right)}{cov\left(\widetilde{V}_c, F\right)} \\
&= \frac{cov\left(\alpha\left(\theta V_y + V_\eta\right) + \zeta, F\right)}{cov\left(\theta V_y + V_\eta + \xi, F\right)} \\
&= \frac{cov\left(\alpha\left(\theta\left(\rho_h H + \rho_f F\right) + V_\eta\right) + \zeta, F\right)}{cov\left(\theta\left(\rho_h H + \rho_f F\right) + V_\eta + \xi, F\right)} \\
&= \frac{cov\left(\alpha\theta\rho_h H + \alpha\theta\rho_f F + \alpha V_\eta + \zeta, F\right)}{cov\left(\theta\rho_h H + \theta\rho_f F + V_\eta + \xi, F\right)} \\
&= \frac{\alpha\theta\rho_f V_F}{\theta\rho_f V_F} \\
&= \alpha
\end{aligned}
$$

Hence, jointly the IV estimates of Euler equation (1) and (2) allow to identify α and θ.

B Additional Tables

Table A1: Summary statistics

	Mean	Std. Dev.
c_{ict}	32,554.6	22,100.22
$\Delta \ln c_{it}$	0.056	0.485
$\widetilde{V}_{cit}$	0.238	0.408
$\widetilde{V}_{yit}$	0.043	0.087
F_{jt}^T	0.021	0.065
F_{jt}^P	0.029	0.07
Years of education	12.905	2.368
Fraction married	0.457	0.498
Male	0.815	0.388
Age	46.199	8.743
Year	2005.9	2.563
Family size	2.306	1.345
Children	0.634	0.973

Notes: The table reports summary statistics for the estimation sample of 327,518 individuals. Values in 2011 USD.

Table A2: First stages of IV regressions

	$\widetilde{V}_y$	$\widetilde{V}_c$
F_{it}^T	0.0510***	0.0290**
	(0.0024)	(0.0111)
F_{it}^P	0.0270***	0.0324***
	(0.0021)	(0.0103)
Year FE	Yes	Yes
Age polynomial	Yes	Yes
Δ children	Yes	Yes
Years of education	Yes	Yes
Observations	327,518	327,518

Notes: The table reports the first stages of the IV estimates in Table 1 of the marginal effect of wage and consumption risk on the growth of consumption, using two instruments - the variance of transitory and permanent shocks to firm's value added. Clustered standard errors are in brackets. Coefficient significance: *** at 1 % or less; ** at 5 %; * at 10 %.