# A Model for National Income Determination in Taiwan

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Abstract: Following Chow (1985 and 2010) and using annual data from 1951 to 2010 for Taiwan this paper estimates a consumption function based on the permanent income hypothesis and an investment function based on the accelerations principle. The data support the permanent income hypothesis Friedman (1957) whereas the permanent income hypothesis of Hall (1978) was supported in Chow (1985 and 2010). The accelerations principle is strongly supported, as in the case of China. An explanation why the two economies have different consumption functions is given.

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Key words: consumption, investment, permanent income, Taiwan, macroeconomics

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# A Model for National Income Determination in Taiwan

This paper presents a simple econometric model to determine national income in Taiwan consisting of a consumption equation and an investment equation, following Chow (1985, 2010 and 2011). The consumption function is based on the permanent income hypothesis and the investment equation is based on the accelerations principle. In section 1 the consumption equation is estimated and found to satisfy the permanent income hypothesis of Friedman (1957). In section 2 the investment function is found to satisfy the accelerations principle. In the model of Chow (1985) for China, the consumption function satisfies the permanent income hypothesis of Hall (1978) instead. Section 3 provides an explanation why the consumption functions of the two economies are different.

## 1. Estimation of the Consumption Function

The consumption and investment equations are estimated by the method of two- stage least squares, with data given in Table 1 and found in the Statistical Yearbook of the Republic of China, various issues. The three structural equations include (1) the national income identity Y = C + I + X, with Y, C, I and X denoting real GDP, consumption, investment and exports minus imports respectively; (2) a consumption function linear in C(t-1) and Y and (3) an investment function linear in Y, Y(t-1) and I(t-1). The endogenous variables are C, I and Y; the predetermined variables are X, Y(t-1), C(t-1) and I(t-1).

In the first stage, Y* is estimated by regressing Y on the predetermined variables using 60 annual observations from 1951 to 2010 to yield:

$$Y^*_t = 88802.5(39053.3) + 1.354(.223)Y_{t-1} - .2584(.2552)\, C_{t-1} - .5116(.2290)\, I_{t-1} - .2470(.2067)\, X_t$$

$$R^2 = 0.9979;\ s = 2.0e{+}05 \qquad (1)$$

The number in parentheses after each coefficient is its standard error. In the second stage of two-stage least squares I have estimated the consumption function

$$C_t = 24106.1(17986.2) + .641(.0892)\, C_{t-1} + .2756(.0621)\, Y^*_t \quad R^2 = 0.9992;\ s = 88650 \qquad (2)$$

Note that the coefficient of Y* is significant, contradicting the permanent income hypothesis of Hall (1978) which states that the consumption function is a random walk with drift. Equation (2) is consistent with Friedman's permanent income hypothesis as shown below.

The consumption function of Friedman (1957) states that consumption C is proportional to permanent income, $C = a\, Y_p$ where permanent income is determined by adaptive expectations as follows:

$Y_p = bY(t) +(1-b)Y_p(t-1) = bY(t) + b(1-b)Y(t-1) + b(1-b)^2Y(t-2)+ ...$

Under adaptive expectations permanent income is a weighted mean of current income Y and permanent income of the preceding period with weights b and (1-b) respectively. By repeated substitutions of lagged Y's for lagged $Y_p$ backward in time $Y_p$ equals to the right-hand side of the above equation. When this expression is substituted into consumption function we obtain

$C_t = a [bY_t + b(1-b)Y_{t-1} + b(1-b)^2Y_{t-2} + ...]$

$C_{t-1} = a [bY_{t-1} + b(1-b)Y_{t-2} + b(1-b)^2Y_{t-3} + ...]$

which imply

$C_t = abY_t + (1-b)C_{t-1}$

From our estimated equation (2), ab = .2756 1-b = .6410 or b = .3590 and a = .2756/.3590 = .7677. The estimate .7677 for a, the fraction of national income devoted to consumption, is reasonable.

According to the permanent income hypothesis of Hall (1978), the coefficient of $C_{t-1}$ equals 1 and the coefficient of Y* should be zero. This hypothesis was confirmed by Chow (1985, 2010, 2011). Section 3 will explain why the data for Taiwan and for China support different versions of the permanent income hypothesis.

## 2. Estimation of the Investment function

When the investment function is estimated by using both current and lagged income, I find the coefficient of the latter to be negative and of the same order of magnitude as the coefficient of current income, thus confirming the accelerations principle.

$$I_t = -232841.6(57266.5) + 3.1415(.546)\ Y^*_t -3.3446(.6046)\ Y_{t-1} + 1.3971(.2015)\ I_{t-1} \qquad (3)$$

$R^2$= 0.9793; s =1.4e+05

When the variables Y* and $Y_{t-1}$ are replaced by their difference the result is excellent:

$$I_t = -81570.96(34760.8) + 1.5471(.2389)(Y^*_t - Y_{t-1}) + .7666(.0441)\ I_{t-1}$$

$$R^2 = 0.9755;\ s = 1.5e+0 \qquad (4)$$

In conclusion, data for Taiwan support Friedman's permanent income hypothesis for consumption and the accelerations principle for investment.

## 3. Why data for Taiwan and China support two versions of the permanent income hypotheses

To explain why data for China support Hall's permanent income hypothesis and data for Taiwan support Friedman's version I begin with a restatement of Friedman's permanent income hypothesis. Friedman estimated permanent income $Y_p(t)$ as a variable to explain consumption by the partial adjustment mechanism

$$Y_p(t) - Y_p(t\text{-}1) = b(Y(t) - Y_p(t\text{-}1)) \qquad (5)$$

After observing Y(t) consumers in Taiwan would change their estimate of $Y_p(t)$ by a fraction b of the difference $Y(t) - Y_p(t\text{-}1)$ whereas the consumers in China would not. The latter followed the permanent income hypothesis of Hall (1978). Their permanent income in t-1 was proportional to C(t-1) by assumption of the permanent income hypothesis. Hence no other data than $C_{t-1}$ that were available in t-1 would be useful in estimating $Y_p(t\text{-}1)$, or in estimating $C_t$. The reason is $C_t = a\,Y_p(t) + u(t)$ by assumption and if only data up to t-1 are available the best estimate of $Y_p(t)$ is $Y_p(t\text{-}1)$ plus some trend and $Y(t\text{-}1) = C(t\text{-}1)/a$. Hence by the permanent income hypothesis of Hall (1978)

$$C(t) = a\,Y_p(t) + u(t) = a[Y_p(t\text{-}1) + \text{trend}] + u(t) = C(t\text{-}1) + \text{const} + u(t) \qquad (6)$$

If the consumers in Taiwan followed Friedman's permanent income hypothesis, they must allow current income Y(t) to influence their estimate of $Y_p(t)$ by equation (5). If only data up to t-1 are available they would allow Y(t-1) to influence their estimate of $Y_p(t\text{-}1)$ while the Hall consumers in China using only C(t-1) to estimate $Y_p(t\text{-}1)$ would not. For the Taiwan consumers to follow (5) data on Y(t) must be informative of their $Y_p(t)$ which determines C(t). This will happen if movement in past Y(t-k) affects movement of current Y(t) substantially. This sufficient condition for the behavior of the Taiwan consumers can be test statistically.

To find out whether movement of past Y(t-k) in Taiwan did affect Y(t), more so than movement of past Y(t-k) affected Y(t) in China, I perform a regression of $\Delta\log Y(t)$ on $\Delta\log Y(t\text{-}1)$ using Taiwan data and expect it to have more predictive power than the corresponding regression using data for China. Data on real GDP of China from 1952 to 2008 are taken from the last column of Table 1 of Chow and Wang (2010). The regressions for Taiwan and China are given in equations (7) and (8) respectively.

$$\Delta\log Y(t) = 0.3953(.1219)\,\Delta\log Y(t\text{-}1) + 0.0431(.0095) \qquad R^2 = 0.1581 \quad s = .02901 \qquad (7)$$

$$\Delta\log Y(t) = 0.3313(.1290)\,\Delta\log Y(t\text{-}1) + 0.0506(.0146) \qquad R^2 = 0.1106 \quad s = .07955 \qquad (8)$$

The observations for Taiwan using data given in Table 1 of this paper cover the period 1951-2010 while the observations for China cover almost the same period 1952-2008. Regression (7) has a standard error of only .029 for the explanation of the change in log income, while

regression (8) has a much larger standard error of .080. The relative magnitudes of these two standard errors confirm our theory for explaining why data for Taiwan support Friedman's version of the permanent income hypothesis and data for China support the Hall version. Changes in real income in Taiwan have been more predictable than in China, leading the Taiwan consumers to use current income to estimate permanent income as specified by the Friedman theory of permanent income to a larger extent than consumers in China.

Table 1 National income and its determinants

| Year | *Y* | *C* | *I* | *X* | *P* |
|---|---|---|---|---|---|
| 1951 | 12,648 | 11,448 | 1,779 | -579 | 0.062509 |
| 1952 | 17,623 | 16,031 | 2,645 | -1,053 | 0.077864 |
| 1953 | 23,422 | 21,378 | 3,230 | -1,186 | 0.094195 |
| 1954 | 25,746 | 23,804 | 4,049 | -2,107 | 0.094158 |
| 1955 | 30,685 | 27,973 | 4,007 | -1,295 | 0.104062 |
| 1956 | 35,194 | 32,015 | 5,538 | -2,359 | 0.113344 |
| 1957 | 41,096 | 36,778 | 6,374 | -2,056 | 0.123385 |
| 1958 | 45,990 | 41,356 | 7,500 | -2,866 | 0.129279 |
| 1959 | 52,980 | 47,463 | 9,798 | -4,281 | 0.137805 |
| 1960 | 63,765 | 55,775 | 12,692 | -4,702 | 0.155144 |
| 1961 | 71,389 | 62,301 | 14,053 | -4,965 | 0.163373 |
| 1962 | 78,539 | 68,857 | 13,799 | -4,117 | 0.166356 |
| 1963 | 88,714 | 73,684 | 16,029 | -999 | 0.17112 |
| 1964 | 103,488 | 83,535 | 19,178 | 775 | 0.1789 |
| 1965 | 114,359 | 92,080 | 25,652 | -3,373 | 0.178373 |
| 1966 | 127,675 | 100,479 | 26,847 | 349 | 0.183162 |
| 1967 | 147,463 | 114,465 | 35,983 | -2,985 | 0.191634 |
| 1968 | 171,817 | 133,885 | 42,764 | -4,832 | 0.204854 |
| 1969 | 199,154 | 152,132 | 48,446 | -1,424 | 0.218498 |
| 1970 | 229,390 | 171,357 | 58,147 | -114 | 0.227555 |
| 1971 | 266,594 | 190,672 | 69,434 | 6,488 | 0.235144 |
| 1972 | 319,573 | 218,305 | 81,525 | 19,743 | 0.249091 |
| 1973 | 415,111 | 273,396 | 119,951 | 21,764 | 0.289386 |
| 1974 | 556,303 | 382,744 | 216,142 | -42,583 | 0.380713 |
| 1975 | 597,660 | 436,800 | 180,166 | -19,306 | 0.388076 |
| 1976 | 717,089 | 484,156 | 217,671 | 15,262 | 0.410566 |
| 1977 | 840,846 | 565,639 | 234,791 | 40,416 | 0.434084 |
| 1978 | 1,006,669 | 661,357 | 281,356 | 63,956 | 0.457755 |
| 1979 | 1,215,395 | 806,709 | 395,167 | 13,519 | 0.511518 |
| 1980 | 1,519,946 | 1,031,759 | 505,941 | -17,754 | 0.596064 |
| 1981 | 1,810,829 | 1,241,979 | 532,633 | 36,217 | 0.667253 |
| 1982 | 1,941,169 | 1,353,111 | 490,261 | 97,797 | 0.687827 |
| 1983 | 2,168,143 | 1,455,987 | 530,731 | 181,425 | 0.709156 |
| 1984 | 2,414,377 | 1,598,490 | 562,150 | 253,737 | 0.721762 |
| 1985 | 2,517,129 | 1,698,270 | 489,140 | 329,719 | 0.722689 |
| 1986 | 2,943,997 | 1,819,992 | 572,782 | 551,223 | 0.760052 |
| 1987 | 3,291,857 | 2,041,083 | 729,921 | 520,853 | 0.76811 |
| 1988 | 3,488,550 | 2,342,933 | 896,435 | 249,182 | 0.77068 |
| 1989 | 4,003,227 | 2,767,709 | 979,185 | 256,333 | 0.802327 |
| 1990 | 4,430,055 | 3,158,157 | 1,079,424 | 192,474 | 0.83074 |
| 1991 | 4,958,220 | 3,539,428 | 1,224,332 | 194,460 | 0.861753 |

| | | | | | |
|---|---|---|---|---|---|
| 1992 | 5,534,544 | 3,959,262 | 1,484,942 | 90,340 | 0.895015 |
| 1993 | 6,110,101 | 4,349,807 | 1,666,512 | 93,782 | 0.925972 |
| 1994 | 6,685,505 | 4,804,963 | 1,775,141 | 105,401 | 0.942348 |
| 1995 | 7,277,545 | 5,224,116 | 1,942,245 | 111,184 | 0.96456 |
| 1996 | 7,906,075 | 5,752,700 | 1,894,666 | 258,709 | 0.992996 |
| 1997 | 8,574,784 | 6,247,746 | 2,150,484 | 176,554 | 1.021137 |
| 1998 | 9,204,174 | 6,715,974 | 2,392,515 | 95,685 | 1.059502 |
| 1999 | 9,649,049 | 6,997,578 | 2,409,154 | 242,317 | 1.04804 |
| 2000 | 10,187,394 | 7,350,642 | 2,615,640 | 221,112 | 1.045662 |
| 2001 | 9,930,387 | 7,419,027 | 1,970,319 | 541,041 | 1.036067 |
| 2002 | 10,411,639 | 7,650,020 | 2,013,786 | 747,833 | 1.031712 |
| 2003 | 10,696,257 | 7,815,029 | 2,129,586 | 751,642 | 1.02207 |
| 2004 | 11,365,292 | 8,253,254 | 2,693,089 | 418,949 | 1.023056 |
| 2005 | 11,740,279 | 8,553,973 | 2,667,855 | 518,451 | 1.010564 |
| 2006 | 12,243,471 | 8,717,640 | 2,776,953 | 748,878 | 1 |
| 2007 | 12,910,511 | 9,027,569 | 2,855,809 | 1,027,133 | 0.995462 |
| 2008 | 12,620,150 | 9,173,629 | 2,826,311 | 620,210 | 0.967407 |
| 2009 | 12,477,182 | 9,197,343 | 2,203,436 | 1,076,403 | 0.975514 |
| 2010 | 13,603,477 | 9,555,488 | 3,077,335 | 970,654 | 0.959713 |

Source: *Statistical Yearbook of the Republic of China*. Taipei, Taiwan: Bureau of Accounting and Statistics, various issues.

**References**


Chow, Gregory C., 1985. "A model of Chinese national income determination." *Journal of Political Economy*, 93, 782–792.

Chow, Gregory C., 2010. "Note on a model of Chinese national income determination." *Economics Letters* 106, 195-196.

Chow, Gregory C., 2011. "Lessons from studying a simple macro-model for China." *Economics Letters*, 112, 233-235.

Chow, Gregory C. and Peng Wang, 2010. "The empirics of inflation in China." *Economics Letters*, 109, 28-30.

Friedman, Milton, 1957. *A Theory of the Consumption Function*. Princeton, NJ: Princeton University Press.

Hall, Robert E., 1978. "Stochastic implications of the life-cycle-permanent income hypothesis: theory and evidence." *Journal of Political Economy* 86, 971–987.

*Statistical Yearbook of the Republic of China*. Bureau of Accounting and Statistics, Republic of China, Taiwan.