PRECAUTIONARY SAVING AND CONSUMPTION GROWTH IN TAIWAN*

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Abstract

Consumption and income have both grown rapidly in Taiwan over the past forty years, with younger birth cohorts experiencing faster growth. The long upward trend in consumption presents a strong challenge to the consumption smoothing predictions of the Permanent Income Hypothesis. Household survey data from 1976-96 are used to examine the extent to which precautionary savings behaviour can explain this rapid consumption growth in an environment with high levels of savings. We find evidence for a strong precautionary motive in Taiwan, with levels of prudence much higher than found in the United States and United Kingdom. These high rates of prudence explain much of the rapid consumption growth, while the faster consumption growth of younger cohorts is attributed in part to their greater participation in industries with more earnings risk.

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1 Introduction

The exceptional economic performance of Taiwan over the past four decades is well-known, resulting in rapid increases in lifetime incomes. Annual per capita real GNP growth and real consumption growth averaged 6.5 percent and 6.8 percent, respectively, over the 1976-96 period. At the same time, Taiwan enjoyed gross savings to GNP ratios of between 0.25 and 0.40. Together, these facts challenge simple formulations of the Permanent Income Hypothesis (PIH) in which individuals smooth their consumption over their lifetime. In particular, they pose the main question to be addressed in this paper: "Why did Taiwanese households have predictable consumption growth and high savings in the presence of rapid income growth?"

This paper explores the extent to which precautionary savings behaviour can explain the rapid consumption growth. Repeated cross-sections from the Taiwan Personal Income Distribution Surveys are used for pseudo-panel estimation of dynamic consumption models. These methods are used to estimate the levels of absolute and relative prudence, which Kimball (1990) shows to be a measure of the intensity of the precautionary motive. We find that the level of prudence in Taiwan is much higher than the levels Dynan (1993), Merrigan and Normandin (1996) and McKenzie (2002) estimate in the United States, United Kingdom and Mexico respectively. This high level of prudence results in high savings rates and rapid consumption growth. We estimate that consumption growth would have been only one to two percent per annum if prudence had been at the U.S. and U.K. levels.

Consumption growth is found to be faster for the younger cohorts than for older cohorts. Levels of prudence are estimated to be similar for all cohorts, so that the more rapid consumption growth of the young is due to greater earnings uncertainty. We trace some of these differences in earnings uncertainty to higher participation of younger cohorts in riskier industries.

The paper is organized as follows. Section 2 details consumption growth in Taiwan at the aggregate level. Section 3 describes the data to be used for microeconomic analysis. Section 4 explains the dynamic pseudo-panel methods to be used in this paper and uses them to test for differences in consumption growth rates across birth cohorts. Sections 5 presents estimates of the rate of prudence, the level of earnings uncertainty, and the extent to which the precautionary motive explains consumption growth. Section 6 concludes the paper and an Appendix derives the results needed for pseudo-panel estimation of relative prudence.

2 Consumption and Income at the Aggregate Level

Figure 1 plots Taiwanese real consumption per capita and real GNP per capita over the period 1952-97.[1] Real GNP per capita grew at an average rate of 6.5 percent per annum over the 1976-96 period, while annual real consumption per capita growth averaged 6.8 percent over the same period. Gross national savings averaged 31 percent of GNP over this time (CEPD, 1999). The Current Account/GDP ratio was positive in every year but 1980 over our sample period, and averaged 6.25 percent, showing that the country as a whole was saving over this time period.[2]

Consumption growth per capita was positive in every single year over the period shown. This provides strong evidence against Hall's (1978) martingale hypothesis of consumption. In this model, a rational, optimizing, consumer in the absence of credit market restrictions will choose to smooth consumption over his or her life-cycle. Consumption growth in this model can only occur if the real interest rate r differs from the rate of subjective time preference δ. Hall (1978, p. 974) shows that consumption then obeys the exact regression

$$C_{t+1} = \frac{\overline{C}\,(r-\delta)}{1+r} + \frac{1+\delta}{1+r}C_t - \varepsilon_{t+1}\ , \tag{1}$$

where $\overline{C}$ is the bliss level of consumption. Estimation of an AR(1) model with drift for real consumption per capita over the period 1976-96 yields the fitted equation $C_{t+1} = 336.04 + 1.065C_t$. Real interest rates were negative in 1980-81 due to higher inflation after the second oil crisis, but were otherwise positive, averaging 2.57 percent over the 1976-96 period[3]. The fitted equation is therefore only consistent with the specification in (1) if the bliss point is negative, which violates the assumption of positive marginal utility. Unit Root tests and tests for stationarity find both income and consumption to be nonstationary, but reject the null hypothesis of a unit root in favour of explosive alternatives unless at least a quadratic deterministic trend is added. Hence at the aggregate level, the Taiwanese experience is not consistent with the permanent income

[1] Note that Taiwan continued to grow during the Asian Financial Crisis, with GDP growth slowing to 4.6 percent in 1998, before returning to 6 percent growth in 1999.

[2] Calculated from various years of *Financial Statistics Monthly, Taiwan District, Republic of China,* Economic Research Department, The Central Bank of China. In 1986 the current account surplus actually reached 20 percent of GDP.

[3] The real interest rate here is the Rediscount rate of the Central Bank of China deflated by the Consumer Price Index (source: CEPD, 1999).

hypothesis (PIH).

Even if individual consumption follows a random walk, aggregate consumption may contain a trend due to aggregation. For example, Flavin (1981) reasons that if per capita income has a positive trend, due to increasing productivity over time, then later generations will have greater lifetime wealth than earlier generations, causing aggregate consumption to trend upward over time. She therefore linearly detrends aggregate consumption in her work. However, a trend may also result from precautionary savings behaviour. Therefore uncritical detrending of consumption can remove important sources of deviation from the PIH and examination of microeconomic data is needed to determine the cause of this trend.

3 Micro Data

The data are taken from the Personal Income Distribution Surveys (PIDS) in Taiwan, which have been collected annually since 1976. The survey design is described in Republic of China (1991) and both interviews and account-keeping are used to collect the data. The sample sizes in 1976 and 1977 are a little over 9,000 households, and are over 14,000 households from 1978 onwards, with the sample size being fixed at 16,434 households after 1983. The twenty-one surveys from 1976-96 are used in this study. Income data are available on an individual basis, but consumption data are available at the household level only. Hence one must examine whether a version of the PIH applies to consumption at the household level. This is the approach used by Deaton and Paxson (1994a) and I follow them in defining birth cohorts by the age of the household head in 1976, and restricting attention to households with heads aged between 20 and 75 inclusive. The number of households in a given cohort-year varies depending on both the year and the age of the household. Typical cohort-year cells contain between 300 and 400 households, but are smaller at young and old ages, which also have less time periods due to the 20-75 age restriction.

The consumption measure we use is nondurable consumption, measured as the total expenditure on all goods less expenditures on furniture and family facilities, purchases of personal transportation equipment, and purchases of recreation facilities. Nominal data were converted into 1996 NT$ using the Consumer Price Index.[4] Income is household after-tax income from all sources.

[4] Source: CEPD (1999). One US dollar = 31.0 New Taiwan dollars (March 1, 2005).

Figure 2 plots mean household consumption against the age of the household head for every fifth birth cohort in our sample. Cohort age-consumption profiles are labelled by their birth year. Consumption trends strongly upwards for all but the oldest cohorts. This demonstrates visually that the evidence against the PIH in the macro data is not merely an aggregation effect arising from different cohorts starting with different levels of lifetime wealth. However, there are noticeable differences between cohorts, with the consumption of the older cohorts appearing to grow more slowly than the consumption of the young. To formally test whether the PIH holds at the cohort-level and determine whether these inter-cohort differences are significant, we employ dynamic pseudo-panel techniques, which are explained in the next section.

4 Econometric Methods

The PIDS surveys a different sample of households every year. This prevents the use of panel data methods, which follow the same individuals over time. However, following the seminal work of Deaton (1985), we can track cohorts of individuals, where a cohort is defined by birth year and perhaps educational attainment. Mckenzie (2004) uses this idea to study the estimation of dynamic pseudo-panel models with parameter heterogeneity and provides the results used in most of the econometric work in this paper. Here we outline how these techniques can be used to test the martingale hypothesis of consumption, and to test whether the differences between cohorts observed in Figure 2 are significant.

Let $C_{i(t),t}$ denote the consumption of individual $i\,(t)$ in period t and $k = 1, 2, ..., K$ denote different birth cohorts. The martingale result of Hall (1978) then gives for all i, t and k:

$$C_{i(t),t} = \beta_k C_{i(t),t-1} + u_{i(t),t} \quad \text{with } \beta_k = 1 \ . \tag{2}$$

The $i\,(t)$ subscript makes explicit the fact that different individuals are observed each period. In particular, consumption for individual $i\,(t)$ in period $t-1$, $C_{i(t),t-1}$, is not observed. This precludes the use of genuine panel data methods. Summing across individuals in the same cohort k gives:

$$\overline{C}_{k(t),t} = \beta_k \overline{C}_{k(t),t-1} + \overline{u}_{k(t),t} \ . \tag{3}$$

The $k(t)$ subscript now indicates that the means are taken over the individuals in cohort k observed at time t. Replacing the unobserved mean consumption at time $t-1$ for individuals observed at time t, denoted $\overline{C}_{k(t),t-1}$, with the cohort mean for those individuals who were observed at time $t-1$, $\overline{C}_{k(t-1),t-1}$, gives the following model to be estimated:

$$\overline{C}_{k(t),t} = \beta_k \overline{C}_{k(t-1),t-1} + \varepsilon_{k,t} \tag{4}$$

$$\varepsilon_{k,t} = \overline{u}_{k(t),t} + \beta_k \left(\overline{C}_{k(t),t-1} - \overline{C}_{k(t-1),t-1} \right) . \tag{5}$$

Our inability to observe the same individuals each period causes the errors to have an MA(1) structure, and to be correlated with the regressor term in finite samples. If T is the number of surveys available and n_k the number of individuals in cohort k, then consistency requires assuming that, for every cohort k, as $n_k \to \infty$,

$$\overline{C}_{k(t),t-1} - \overline{C}_{k(s),t-1} \xrightarrow{p} 0 \text{ for all } t, s. \tag{6}$$

This condition is the crucial identification assumption underlying the construction of the pseudo-panel. It requires that each of the surveys is sampled from cohort populations with the same mean properties. If the poorer individuals in a cohort die, emigrate, or move in with relatives, then one would observe growth in the cohort consumption mean, even if there was zero growth in individual consumption for those individuals left in the cohort. McKenzie (2001) studies in detail the effects of mortality, international migration, and changes in household composition on the validity of this assumption and concludes that such effects are only a concern for very young and very old households. For households with heads aged 25-65, changes in household headship is found to explain at most 0.1 to 0.5 percent of the 6-7 percent consumption growth.

The second key assumption needed for consistency regards the term $\overline{u}_{k(t),t}$, which represents the cross-sectional cohort average of the forecast errors $u_{i(t),t}$. As Chamberlain (1984) and Marigar and Shaw (1993) note, innovations in earnings can contain a common component across individuals as a result of unanticipated macroeconomic disturbances. Therefore it is unlikely that the cohort average $\overline{u}_{k(t),t}$ will be zero in any particular time period. However, rational expectations implies that the time average of this error term should be zero. We therefore rely on having sufficient observations per cohort and sufficient time observations to achieve consistent estimates. More formally, we rely on sequential path asymptotic results for which $n_k \to \infty$ followed by $T \to \infty$, or on diagonal path asymptotics in which $n_k \to \infty$, $T \to \infty$ and $T/n_k \to 0$. With 300-400 observations per cohort each period, and 21 time periods, the simulations in McKenzie (2004) suggest that either of these asymptotics will provide a reasonable approximation. McKenzie (2004) then shows that both OLS and instrumental variables[5] estimators of equation (4) will be consistent and asymptotically normal.

Estimation of equation (4) enables us to test whether the martingale form of the permanent income hypothesis holds separately for each cohort. We can write $\beta_k = 1 + g_k$, where g_k is the annual consumption growth rate for cohort k. Rejection of the null hypothesis that $\beta_k = 1$ in favour of $\beta_k > 1$ therefore indicates positive consumption growth. Allowance for inter-cohort parameter heterogeneity enables us to determine whether consumption growth rates differ across birth cohorts.

4.1 Testing for Cohort-level Consumption Growth

Failure to take account of changes in household size can affect our estimation of β_k. In particular, a falling (rising) household size will cause us to understate (overstate) the true value. Therefore one needs to standardize consumption by the number of household members to approximate individual consumption levels. In the absence of equivalence scales for Taiwan, we follow Deaton and Paxson (1994a) in using consumption per adult equivalent, where the number of adult equivalents is defined as the number of household members over 17 years of age plus one half of the number aged 17 or less. Secondly we use the number of adults (members aged over 17), which Schultz (1999) argues goes some way towards addressing the problems of endogenous family size and directly links consumption to the individuals earning the income to pay for this consumption.

Figure 3 compares the OLS estimates for total consumption, consumption per adult and consumption per adult equivalent.[6] Using total consumption, we see that there is a strong downward trend in the estimated β_k as one moves from younger to older cohorts. Pointwise two-sided t-tests reject the null of a unit root for all

[5] The instruments in this model are $\overline{y}_{k(t-2),t-2}$ and earlier lags. Lags of additional regressors can also be used as instruments in the more general model.

[6] Instrumental variables estimates using lagged variables as instruments are very similar to the OLS estimates.

cohorts aged between 5 and 50 in 1976, with $\beta_k > 1$ for these cohorts. A Wald test for parameter homogeneity overwhelmingly rejects the null hypothesis, and we conclude that cohorts experienced significantly different growth rates of consumption. This confirms the visual findings of Figure 2.

Standardizing by a measure of the number of household members accounts for some of the difference between cohorts, as the elder households are measured over a period where their household size is declining, whereas younger household sizes were increasing or remained constant. Again Wald Tests reject the null of parameter homogeneity, but least strongly for consumption per effective adult. Thus, even after accounting for the effects of household size, we find that younger cohorts experienced faster consumption growth than the older cohorts.

5 Precautionary saving

Consumption theory suggests that precautionary savings behaviour can help to explain the persistent growth of consumption. Uncertainty about future income can make young people unwilling to borrow to finance current consumption, even though they expect their incomes to rise, due to the possibility of a bad future outcome (Deaton, 1992). Browning and Lusardi (1996) remark that the degree to which the certainty-equivalent model approximates models with uncertainty depends on the time path of expected income. There can be wide divergence between the two models in situations in which current period income and cash-on-hand are low relative to future expected earnings. This situation fits the Taiwan case, whereby rapid income growth has meant current income has been low relative to future earnings. The ability of precautionary savings to explain consumption growth depends on the intensity of the precautionary savings motive, and the amount of uncertainty faced. The next two sub-sections examine these two factors.

5.1 Prudence

Precautionary saving in response to risk requires convexity of the marginal utility function. Kimball (1990) showed that the intensity of the precautionary saving motive can be measured by absolute prudence, defined as $-U'''/U''$; and by relative prudence, defined as $-CU'''/U''$. A higher level of prudence means that consumers will engage in more precautionary savings in response to a given level of uncertainty. Dynan

(1993) found that a second-order Taylor expansion of the consumer's first-order condition enables one to estimate these coefficients of prudence using panel data. In Appendix 1, we derive the corresponding result for pseudo-panel data. Assuming a constant real interest rate[7] gives the following equation to be estimated:

$$\left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t),t}\right) = \lambda + \frac{\rho^*}{2}\left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t),t}\right)^2 + \varepsilon_{k,t+1} \ , \tag{7}$$

where $\rho^* = -U'''/U''$ is the coefficient of absolute prudence. For the CARA utility function $u(C_t) = -\theta^{-1}\exp(-\theta C_t)$, $\rho^* = \theta$, a constant, and hence estimation of (7) enables one to determine the intensity of the precautionary saving motive. Note that $\rho^* = 0$ for quadratic utility, reflecting the absence of a precautionary motive when utility takes this form. A positive value of ρ^* means that higher expected consumption growth (reflecting higher saving) is associated with higher squared consumption growth (reflecting greater uncertainty).

Similarly, letting $c_{k,t+1}$ be the mean of log non-durable consumption for individuals in cohort k, one can estimate the model

$$\Delta c_{k,t+1} = \lambda^* + \frac{\rho}{2}\left(\Delta c_{k,t+1}\right)^2 + \varepsilon^*_{k,t+1} \tag{8}$$

Here $\rho = -CU'''/U''$ is the coefficient of relative prudence. The constant relative risk aversion (CRRA) utility function $U(C) = (1-\gamma)^{-1} C^{1-\gamma}$ exhibits constant relative prudence, with coefficient $\rho = 1 + \gamma$.

Dynan (1993) uses panel data from the United States to estimate absolute and relative prudence and levels of relative prudence below one, suggesting a relatively weak precautionary motive. Merrigan and Normandin (1996) use repeated cross-sections from the United Kingdom and obtain estimates of relative prudence close to one. We expand their approach by allowing the level of prudence to vary by cohort, in order to determine whether the faster consumption growth of the younger cohorts is due to them facing greater income uncertainty, or to a stronger degree of prudence when facing the same or lower amounts of income uncertainty.

Following the discussion in Section 4, one can estimate equations (7) and (8) by ordinary least squares on the cohort mean, allowing the parameters ρ^* and ρ to vary across cohorts. The results are reported in

[7] Allowing for a time-varying interest rate did not significantly alter the results.

Table 1 for every fifth cohort. The first six columns are estimates from equation (7), while the last column reports the estimated relative prudence based on equation (8) for comparison purposes. Controlling for household size increases the estimated degree of absolute prudence. After controlling for household size, the estimated degree of absolute and relative prudence does not appear to differ across cohorts in a systematic way. In addition, the last two columns of Table 1 show that the implied coefficients of relative prudence from equation (7), based on the CARA utility function, are similar to those based on a CRRA utility function obtained from equation (8). The main finding is that the estimated levels of relative prudence are high across all cohorts. The coefficient of relative prudence in Taiwan is found to lie between 8 and 14, which is much higher than the levels found previously in the United States and United Kingdom. This implies that in response to a given level of uncertainty, the Taiwanese save more than the Americans or British.

5.2 Unpacking the precautionary drift

In order to illustrate the extent to which high prudence can account for rapid consumption growth in Taiwan and to estimate the differences in uncertainty facing different cohorts, we follow Caballero (1990) in now assuming a CARA utility function, $u(C_t) = -\theta^{-1}\exp(-\theta C_t)$. Caballero shows that with this utility function, if labour income follows any ARMA process (with possibly a unit root) and the return on assets is certain, then the consumption process is a martingale with drift. In particular, if labour income is a random walk, with $N\left(0, \sigma_\omega^2\right)$ innovations, then the consumption process is:

$$C_{t+1} = \left(\frac{\theta\sigma_\omega^2}{2} + \frac{(r-\delta)}{\theta}\right) + C_t + u_{t+1} \ . \tag{9}$$

Where r is the interest rate and δ the rate of time preference and $u_{t+1} \sim N\left(0, \sigma_\omega^2\right)$. Following the proof in Caballero (1990), one can show that if labour income instead follows the explosive process $y_{t+1} = \rho y_t + \omega_{t+1}$, with $1 < \rho < 1 + r^{-1}$, then consumption follows the same form as equation (9), with only the variance of the u_{t+1} increasing. The precautionary drift is increasing in the riskiness of income.

Assume that the rate of time preference equals the real interest rate and that the term $\theta\sigma_\omega^2/2$ is the same for all individuals within a cohort. Then summing equation (9) over the individuals in cohort k and taking cohort means gives the following model:

$$\overline{C}_{k(t),t} - \overline{C}_{k(t-1),t-1} = \alpha_k + \varepsilon_{k,t} \quad (10)$$

$$\varepsilon_{k,t} = \overline{u}_{k(t),t} + \left(\overline{C}_{k(t),t-1} - \overline{C}_{k(t-1),t-1}\right) . \quad (11)$$

The precautionary savings term α_k is then predicted to be positive, and increasing in uncertainty. The dynamic pseudo-panel methods outlined in Section 4 can then be used to estimate these coefficients. Figure 4 plots the cohort-specific estimates of α_k for total, per adult, and per adult-equivalent non-durable consumption. The estimated drift term is significantly greater than zero for all but the oldest cohorts. Failure to allow for changing household size results in a very large drift term for younger cohorts, but even after appropriate scaling we find that the drift term is larger for younger cohorts than older cohorts. This again reveals the faster consumption growth experienced by younger cohorts.

Under CARA utility, $\theta = \rho^*$ and so the estimates of absolute prudence from equation (7) can be used together with the estimated drift term from equation (9) to calculate the estimated uncertainty surrounding future labour earnings shocks, σ_ω^2. Figure 5 plots the standard deviations of earnings shocks inferred from this process. The estimated standard deviations for most cohorts lie between 10,000NT$ and 15,000NT$, representing between 5 percent and 7 percent of average income for most cohorts. The younger cohorts have greater income uncertainty than most of the older cohorts, which accounts for the larger drift term estimated for the young, and hence their faster consumption growth. Thus using a CARA utility representation, one finds that Taiwanese consumers exhibited strong prudence in the face of moderate income uncertainty, leading to a large amount of precautionary saving and fast consumption growth.

To illustrate the effect of different levels of prudence on consumption growth, we use the estimates of σ_ω^2 together with equation (9).[8] Using the actual level of consumption per adult equivalent in 1976, one can then predict the 1996 level for various levels of relative prudence. Table 2 compares the actual consumption growth per adult equivalent to that predicted with rates of relative prudence of 2, 5 and 10. Prudence is shown to have a strong effect on consumption growth: consumption growth in Taiwan would have only been

[8] For a CARA utility function, the parameter $\theta = \rho/\overline{C}$, where ρ is the coefficient of relative prudence and $\overline{C}$ is mean consumption.

1-2 percent if relative prudence were two, and 3-4 percent if relative prudence were five. Thus higher levels of prudence are needed to explain the 5-8 percent consumption growth rates observed in Taiwan.

5.3 Understanding earnings uncertainty

The above analysis suggests that the reason that consumption growth is faster for the younger cohorts than for the older cohorts is greater income uncertainty for the young. Taiwan does not have detailed panel data on income available, preventing us from directly estimating time-varying uncertainty in the income process, as has been done in the United Kingdom by Banks, Blundell, and Brugiavini (2001). We therefore instead examine measureable sources of differences across cohorts in income uncertainty.

There are several measurable differences across cohorts which may affect income uncertainty. The younger cohorts are more highly educated and less likely to live on farms and in rural regions. Figure 6 shows the average proportion of each cohort working in different industries in Taiwan. The variation over time around the mean proportions is relatively small, except for the oldest cohorts where individuals are retiring and moving into the jobless category. Individuals in the younger cohorts are much more likely to work in manufacturing, construction and commerce than individuals in older cohorts, who are more likely to work in agriculture, or to be jobless (as a result of retirement).

While traditionally agriculture is thought of as being subject to high earnings variability, most of this is of a transitory nature. In contrast, the faster growing manufacturing, commerce, financial and construction industries are likely to have experienced more persistent shocks. This suggests that a major source of the differences in uncertainty across cohorts may arise from the young being more likely to work in higher uncertainty industries. Workers in agriculture are found to have had lower initial earnings, and experienced slower earnings growth over the 1976-96 period, than workers in the other industries shown. Some studies of precautionary behaviour use the earnings or income variance as a measure of risk (see Table 5.2, p.1836, in Browning and Lusardi 1996). Using this measure one would directly conclude that the younger cohorts face more risk, due in part to working in riskier industries.

A problem with using earnings growth to measure risk is that only unanticipated earnings growth is a source of risk. A common practice in the literature (see Browning and Lusardi, 1996) is therefore to estimate the following log-linearized Euler equation:

$$\ln C_{t+1} - \ln C_t = \alpha + \phi r_t + \gamma \sigma^2_{t+1} + u_{t+1} \ . \tag{12}$$

where σ^2_{t+1} is the consumption shock variance. The precautionary saving motive means that the higher is this variance, the greater is precautionary saving and consumption growth. The main empirical challenge involved is that the consumption shock variance, σ^2_{t+1}, is not observed. To examine the effect of industry on uncertainty, consider the following decomposition of the uncertainty for individual i in industry j at time $t+1$:

$$\sigma^2_{i,j,t+1} = d_{i,j,t+1}\sigma^2_j + \varphi_c + \mu_i \ , \tag{13}$$

where $d_{i,j,t+1}$ is a dummy variable which is unity if individual i works in industry j at time $t+1$, and σ^2_j is the earnings uncertainty in industry j.[9] Substituting equation (13) into (12) and averaging over individuals in the same cohort gives the following equation to be estimated:

$$\Delta c_{k,t+1} = \alpha_k + \phi r_t + \sum_{j=1}^{J} p_{k,j,t+1}\sigma^2_j + \varepsilon_{k,t+1} \tag{14}$$

$$\varepsilon_{k,t+1} = \overline{u}_{k(t+1),t+1} + \mu_k + \left(c_{k(t+1),t} - c_{k(t),t}\right) \ , \tag{15}$$

where $p_{k,j,t+1}$ is the proportion of individuals in cohort k working in industry j at time $t+1$, and the σ^2_j's are now parameters to estimate. That is, estimation of (14) allows one to estimate whether precautionary savings behaviour is affected by earnings uncertainty which differs across industries.

The first column of Table 3 contains the results of estimating equation (14). The industry coefficients are higher for the industries identified above as being riskier, but are not significant. Column four shows that this remains the case when we set $\alpha_k = \alpha$ for all cohorts. Lack of significance is caused by severe multicollinearity between the industry variables.[10] In the second column we include only the proportion of workers in agriculture as a regressor. This is now significant and negative, showing that a higher proportion

[9] It is assumed that individuals work only in one industry. This is in accordance with the data.

[10] As we omit industry categories in which less than 3 percent of any cohort participates, the industry variables do not sum to exactly unity, and so are not perfectly collinear with the constant.

of workers in agriculture reduces consumption growth. Principal components analysis of the proportion of workers in each industry, $p_{k,j,t+1}$, finds that one component adequately summarizes the five industries: commerce, finance, construction, manufacturing and agriculture. The industry composite variable captures this component, and is the proportion of the cohort in any of the first four industries less the proportion in agriculture. This variable has a significant and positive coefficient, so that consumption growth is higher the more workers are in manufacturing, finance, commerce and construction relative to those in agriculture. Allowing for these industry effects accounts for much of the difference among cohorts, with the α_k's varying much less across cohorts for cohorts aged under 45 in 1976. The older cohorts now have higher α_k's, indicating that their consumption growth is higher than one would expect from their industry uncertainty. These cohorts approach and reach retirement during the sample period, and it is likely that uncertainty related to aging becomes a more important source of risk for these cohorts.

6 Conclusions

Our analysis finds that Taiwan's rapid consumption growth is a result of high levels of prudence coupled with uncertainty about future income. Younger cohorts experienced faster consumption growth than did older cohorts. This difference across cohorts is not due to differences in prudence, but due to the greater riskiness of earnings in the industries in which the young are more prevalent.

The high level of prudence found in Taiwan can also help explain the high savings rates experienced in Taiwan: consumers save to prepare and forearm themselves in the face of uncertainty. Precautionary behaviour reduces the incentives of the young to borrow in anticipation of income growth over their lifetimes. One implication of this strong precautionary motive is that it suggests that an aging population may result in a greater fall in aggregate savings than calculated by Deaton and Paxson (1994b, 2000) under the PIH model. Thus demographic changes may help to explain the rise in savings rates during Taiwan's initial growth period, and the fall in the aggregate savings rate since 1987.

Our finding that high levels of relative prudence are behind Taiwan's high saving rates and rapid consumption growth begs the question of whether we can seek to explain this behavioural parameter. One possible explanation is that hardship endured in fleeing from mainland China and the subsequent first few years of high inflation caused the Taiwanese to become prudent. Bodkin (1963, p.447) suggests this line of reasoning in explaining the high marginal savings of Israeli restitution recipients, writing that "...restitution recipients had, as a group, experienced many hardships (and worse) during an earlier period of their lives. It seems quite likely that such experiences would make individuals cautious, alert to adverse possibilities, and hence less likely to spend a one-time receipt...".[11] Such an explanation would not apply to other high saving, fast consumption growth East Asian economies, and so application of the methods in this paper to other countries would shed additional light on international differences in prudence.

Appendix 1: Second-order Taylor expansion of the Euler equation

The Euler equation for consumer i in the standard consumer's problem, with real interest rate r_t and rate of time preference δ, is:

$$U'\left(C_{i,t}\right) = \left(\frac{1+r_t}{1+\delta}\right) E_t\left(U'\left(C_{i,t+1}\right)\right) \ . \tag{16}$$

Following Dynan (1993), we take a second-order Taylor expansion of $U'\left(C_{i,t+1}\right)$ about $C_{i,t}$ to get:

$$U'\left(C_{i,t+1}\right) = U'\left(C_{i,t}\right) + U''\left(C_{i,t}\right)\left(C_{i,t+1} - C_{i,t}\right) + \frac{1}{2}U'''\left(C_{i,t}\right)\left(C_{i,t+1} - C_{i,t}\right)^2 \ . \tag{17}$$

Substituting (17) into (16) and rearranging gives Dynan's (1993, p. 1106) equation 4:

$$E_t\left(\frac{C_{i,t+1} - C_{i,t}}{C_{i,t}}\right) = \frac{1}{\xi}\left(\frac{r_t - \delta}{1+r_t}\right) + \frac{\rho}{2}E_t\left[\left(\frac{C_{i,t+1} - C_{i,t}}{C_{i,t}}\right)^2\right] \ , \tag{18}$$

where $\xi = -C_{i,t}U''/U'$ is the coefficient of relative risk aversion and $\rho = -C_{i,t}U'''/U''$ is Kimball's (1990) coefficient of relative prudence. For pseudo-panel analysis, it is more convenient to multiply through by $C_{i,t}$ to obtain a variant of equation 1a in Merrigan and Normandin (1996):

$$E_t\left(C_{i,t+1} - C_{i,t}\right) = \frac{1}{\xi^*}\left(\frac{r_t - \delta}{1+r_t}\right) + \frac{\rho^*}{2}E_t\left[\left(C_{i,t+1} - C_{i,t}\right)^2\right] \ . \tag{19}$$

[11] See also Landsberger (1966) for a critique of this view and Bodkin's (1966) reply.

Now $\xi^* = C_{i,t}\xi$ and $\rho^* = -U'''/U''$ is the coefficient of absolute prudence, as defined in Kimball (1990). Under rational expectations we can write $C_{i,t+1} = E_t(C_{i,t+1}) + u_{i,t+1}$, with $E_t(u_{i,t+1}) = 0$, and $E_t(C_{i,t+1} - C_{i,t})^2 = (C_{i,t+1} - C_{i,t})^2 + v_{i,t+1}$ where $E_t(v_{i,t+1}) = 0$. Then equation (19) relates the realized change in consumption to the squared change in consumption as follows:

$$(C_{i,t+1} - C_{i,t}) = \frac{1}{\xi^*}\left(\frac{r_t - \delta}{1 + r_t}\right) + \frac{\rho^*}{2}(C_{i,t+1} - C_{i,t})^2 + u_{i,t+1} + \frac{\rho^*}{2}v_{i,t+1} \tag{20}$$

With genuine panel data, one could estimate this equation using instrumental variables, as in Dynan (1993). Merrigan and Normandin (1996) apply Moffitt's dynamic pseudo-panel estimator to a general version of equation, although Verbeek and Vella (2000) have since shown that this does not produce consistent estimates when there are time-varying exogenous regressors. We therefore follow the methods developed in McKenzie (2004), which are still consistent with time-varying exogenous regressors, and additionally allow for parameter heterogeneity across cohorts. Thus one can determine whether the degree of absolute (or relative) prudence varies across cohorts.

The first step is to take means of (20) across individuals in cohort k at time $t+1$ to get:

$$\begin{aligned}\left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t+1),t}\right) &= \frac{1}{\xi^*}\left(\frac{r_t - \delta}{1 + r_t}\right) \\ &+ \frac{\rho^*}{2}\frac{1}{n_k}\sum_{i=1}^{n_k}(C_{i,t+1} - C_{i,t})^2 + \overline{u}_{k(t+1),t+1} + \frac{\rho^*}{2}\overline{v}_{k(t+1),t+1}\ ,\end{aligned} \tag{21}$$

where $\overline{C}_{k(t+1),t+1} = (1/n_k)\sum_{i=1}^{n_k} C_{i,t+1}$. Let $C_{i,t+1} = \overline{C}_{k(t+1),t+1} + \mu_i + \eta_{i,t+1}$, with $\mu_i \sim i.i.d.\left(0, \sigma_\mu^2\right)$ and $\eta_{i,t+1} \sim i.i.d.\left(0, \sigma_\eta^2\right)$.[12] Then algebraic manipulation of $(1/n_k)\sum_{i=1}^{n_k}(C_{i,t+1} - C_{i,t})^2$ gives:

$$\frac{1}{n_k}\sum_{i=1}^{n_k}(C_{i,t+1} - C_{i,t})^2 = \left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t+1),t}\right)^2 + 2\sigma_\eta^2 + o_p(1)\ .$$

This decomposes the average squared consumption change into a component measuring changes in the cohort mean, a second component reflecting dispersion about the cohort mean, and a term which converges

[12] The i.i.d. assumption can be weakened to one allowing for general forms of temporal dependence and weak spatial dependence without impacting on the consistency results (see Mckenzie, 2000a).

in probability to zero. Substituting into (21) gives:

$$\left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t+1),t}\right) = \frac{1}{\xi^*}\left(\frac{r_t - \delta}{1 + r_t}\right) + \rho^* \sigma_\eta^2 + \frac{\rho^*}{2}\left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t+1),t}\right)^2 + \overline{\omega}_{k(t+1),t+1} \ , \tag{22}$$

Estimation using pseudo-panel data requires replacing the unobserved $\overline{C}_{k(t+1),t}$ with the mean over individuals in the sample at time t, $\overline{C}_{k(t),t}$. Therefore the equation to be estimated is:

$$\left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t),t}\right) = \frac{1}{\xi^*}\left(\frac{r_t - \delta}{1 + r_t}\right) + \rho^* \sigma_\eta^2 + \frac{\rho^*}{2}\left(\overline{C}_{k(t+1),t+1} - \overline{C}_{k(t),t}\right)^2 + \varepsilon_{k,t+1} \tag{23}$$

$$\varepsilon_{k,t+1} = \overline{\omega}_{k(t+1),t+1} + \left(1 - \rho^* \overline{C}_{k(t+1),t+1}\right)\left(\overline{C}_{k(t+1),t} - \overline{C}_{k(t),t}\right) + \frac{\rho^*}{2}\left(\left(\overline{C}_{k(t+1),t}\right)^2 - \left(\overline{C}_{k(t),t}\right)^2\right) \ . \tag{24}$$

Then under the assumptions set out in Section 4, applying OLS (23) will be consistent as $n_k \to \infty$ followed by $T \to \infty$.

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Table 1: Estimates of the Coefficients of Absolute and Relative Prudence

Cohort	Total Consumption: Absolute Prudence	Total Consumption: Relative Prudence	Cons. per Adult: Absolute Prudence	Cons. per Adult: Relative Prudence	Cons. per Adult Equivalent: Absolute Prudence	Cons. per Adult Equivalent: Relative Prudence	Cons. per Adult Equivalent: Relative Prudence from Log Specification
10	1.99E-05	10.0	5.74E-05	10.5	8.19E-05	12.9	11.2
	(1.62E-07)	(0.2)	(3.73E-06)	(0.7)	(7.99E-06)	(1.3)	(0.4)
15	2.29E-05	10.4	5.61E-05	10.3	9.26E-05	13.1	13.1
	(2.29E-06)	(1.1)	(6.35E-06)	(1.2)	(1.02E-05)	(1.5)	(0.5)
20	3.48E-05	14.5	5.90E-05	10.5	9.43E-05	11.9	9.6
	(2.53E-06)	(1.1)	(2.78E-06)	(0.6)	(8.85E-06)	(1.1)	(0.4)
25	3.10E-05	12.1	9.90E-05	16.4	1.12E-04	12.9	9.1
	(3.78E-06)	(1.5)	(8.73E-06)	(1.5)	(4.88E-06)	(0.6)	(0.4)
30	2.70E-05	10.9	1.00E-04	16.2	9.93E-05	11.4	14.0
	(3.75E-06)	(1.5)	(1.14E-05)	(1.9)	(1.01E-05)	(1.2)	(0.9)
35	1.59E-05	6.4	1.39E-04	19.7	1.24E-04	13.3	14.2
	(1.10E-05)	(4.4)	(1.57E-05)	(2.2)	(1.91E-05)	(2.1)	(0.6)
40	3.53E-05	13.4	7.37E-05	9.5	7.31E-05	7.8	14.0
	(5.67E-06)	(2.2)	(1.60E-05)	(2.1)	(8.84E-06)	(1.0)	(0.5)
45	5.01E-05	17.5	1.17E-04	14.6	9.48E-05	10.3	11.4
	(8.02E-06)	(2.8)	(1.54E-05)	(1.9)	(1.05E-05)	(1.1)	(1.3)
50	6.15E-05	18.2	1.17E-04	13.2	1.38E-04	13.2	14.6
	(1.35E-05)	(4.0)	(1.37E-05)	(1.5)	(2.04E-05)	(2.0)	(0.7)
55	-1.83E-06	-0.5	1.85E-04	17.8	1.71E-04	14.5	9.2
	(3.71E-05)	(9.8)	(2.48E-05)	(2.4)	(1.57E-05)	(1.3)	(0.6)

Cohorts are described by the age of the household head in 1976. Standard errors in parentheses.
The implied coefficient of Relative Prudence is calculated at the Cohort sample mean consumption level.

TABLE 2: What difference does prudence make?

Actual and Counterfactual Consumption per Adult Equivalent Growth Rates Under Varying Degrees of Prudence

Cohort age in 76	Actual growth rate	Predicted growth rate with Relative Prudence of		
		10	5	2
10	7.8	6.8	3.9	1.7
12	8.6	6.8	3.9	1.7
14	8.0	6.3	3.6	1.6
16	7.7	5.8	3.3	1.4
18	7.2	5.9	3.3	1.5
20	7.0	6.1	3.8	1.9
22	6.5	7.0	4.6	2.3
24	6.6	5.3	3.3	1.6
26	5.6	5.0	3.1	1.5
28	5.6	5.0	3.0	1.4
30	6.1	5.4	3.3	1.6
32	5.6	3.7	2.2	1.0
34	5.5	4.7	2.9	1.3
36	6.0	5.0	3.1	1.4
38	5.7	5.9	3.7	1.8
40	5.9	7.0	4.5	2.3
42	6.1	6.4	4.1	2.0
44	5.8	5.4	3.4	1.6
46	5.6	3.7	2.2	1.0
48	5.3	5.4	3.4	1.6
50	5.6	5.5	3.4	1.6
52	5.1	5.9	3.7	1.8
54	5.1	3.8	2.2	1.0

Results for every second cohort are shown.
Consumption growth for Cohorts aged 20-55 is over the 1976-96 period.
For cohorts aged 10-19 in 1976, growth is over the 1986-96 period.
Prediction method is described in text.

Table 3: Estimation of the log Precautionary Savings Equation using Industry of household head as a measure of earnings risk.

Dependent variable: change in log non-durable consumption per adult equivalent

	(1)	(2)	(3)	(4)	(5)	(6)
cohort 5-9	-0.266	0.078	-0.001			
	(0.330)	(0.009)	(0.037)			
cohort 10-14	-0.269	0.065	-0.015			
	(0.331)	(0.006)	(0.035)			
cohort 15-19	-0.263	0.066	-0.012			
	(0.329)	(0.007)	(0.033)			
cohort 20-24	-0.268	0.060	-0.017			
	(0.327)	(0.008)	(0.032)			
cohort 25-29	-0.270	0.062	-0.013			
	(0.324)	(0.009)	(0.028)			
cohort 30-34	-0.261	0.070	-0.005			
	(0.321)	(0.013)	(0.024)			
cohort 35-39	-0.244	0.084	0.008			
	(0.317)	(0.021)	(0.017)			
cohort 40-44	-0.235	0.095	0.021			
	(0.315)	(0.026)	(0.010)			
cohort 45-49	-0.249	0.089	0.026			
	(0.317)	(0.024)	(0.007)			
cohort 50-54	-0.252	0.087	0.026			
	(0.318)	(0.024)	(0.007)			
cohort 55-59	-0.230	0.107	0.039			
	(0.320)	(0.033)	(0.004)			
cohort 60-64	-0.182	0.144	0.071			
	(0.319)	(0.040)	(0.013)			
constant				-0.237	0.055	0.037
				(0.269)	(0.004)	(0.003)
interest rate	0.454	0.400	0.405	0.473	0.425	0.428
	(0.124)	(0.120)	(0.118)	(0.120)	(0.114)	(0.113)
jobless	0.224			0.180		
	(0.309)			(0.257)		
agriculture	0.096	-0.235		0.221	-0.065	
	(0.345)	(0.114)		(0.306)	(0.018)	
construction	0.280			0.260		
	(0.374)			(0.330)		
commerce	0.313			0.339		
	(0.365)			(0.301)		
transportation	0.465			0.309		
	(0.431)			(0.389)		
finance	0.505			0.489		
	(0.462)			(0.353)		
other services	0.488			0.427		
	(0.336)			(0.274)		
manufacturing	0.241			0.193		
	(0.362)			(0.271)		
industry composite[1]			0.108			0.024
			(0.053)			(0.005)

Notes:

Dynamic pseudo-panel standard errors are given in parentheses.

1. Industry composite is the proportion in manufacturing, finance, construction and commerce less the proportion in agriculture

Figure 1:
Taiwanese Real Income and Consumption per Capita

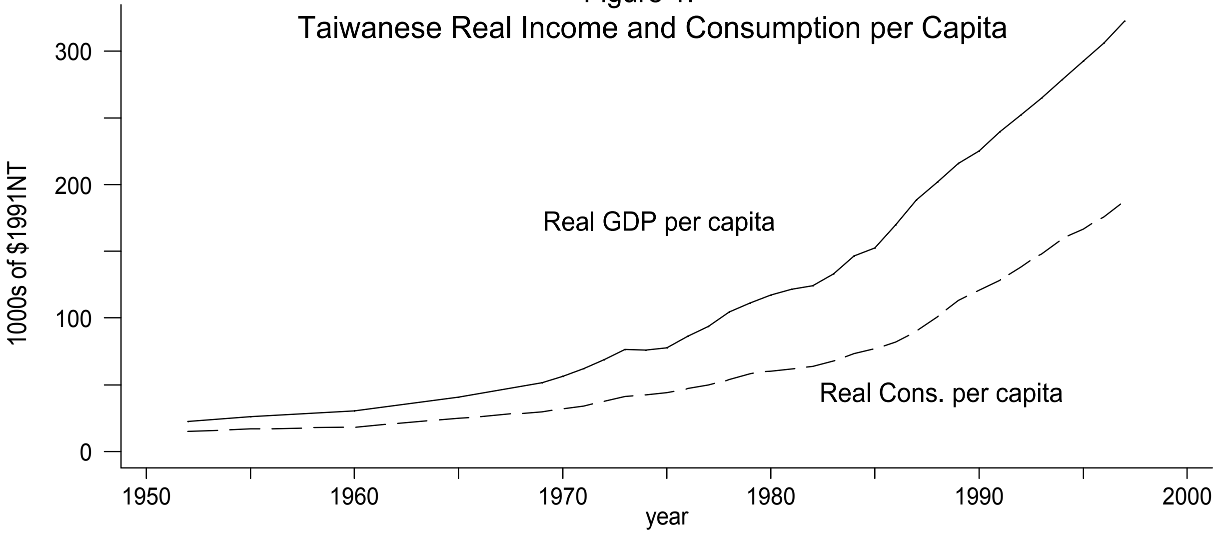
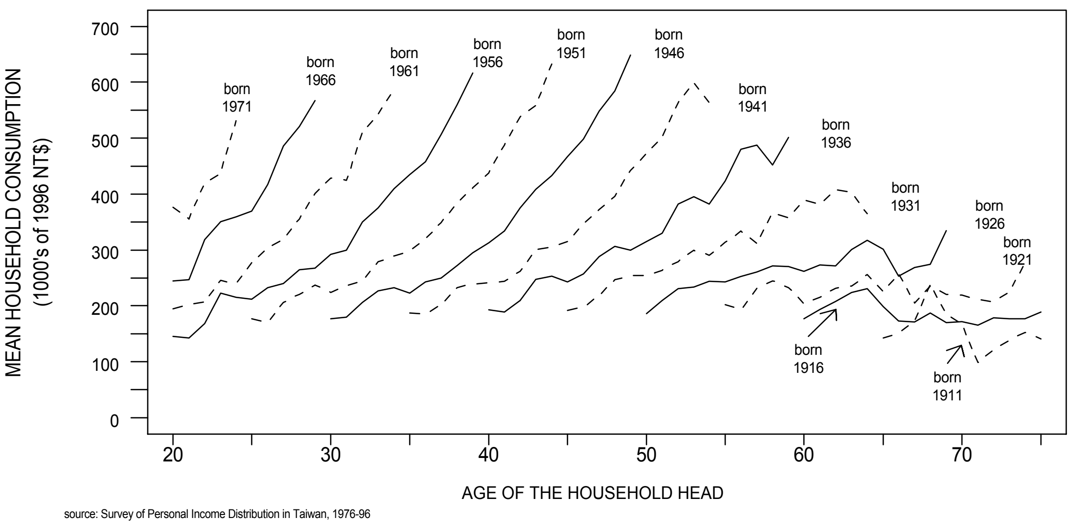


Figure 2: Taiwanese Consumption over
the Life-Cycle for Cohorts



source: Survey of Personal Income Distribution in Taiwan, 1976-96

Figure 3: Comparison of OLS estimates of Beta
AR(1) model: C(t)=b(c)C(t-1)+u(t)

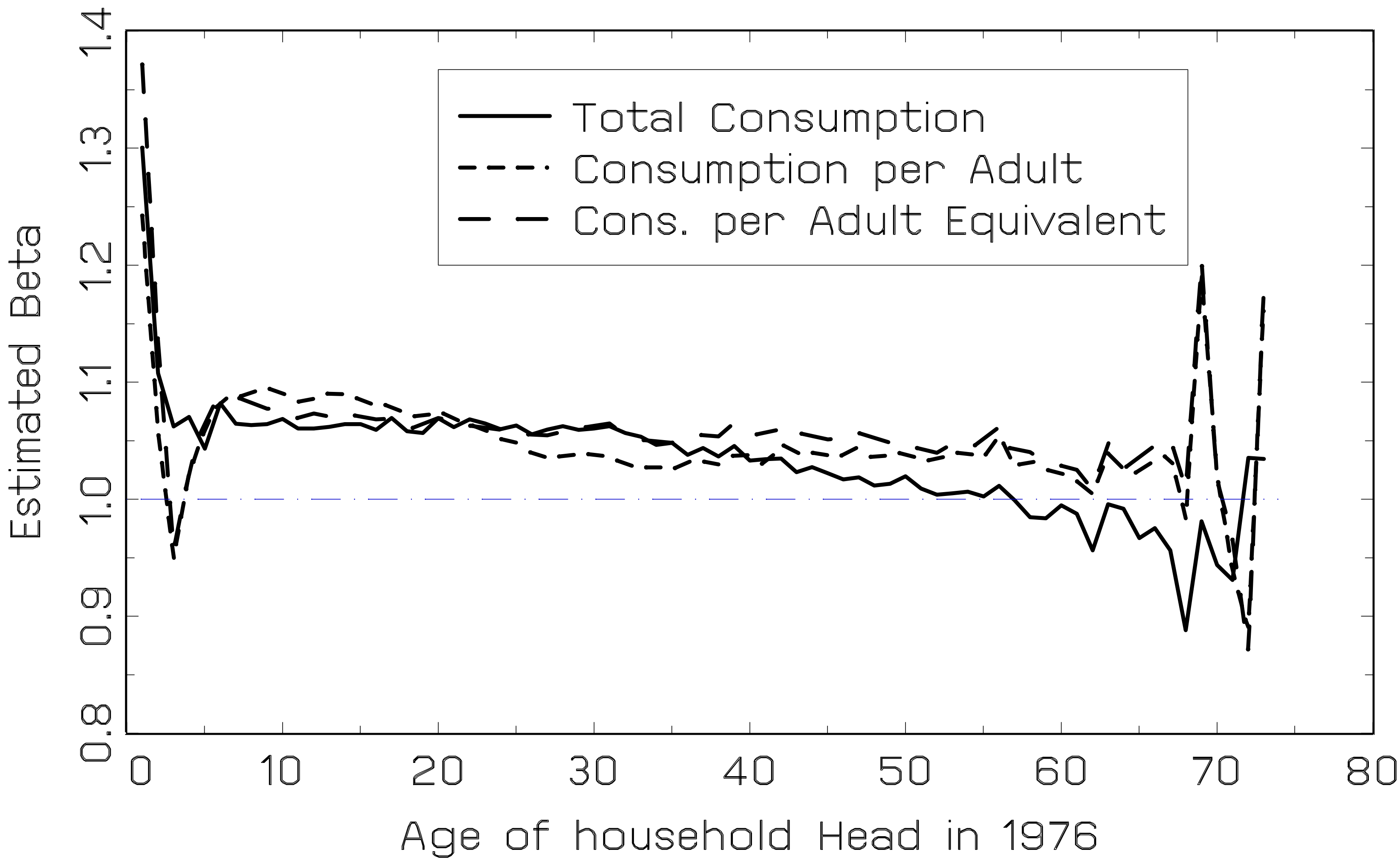


Figure 4: Estimates of the Precautionary Drift Term
Model C(c,t)−C(c,t−1)=a(c)+u(c,t)

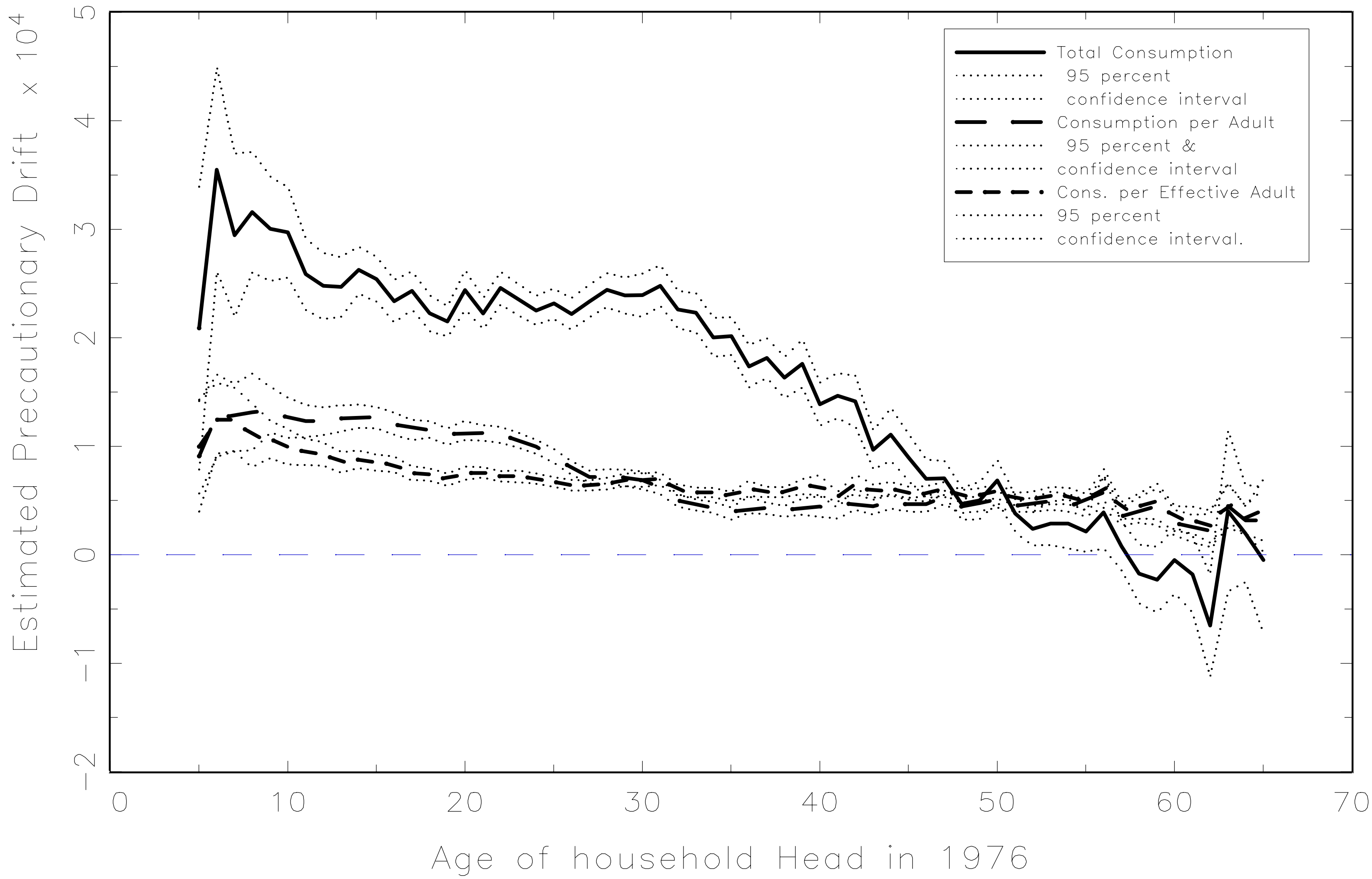
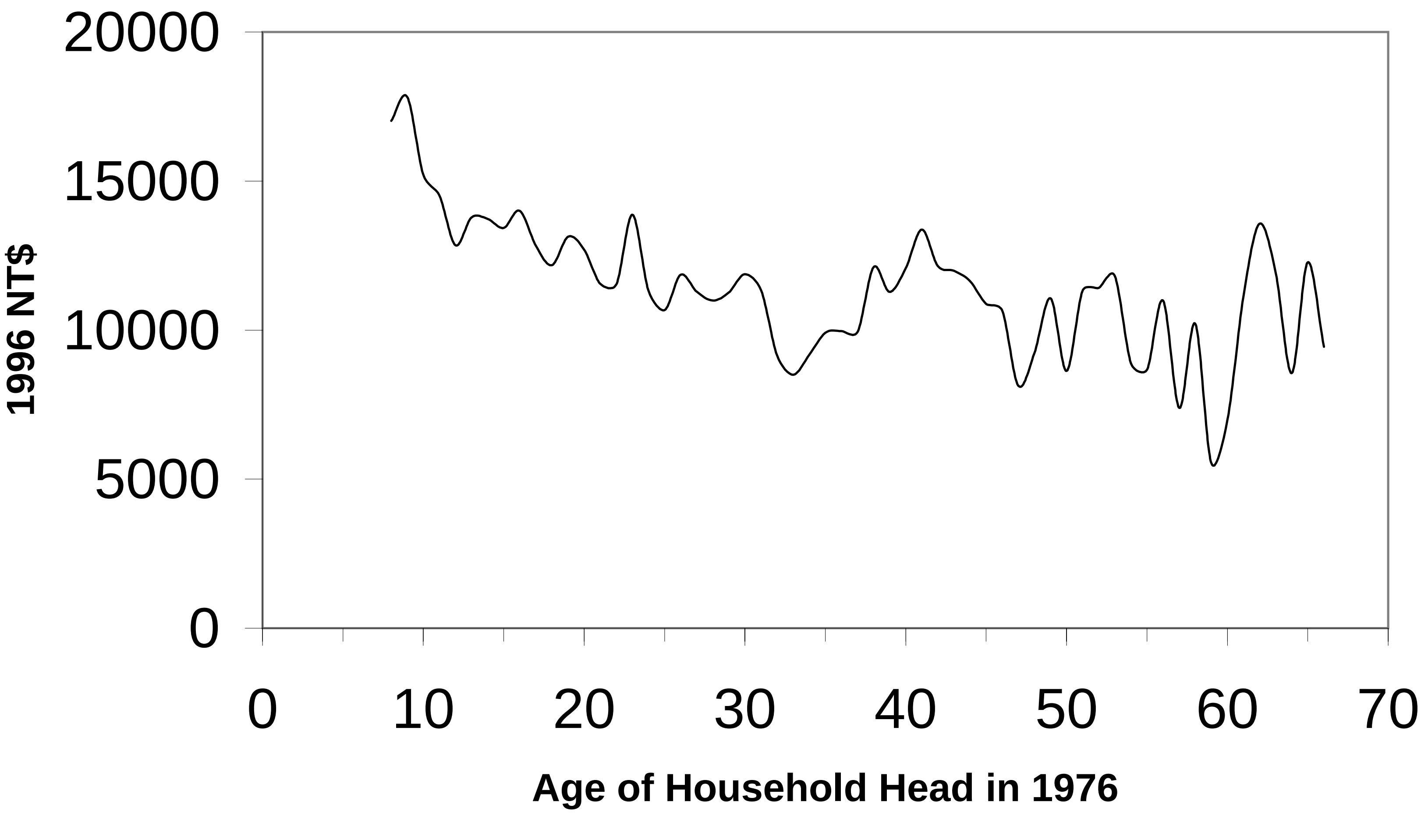


Figure 5: Estimated Standard Deviation of Labour Income Shocks



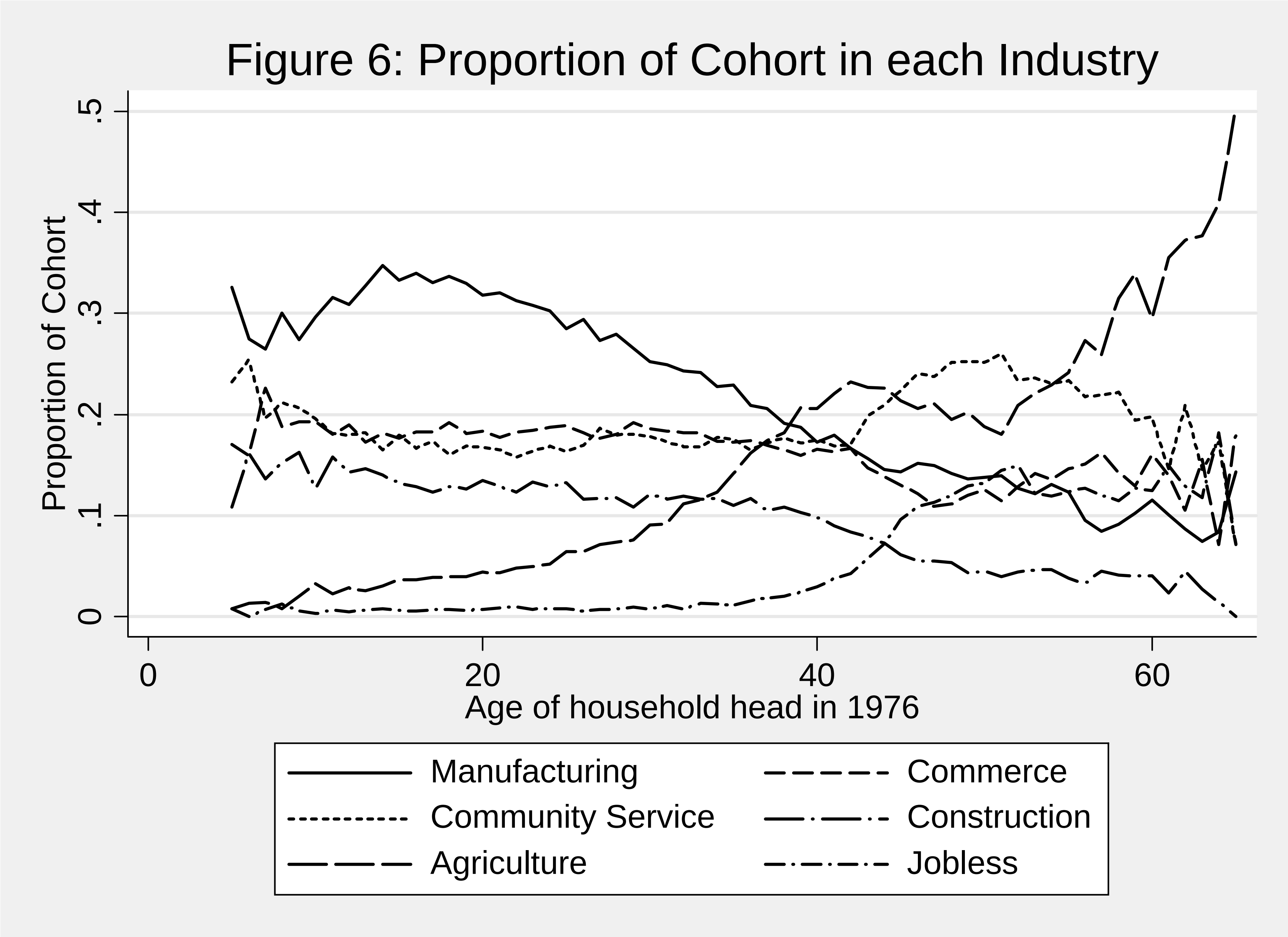


Figure 6: Proportion of Cohort in each Industry
Proportion of Cohort
0
.1
.2
.3
.4
.5
0
20
40
60
Age of household head in 1976
Manufacturing
Commerce
Community Service
Construction
Agriculture
Jobless