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Agricultural Precautionary Wealth

Farrell E. Jensen and Rulon D. Pope

Using panel data, the relationship between income uncertainty and the stock of wealth through precautionary saving is examined. Evidence from Kansas data is consistent with the precautionary saving motive in that farm households facing greater uncertainty in income maintain larger stocks of wealth in order to smooth consumption. These results are found by regressing net worth against measures of permanent income (life-cycle income), measures of uncertainty, and demographic variables.

Key words: precautionary saving, precautionary wealth, risk

Introduction

Recent empirical studies testing the theory of precautionary saving have reported evidence that households with higher levels of income uncertainty[1] compensate by increasing their precautionary savings (e.g., Carroll and Samwick, 1995, 1997; Kazarosian, 1997; Lusardi, 1997). These analyses concluded, ceteris paribus, that income streams with greater uncertainty imply more saving and higher wealth until a desired buffer-stock level is attained. Studying only older men and using at most eight years of data ending in 1980, Kazarosian (1997) found some evidence indicating farmers exhibit a stronger precautionary saving behavior compared to individuals of other occupations. In their 1997 study of precautionary wealth, Carroll and Samwick use data from 1981–1987, comprising only 30 farms and farm laborers. Hence, uncertainty measures in previous studies have been based upon small samples or short time series, and there are no attempts to control for business organization and other heterogeneities among farms.

Previous agricultural studies focusing on saving or consumption behavior have empirically tested the life-cycle/permanent-income models, but have not considered the precautionary saving effect (Langemeier and Patrick, 1990, 1993; Carriker et al., 1993; Phimister, 1995). However, Carriker et al. did find that the marginal propensity to consume (MPC) out of income judged to be more volatile is less than the MPC from more stable income sources. None of these studies addressed the impact of uncertainty on precautionary saving and wealth accumulation.

The objective of this paper is to extend the previous empirical work in agriculture by searching for evidence of the precautionary motive for saving. If farms respond to higher levels of income uncertainty by increasing buffer-stock savings, this result has important policy implications (Paxson, 1992). To illustrate, under the precautionary saving hypothesis, any agricultural policy affecting income uncertainty will affect saving, and

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[1] Uncertainty is treated as synonymous with risk in this paper.

thus capital accumulation through buffer-stock savings behavior. Consequently, attempts to reduce income uncertainty through policy may also reduce the level of precautionary saving and net worth. Economists study the level of wealth and distribution of income (as embodied, e.g., by Gini coefficients) because they are related to societal welfare (Atkinson, 1980; Just, Hueth, and Schmitz, 1982). Larger wealth is presumed to imply greater societal welfare. However, the meaning and significance of an increase in wealth in expected utility terms depends on whether uncertainty is a significant factor in saving behavior.

Using panel data from the Kansas State University Farm Management Data Bank, the relationship between income uncertainty and the stock of wealth through saving is examined. Evidence from these data is consistent with the precautionary saving motive in that farm households facing greater uncertainty in income maintain larger stocks of wealth in order to smooth consumption. These results are found by regressing net worth against predetermined measures of permanent income (life-cycle income), measures of uncertainty, and demographic variables.

The Precautionary Motive for Wealth Accumulation

Economists have known for some time that consumers attempt to smooth consumption across time and across states of nature (Modigliani, 1986; Samuelson, 1969; Sandmo, 1970). Early papers by Sandmo (1970) and Leland (1968) distinguished between (*a*) labor income uncertainty and (*b*) uncertainty in the rate of return on investment or saving (e.g., interest rate). Though the substitution effect is unambiguous in sign, decreasing temporal risk aversion is sufficient to suggest increased uncertainty on either rate of return on investment or future labor income implies increased precautionary saving.

Hall (1978) demonstrated that when future income is uncertain, consumers solve a stochastic dynamic program which yields a convenient Euler equation for the evolution of consumption. Specifically, for time t, a single consumer solves (to simplify notation, subscripts to denote individuals are suppressed):

$$\text{(1)} \qquad \underset{\{c_t\}}{\text{Max}}\, E_t \left\{ \sum_{i=0}^{\infty} u(c_{t+i})(1+\delta)^{-t} \colon c_{t+i} = y_{t+i} + A_{t+i} - \alpha A_{t+i+1} \right\}, \quad i = 0, 1, \ldots,$$

where c denotes consumption, δ is the marginal rate of time preference, y is often interpreted as uncertain labor income, and A represents assets (nonhuman wealth); $\alpha = 1/(1+r)$, where r is the constant and certain interest rate (return on investment); and subscripts denote the time period such that $\lim_{i\to\infty} \alpha^i A_{t+i} = 0$, and concavity of utility is generally assumed.[2]

As shown by Hall, (1) implies the Euler equation:

$$u'(c_{t+1}) = \alpha(1+\delta)u'(c_t) + \varepsilon_{t+1}, \quad E(\varepsilon_{t+1}) = 0, \quad t = 1, \ldots, \infty.$$

When utility is quadratic, this reduces to the familiar certainty equivalence case generally known as the permanent income hypothesis.

[2] The model in (1) focuses on consumption, and thus has a very simple representation of the opportunity cost of consumption using a single investment with rate of return r.

From the constraints in (1), once an evolution for consumption is chosen by the consumer and the evolution of exogenous income is specified, then an evolution for assets (nonhuman wealth) is determined. Using net worth as the measure for A_t, rewriting the constraint in (1) as $A_{t+i+1} = (1 + r)(A_{t+i} + y_{t+i} - c_{t+i})$, and inserting optimal consumption implies that the evolution of A_t depends on permanent income as well (Carroll, 1996).

In many cases, because wealth data are more readily available and accurate than saving data, wealth or wealth accumulation is often studied. The approach of several early studies was to specify a solution (reduced form) for net worth in a problem like (1), ignoring initial wealth. The right-hand-side variables explaining A_t typically include permanent income (y_t^p), interest rate (r), and other demographic variables associated with the life cycle ($\mathbf{z}_t$) (King and Dicks-Mireaux, 1982; Kazarosian, 1997):

$$A_t = f(r_t, y_t^p, \mathbf{z}_t). \tag{2}$$

Because expected future consumption is approximately constant and equal to current consumption, the life-cycle hypothesis essentially implies that saving and wealth rise during the middle years of one's life, preparing for dissaving during retirement. The $\mathbf{z}_t$ variables are used to capture this effect. As specified, (2) represents the wealth accumulation under the certainty equivalent hypothesis.

Beyond Certainty Equivalence

Since Hall (1978), there has been a substantial rejection of the certainty equivalent hypothesis, spawning a variety of conceptual generalizations. These generalizations have considered the existence of liquidity constraints (Hall and Mishkin, 1982), habits (Alessie and Lusardi, 1997), deviations from additivity (e.g., Epstein and Zin, 1985), and whether there are significant deviations from certainty equivalence (Caballero, 1991). The focus here is on the idea that deviations from certainty equivalence lead to buffer-stock savings behavior.

In an examination of consumers participating in the Federal Reserve Board's 1983 Survey of Consumer Finances, Carroll (1996) notes 43% listed "saving for contingencies" as the most important reason for saving, while only 15% listed "preparing for retirement" as the most important reason for saving. In their study of earnings uncertainty and precautionary saving, Guiso, Jappelli, and Terlizzese (1992) found that precautionary saving accounts for 2% of households' net worth. Carroll (1992) argues that individuals may save to achieve a target level of saving to be used against negative shocks. Based on the findings of these studies, deviations from certainty equivalence may be commonplace, and these deviations imply that higher moments, such as the variance of income, affect consumption decisions (Blanchard and Mankiw, 1988). This precautionary motive for saving or wealth accumulation is conceptually linked to the properties of the third derivative of the utility function as defined by prudence (Kimball, 1990).[3]

Except in only a very few cases, finding an explicit solution for consumption trajectories in terms of higher moments of income (e.g., variance) is difficult. However, for illustrative purposes, consider a case where an explicit solution can be obtained. This is the

[3] Absolute prudence is defined as $P = -u'''(\cdot)/u''(\cdot)$. Decreasing absolute prudence is sufficient to generate buffer stock or a marginal precautionary saving effect.

case of constant absolute risk aversion and normality of future income following a random walk (e.g., Hahm and Steigerwald, 1999; Caballero, 1991):[4]

$$(3) \qquad c_{t+1} = c_t + (\theta/2)E_t(V_{t+1}^2) + V_{t+1}, \; E_t(V_t) = 0,$$

where $V_{t+1} = c_{t+1} - E_t(c_{t+1})$ for all t, where θ is the Arrow-Pratt uncertainty aversion coefficient and it is assumed $\chi = \alpha(1 + \delta) = 1$. In (3), unlike the case of certainty equivalence, the conditional variance of future consumption enters the Euler equation in addition to present consumption, so uncertainty affects the evolution of consumption. Thus, consumption stochastically grows and consumption is a sub-martingale.

Under specific assumptions about utility and the evolution of income—namely, utility with constant absolute risk aversion, Gaussian labor income following a simple random walk, and $\chi = 1$—Caballero (1991) established that consumption at any time t is a function of permanent income and the variance of consumption:

$$(4) \qquad c_t = \alpha r\left(A_t + \sum_{i=1}^{\infty} \alpha^i E_t(y_{t+i})\right) - \alpha r\left(\sum_{i=1}^{\infty} \alpha^i \left[\sum_{j=1}^{i} E_t(V_{t+j}^2)\right]\right).$$

The first term in (4) is the annuity value of wealth and is thus permanent income, and the second term is an adjustment due to uncertainty.

A link between wealth and uncertainty is made evident when Caballero, in a discrete time model with terminal time T, calculates total endogenous wealth at time t when initial wealth equals zero:[5]

$$(5) \qquad A_t = (\theta/2)\sigma_y^2(T - t)(t/2),$$

where σ_y^2 is the variance of income, y. The impact of uncertainty on asset accumulation in (5) is in marked contrast to the certainty equivalent case where there is no motive for asset accumulation when income follows a random walk. As expected, assets at any time t grow with increased risk aversion, θ, and with increased variance of income, σ_y^2. Further, assets grow with age until $t = T/2$, and then decline.[6] Thus, even under the simplistic assumption that income is a random walk, the usual life-cycle insights are obtained, i.e., assets are accumulated early in life to provide for later consumption.[7] These are important insights, albeit derived with very special assumptions about prudence and the evolution of income. This rather specific example establishes the plausibility that consumption is reduced by increased uncertainty of income, suggesting an increase in saving and assets. Therefore, the level of assets and uncertainty are positively correlated, as implied by the precautionary saving hypothesis.

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[4] These assumptions lead to an instructive case, but are clearly not descriptive of agricultural income.

[5] Of course, realistically, income wouldn't follow a random walk throughout one's life. Typically, income at retirement follows a much different process than earlier in life due to the labor income component of income.

[6] Specifically,

$$\frac{\partial A_t}{\partial t} = \frac{\theta}{2}\sigma_y^2\left(\frac{T}{2} - t\right).$$

Thus, the interpretation is that as age increases (t increases), one obtains the inverted-U pattern of wealth when graphed against age.

[7] Note that under certainty equivalence with income following an inverted-U pattern (rather than a random walk), one obtains a similar conclusion (Modigliani, 1986).

A Difficulty with Testing the Precautionary Saving Hypothesis

The precautionary hypothesis is opposite of the common portfolio view: higher levels of net worth lead to decreased risk aversion, which causes individuals to choose risky portfolios with a higher variance of income.[8] In most common static descriptions of this hypothesis, net worth is treated as exogenous and drives portfolio choice. In the equilibrium form of the portfolio model, a decline in agricultural income uncertainty increases agricultural land values, e.g., by reducing the risk-adjusted discount rates (Just and Miranowski, 1993). Net worth then increases if consumption, and the firm's capital structure, remain constant.

These two portfolio effects are in contrast to the precautionary saving hypothesis which treats net worth as endogenously driven by income uncertainty. It is reasonable to assume the precautionary saving and the portfolio effects are both present. That is, individuals increase buffer-stock wealth as uncertainty increases, as well as select portfolios with greater uncertainty as net worth increases. To model both the portfolio and precautionary saving effects would require a structural model of decision making (Hansen and Singleton, 1983). However, if the Hansen and Singleton approach were followed, it would be necessary to include in a model all of the structural complexity of both agricultural and off-farm investments.[9] Mishra and Morehart (2001) found evidence indicating off-farm investment is an important behavior by farmers. Based on their calculations, off-farm financial assets rose from 14% of total assets in 1992 to more than 18% in 1995.

The empirical data used here simply do not allow the specification of such a complex dynamic structure which could sort out all of these effects. This study utilizes various techniques to isolate, to the extent possible, the separate impact of the precautionary saving hypothesis using current wealth regressed against lagged or predetermined permanent income and measures of uncertainty.

The Empirical Model

To obtain analytical reduced-form solutions analogous to (5), under general forms of prudence and general models of the evolution of income, poses great challenges (Deaton, 1992, chapter 6; Ludvigson and Paxton, 2001). These difficulties have led researchers to focus on three alternative approaches to specifying a precautionary saving or consumption model. First, for time-series data, a general Euler equation like (3) is estimated (e.g., Weber, 2000; Hahm and Steigerwald, 1999). Second, approximate or numerical simulations are used to analyze solutions (Carroll and Samwick, 1995). Third, for cross-section applications, an arbitrary reduced-form solution is specified analogous to (5) (Lusardi, 1997; Guiso, Jappelli, and Terlizzese, 1992; Kazarosian, 1997).

Specifically, the model in (2) is generalized to include some measure of income uncertainty as in (5). Using survey data, proxies for uncertainty are used to estimate whether

[8] Another response to uncertainty is that farm households hold credit reserves in the form of unused borrowing capacity in order to ameliorate the impact of uncertain cash flows. We also do not distinguish between business risk and financial uncertainty (Barry et al., 2000).

[9] A structural model of agricultural storage using the Hansen and Singleton approach is found in Myers (1989).

precautionary asset or wealth accumulation is supported by the data. As is often the case, cross-sections illuminate the problem in ways aggregate time series cannot, and vice versa. The strength of panel data is that the time-series component of income can be utilized to develop a more precise measure of uncertainty facing a household. Assuming there are no major structural changes, longer time series as used in this study allow more accurate estimates of the uncertainty of the income in contrast to the shorter series employed by Kazarosian (1997) and Carroll and Samwick (1997).

By adding uncertainty, the amended version of (2) is written as:

$$A_t = f(r_t, y_t^p, \sigma_{ty}^2, \mathbf{z}_t), \quad t = 1, \ldots, T, \tag{6}$$

where σ_{ty}^2 measures the uncertainty in income. To amend (6) for an application to a cross-section, some assumptions must be made. The approach taken here is consistent with other studies (Kazarosian, 1997; Carroll and Samwick, 1997), whereby a cross-section regression of the form is estimated as follows:

$$A_k = f(y_k^p, \sigma_{ky}^2, \mathbf{z}_k), \quad k = 1, \ldots, n. \tag{6'}$$

Here, wealth is regressed against a measure of permanent income, uncertainty, and demographic variables for each household using a common functional form and assuming a constant opportunity cost of consumption, r. Given conventional assumptions about prudence, the coefficient of σ_{ky}^2 in f is expected to be positive [see equation (5)]. That is, increased uncertainty leads to increased saving, and hence asset or wealth accumulation. Using similar methodologies, Kazarosian (1997), and Carroll and Samwick (1997) found evidence of a precautionary motive for wealth accumulation. An advantage of our data set is that it contains returns to labor, capital, and management, and thus is a more complete measure of income and income uncertainty than previous studies based primarily on labor income.

Data

The panel data for 1973–1999 were obtained from the Kansas Farm Management Association (KFMA). To reduce heterogeneity in the precision of estimates of permanent income and measures of uncertainty, only farms that provided continuous data each year for this period were included.[10] There were 262 farms with continuous data for the 27-year study period, giving a total of 7,074 observations in the complete panel. One of our methodologies for estimating uncertainty requires a long continuous time-series component on income.

There are two approaches that could be pursued to estimate the precautionary saving effect. The first would be to create a rolling measure of permanent income and variance for each farm and for each year to be used in a panel regression [similar to combining (6) and (6′)]. The second approach is to consider a cross-section regression as in (6′) where the time-series component of the panel is used to estimate permanent income and variances for each farm for a particular period. The second approach is selected because

[10] This choice may introduce selection bias into the sample. However, we needed a long time-series component to our data in order to estimate moments of permanent income. In any case, one should not interpret our results as being representative. We have no reason to believe our sample of KFMA farms represents a random sample of even Kansas farms.

it utilizes virtually all of the time-series data available to estimate permanent income and measures of variance. These estimates are used to explain net worth in a cross-section for the final period of the sample. Further, attempts to explain year-to-year changes in wealth, as in the first method, would result in considerably more noise than using a cross-section.

Adopting the second approach requires an accurate measure of ending wealth, permanent income, uncertainty, and demographic variables. To reduce noise from year to year, an average of these variables (1997–1999) is included for the last period. As will be seen later, initial wealth [which is embedded as a zero in (5) and should be in (6′)] is also an independent variable.

Definitions and Estimation of Empirical Variables

Land values in the KFMA data are a major component of net worth for agricultural firms. Land values are updated every five years in the Association's database. The KFMA land value data were adjusted forward four years (from 1995 forward to 1999) using land value survey data taken from the U.S. Department of Agriculture's (USDA's) online "State Statistical Report." USDA reports values for type of land which completely conform with the KFMA designations. These include all land, non-irrigated cropland, irrigated cropland, all cropland, and pastureland.[11] Total farm assets for each farm include the value of land, buildings, current assets, and intermediate farm assets.

The model requires data on the value of all farm and nonfarm assets held by the farm household, including cash, personal residence, investments, marketable corporate stock, and IRAs. All of this information was in the database. No information was available on the present value of retirement accounts that individuals may have beyond those listed previously. To obtain an estimate of net worth, the value of farm and nonfarm debt was included. Net worth (A_t) was calculated in the usual manner as the difference between assets and liabilities.

Income

Income for each farm in each year included farm income, off-farm income, and government payments. To obtain farm income (y_t), annual depreciation costs are added to gross farm income minus cash operating costs and income taxes, social security taxes, and property taxes. All tax data are actual tax values reported for each farm for each type of tax. Under this definition, farm income represents the cash flow that would be available for consumption from farming operations after taxes without considering the impact of borrowing or retiring loans. Off-farm income included miscellaneous nonfarm income, nontaxable income, wages, rent and royalties, and dividends and interest. All variables in our empirical model are expressed in real terms by using the consumer price index with 1982–84 = 100.

[11] Clearly, there is potential for measurement error in this approach. Even if USDA reports values by land types, those values can only serve as proxies for actual values because of heterogeneity in land quality. However, our approach seems superior to using the values in the database.

Permanent Income (y_t^p)

Estimating the precautionary saving effect requires estimates of permanent income and the variance around permanent income. One of the common stochastic specifications for the evolution of income is provided in Carroll and Samwick (1997). The key assumption is that for each farm

(7) $$y_{kt} = y_{kt}^p + \varepsilon_{kt},\quad E(\varepsilon_{kt}) = 0,\quad k = 1, ..., n;\ t = 1, ..., T,$$

where y_{kt}^p is permanent income for the kth farm in year t, and similarly, y_{kt} is observed income and ε_{kt} is a random shock. Thus, income is assumed to randomly deviate about permanent income. Permanent income is assumed to follow:

(8) $$y_{kt}^p = g(\mathbf{z}_{kt}) + y_{kt-1}^p + u_{kt},\quad E(u_{kt}) = 0,\quad k = 1, ..., n;\ t = 1, ..., T,$$

where u_k and ε_k ($k = 1, ..., n$) are uncorrelated white noise, and $\mathbf{z}_{kt}$ are demographic variables. Combining (7) and (8), it follows that observed income (y_{kt}) deviates about the demographic function $g(\mathbf{z}_{kt})$ and lagged permanent income. This statement in turn implies observed income deviates around $g(\mathbf{z}_{kt})$ plus lagged observed income.

Included in the $g(\mathbf{z}_{kt})$ functions are the following variables: operator age, operator age squared, number of dependents, time trend, time trend-age interaction,[12] dummy variables to denote each farm, lagged income (y_{kt-1}), and numbers of acres managed. These variables are regressed in a panel regression across farms and years on income (y_{kt}) to create $y_{kt}^p = \hat{g}(\mathbf{z}_{kt}) + y_{kt-1}$, where y_{kt}^p is estimated permanent income. By introducing farm dummy variables, an estimate of permanent income was obtained for each farm.

The entire time series of 27 years is used to estimate permanent income. Commonly used specifications, like (7) and (8), allow for shocks to permanent income. For example, a health shock might imply permanent income is reduced, while a weather shock implies a transitory change in income. In our case, the predictable portion of the growth in income or permanent income (g) is specified as linear in $\mathbf{z}_{kt}$. Next, we turn to a procedure to identify and estimate the variances associated with shocks to permanent income (u) and transitory income (ε).

Once the predictable growth of income, g_k, is removed, (8) can be rewritten as:

(9) $$y_{kt}^p = y_{kt-1}^p + u_{kt};\ y_{kt} = y_{kt}^p + \varepsilon_{kt}.$$

Defining the dth difference as r_{dk} (lag length d):

(10) $$r_{dk} = y_{kt+d} - y_{kt},$$

using recursive substitution and taking expectations yields:

(11) $$\text{var}(r_{dk}) = d_k\sigma_{ku}^2 + 2\sigma_{k\varepsilon}^2,$$

[12] This interaction allows for the possibility that year effects on income might depend on the age of the farmer. One might expect that a secular decline in income, such as in the early 1980s, affected older farmers differently than younger farmers.

where the variance of the difference of lag length d in income, var(r_{dk}), is separated into σ^2_{ku}, the variance of permanent income shocks, and $\sigma^2_{k\varepsilon}$, the variance of transitory shocks. Equation (11) implies a regression for calculating and decomposing variances. Squared differences in (10) (labeled v_{dk}), or differences from 1 through 23 (there are 24 years of data used for this estimation), are regressed against the lag length (d_k) and the constant 2.

Following Carroll and Samwick (1997), we define for each farm k:

$$v_{dk} = \text{var}(r_{dk}) + \gamma_{dk}, \quad d = 1, ..., 23, \tag{12}$$

where γ_{dk} is a disturbance term. Substituting (11) into (12) gives a regression equation which allows the estimation and identification of permanent and transitory variances. For example, v_{1k} would include all squared first differences, while v_{2k} represents all squared second differences, until finally v_{23k} represents all squared 23rd differences. These differences represent the dependent variable for a given farm. The independent variable is $\mathbf{d}_k = [d_k(1), ..., d_k(23)]$. These denote the length of the time lags. Thus, the dependent variable $\mathbf{v}_k = [v_{dk}(1), ..., v_{dk}(23)]$ is regressed on $[\mathbf{d}_k\ \mathbf{2}]$, where the $\mathbf{d}_k$'s represent the length of time lag, and $\mathbf{2} = (2, ..., 2)$. Coefficients on $\mathbf{d}_k$ and $\mathbf{2}$ provide estimates of the decomposed permanent and transitory variances.

Estimating Uncertainty by Variance

To test the robustness of the model to another measure of uncertainty, a less fashionable method was employed by using a 10-year simple variance of y_{kt} (Baba, Hendry, and Starr, 1992). A 10-year horizon for the simple variance was selected because of the distinct possibility of major structural changes in agriculture that occurred around 1990. The 10-year variance did not provide the capability to distinguish between permanent and temporary variances as in the previously described methodology.

Demographic variables included in the estimation of (6′) are: age, family size, age squared, and a measure of beginning farm size or beginning net worth. Beginning net worth and acres managed are included as independent variables in different specifications of the model so a farm size effect or wealth effect can be estimated. If the estimated coefficient is 1, the model would be equivalent to one with the change in net worth as the dependent variable. Regarding the wealth effect, large initial net worth could imply differences in the level of prudence that in turn imply differing levels of saving. There are, of course, other interpretations and reasons for including beginning net worth. Conditioning on acres managed also accounts for differences in beginning farm size. It might be argued that larger farms have economies of scale or other similar impacts which account for these effects differently than beginning net worth.

Descriptive Measures of the Data

Table 1 provides summary data for the 262 continuous farms in the sample. As expected, transitory shocks to income due to weather, pests, and demand fluctuations imply the transitory variance is larger than the permanent variance. In table 1, average transitory variance is \$2.27 billion and more than an order of magnitude larger than the average of permanent variance (\$0.15 billion). Further, the sample average of the total variance (\$2.42 billion) calculated by summing the permanent and transitory variances is higher

Table 1. Descriptive Statistics of Variables in Models, 1996 or Mean of 1997–99 (N = 262 farms)

Variable	Period	Mean	Standard Deviation
Net Worth ($ millions)	1997–99	0.538	0.400
Transitory Variance ($ billions)	1996 [a]	2.267	3.579
Permanent Variance ($ billions)	1996 [a]	0.151	0.540
10-Year Variance ($ billions)	1996 [a]	1.359	2.626
Permanent Income ($)	1997–99 mean [b]	64,192	79,862
Operator's Age	1997–99 mean [b]	62.4	10.3
Number of Dependents	1997–99 mean [b]	2.3	1.3
Beginning Real Net Worth ($)	1973	210,443	232,613
Beginning Acres Managed	1973	1,330	1,162

[a] Permanent income and variances are estimated using data up through 1996 and recorded for that year so they will be predetermined for the empirical model [see text equation (6′)].
[b] Net worth and all other variables are essentially a cross-section using averaged 1997–99 data.

than the simple variance ($1.36 billion). There is considerable variation among farms, as the sample standard deviation of variance estimates are larger than the sample means. For permanent income, the standard deviation is slightly larger than the mean. Not surprisingly, the average age of operators is 62.4 years with a much lower sample variation.

Testing for Precautionary Wealth Accumulation with the Empirical Model

Table 2 reports estimates of the effects of permanent income and uncertainty on wealth for four different specifications of equation (6′). Only income prior to 1997 was used in the calculation of permanent income and uncertainty. These become predetermined variables used in the cross-section regression of (6′) with average wealth calculated for the period 1997–1999 to smooth out major year-to-year differences. Using predetermined values for permanent income and uncertainty reduces bias due to possible endogeneity issues caused by using contemporaneous income and wealth data for estimation. For example, one could envision a shock to income that would alter calculated permanent income and get capitalized into farm wealth. Hence, the errors in the precautionary wealth regression would be correlated with permanent income, a right-hand-side variable. A similar argument might be made for transitory and permanent variance and the 10-year variance.[13]

After estimating the three variances and permanent income, (6′) was estimated. In order to test robustness to the variance measures, (6′) was estimated first with permanent and transitory uncertainty measures, and then with the 10-year variance uncertainty measure to test for precautionary wealth accumulation. In specifications [1] and [2] (table 2), farm real net worth (A_{kt}) is regressed linearly against permanent income (y^p_{kt}),

[13] Additionally, it is assumed all measured variables are exact. Were this not so, generated regressors least squares would lead to biased and inconsistent estimates of coefficients (Pagan and Ullah, 1988). Further, conventional IV estimators will not solve the problem (Amemiya, 1990).

Table 2. Estimated Parameters for Permanent Variance and Transitory Variance Model and 10-Year Variance Model (dependent variable = *Real Net Worth per Farm Household*)

	SPECIFICATION			
Independent Variable	[1] Permanent and Transitory Variance Model	[2] Permanent and Transitory Variance Model	[3] 10-Year Variance Model	[4] 10-Year Variance Model
Constant	669,204	948,151*	692,063	1,018,267*
	(505,444)	(546,903)	(489,389)	(535,666)
Transitory Variance	0.00000359**	0.00000396**		
	(0.00000152)	(0.00000181)		
Permanent Variance	0.00003227	0.00007335*		
	(0.00003813)	(0.00004094)		
10-Year Variance			0.00002287***	0.00002974***
			(0.00000813)	(0.00000874)
Permanent Income	1.79***	1.80***	1.74***	1.72***
	(0.26)	(0.29)	(0.26)	(0.28)
Operator's Age	-20,503	-29,185*	-20,505	-30,741*
	(16,280)	(17,627)	(16,091)	(17,312)
Operator's Age Squared	201.80	271.95*	199.77	280.51**
	(132.60)	(143.53)	(131.25)	(141.22)
Number of Dependents	16,145	22,973	12,425	18,056
	(16,971)	(18,414)	(16,895)	(18,257)
Beginning Net Worth (1973)	0.71***		0.73***	
	(0.09)		(0.09)	
Beginning Acres Managed (1973)		80.02***		92.09***
		(21.23)		(18.51)
Adjusted R^2	0.38	0.27	0.38	0.28
Sample Size	262	262	262	262

Notes: Single, double, and triple asterisks (*) denote statistical significance at the 10%, 5%, and 1% levels, respectively, in two-tailed tests. Numbers in parentheses are standard errors, calculated using White's robust estimates.

permanent and transitory variances (σ^2_{ku} and σ^2_{ke}), age of operator, number of dependents, and beginning net worth or acres managed.[14] In specifications [3] and [4], the 10-year variance is used in place of the permanent and transitory variances. This is very similar in method to the Carroll and Samwick (1997) study. The inclusion of other variables is an attempt to control for household composition, the expected age-saving profile associated with the life-cycle hypothesis, and initial (1973) net worth or farm size.[15]

[14] As in Carroll and Samwick (1997), there was no evidence of the usual inverted-U pattern of wealth accumulation.

[15] Although in principle, the entire panel could be used to study wealth accumulation at each given year for each farm, the difficulties in estimating an appropriate permanent income, variance, and net worth for each point in time for each farm are insurmountable. Thus, we concentrate our attention on developing estimates of uncertainty using the time-series components of our sample and essentially running a cross-section at the end of the sample for the other variables in the empirical model. As previously mentioned, we try to isolate the portfolio effect and the precautionary saving effect by not using contemporaneous data to estimate the relevant distribution of income (uncertainty measures and permanent income), and net worth.

Because the goal here is to ascertain whether there is evidence for precautionary wealth accumulation, the focus is particularly on the signs and the statistical significance of the coefficients of variance. That is, we expect [see (6′)] increases in the variances of income to alter saving, and hence increases in net worth.

In the first two columns of table 2 (specifications 1 and 2), coefficients of transitory variance are positive and statistically significant at the 5% level, regardless of whether beginning net worth or acres managed are included in the regression. The coefficients of permanent variance are also both positive but with lower statistical significance (only significant in specification 2, the beginning acres managed model). The marginal impact on net worth of an increase in the permanent variance is much larger (4 to 10 times larger) than the marginal impact of transitory variance. This result is as anticipated: permanent shocks imply larger adjustments in saving in order to reach a target level of wealth. For the 10-year variance models, increasing variance leads also to an increased level of saving and wealth. Both variance parameters are significant at the 1% level. Thus, there is strong evidence across all of the specifications for the precautionary saving hypothesis.

In addition, the coefficient on permanent income is positive and highly significant in all specifications (1% level of significance), suggesting farms with higher levels of permanent income have higher levels of net worth, as found in other settings (e.g., Carroll and Samwick, 1997; Kazarosian, 1997). As in other studies (e.g., Carroll and Samwick, 1997), our data do not contain an age-wealth profile consistent with the inverted-U shape expected from the life-cycle hypothesis. Indeed, there is weak evidence in the data that wealth (on average) does not rise until a farmer is in his or her 50s. Even then, it is a convex pattern of wealth accumulation. However, given the majority of those in the sample are relatively older, still active farmers, it is reasonable not to observe the portion of the age-wealth profile that is declining. To obtain the concave inverted-U shaped age-wealth profile, a sample would have to include people who are actually retired and drawing down their wealth.

There is also strong evidence indicating it is necessary to control for initial wealth or farm size. As shown in table 2, in all cases the initial wealth and farm size coefficients are positive and significant at the 1% level. In specifications 1 and 3, the coefficients are significantly different from 1, suggesting that simply estimating the change in net worth does not capture the total initial net worth effect.

Elasticity estimates for the variance decomposition models (specifications 1 and 2 in table 2), calculated at the means of the sample with standard errors in brackets, are approximately: transitory variance (specification 1 = 0.015 [0.006], specification 2 = 0.015 [0.008]); permanent variance (specification 1 = 0.009 [0.011], specification 2 = 0.021 [0.011]; and permanent income (specification 1 = 0.210 [0.031], specification 2 = 0.210 [0.034]. For the 10-year variance specifications (3 and 4), the elasticity of net worth with respect to the variance is 0.058 [0.021] for specification 3, and 0.075 [0.022] for specification 4, while the elasticity for permanent income is 0.200 [0.208] for specification 3, and 0.200 [0.033] for specification 4. Thus, wealth is relatively inelastic with respect to variance by any of the measures. The response of wealth to permanent income also is quite inelastic, as expected.

Based upon the evidence in table 2, variance of income does have a significant impact on wealth accumulation in agriculture. These results provide initial support for the precautionary model of wealth accumulation in agriculture.

Concluding Remarks

Our findings provide clear initial support for the precautionary model of saving by agricultural households. Increased levels of uncertainty are associated with increased levels of saving, and hence increased levels of net worth as a buffer stock. This response implies that agricultural policies which reduce the overall uncertainty of the economic environment will lead to lower levels of farm household saving and net worth. This finding has far-reaching implications. For example, wealth cannot be used alone as a measure of economic well-being.

In closing, we offer a few suggestions for future research. Though initial wealth is controlled for in the estimation of (6′), the role of bequests and their impact on wealth formation is potentially an important issue in agriculture. Second, if reasonably accurate consumption data can be obtained, general Euler equations can be specified to test the precautionary motive as in Weber (2000). Third, using more computer-intensive techniques with the appropriate data, it may be possible to estimate more complicated structural models that are explicit with regard to preferences and the dynamics of income, and investment opportunities (Gourinchas and Parker, 2002). Finally, more sophisticated econometric methods should be used to account for the possibility of endogeneity and errors-in-variables in order to see if the results are robust to these issues.

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