

A MODEL OF CHINESE NATIONAL
INCOME DETERMINATION

Gregory C. Chow^{*}
Princeton University

Econometric Research Program
Research Memorandum No. 309

October 1983

* I would like to acknowledge financial support from the
National Science Foundation.

ECONOMETRIC RESEARCH PROGRAM
Princeton University
207 Dickinson Hall
Princeton, New Jersey

A MODEL OF CHINESE NATIONAL INCOME DETERMINATION

Gregory C. Chow*

Since the establishment of the People's Republic of China in 1949, the national income of China was subject to two downswings. One occurred in 1960-1962 as a result of the economic failure of the Great Leap Forward movement which began in 1958. The second occurred in 1967-1968 and may be attributed to the economic disruptions of the Cultural Revolution. Most observers, including this author, agree that political factors have contributed to the explanation of national income and output in China. However, it is the main thesis of this paper that, in spite of the influence of political forces, there are basic economic laws at work which can explain to a large extent the fluctuations and growth of national income in China from 1953 to 1981. Specifically, a model explaining the two major components of Chinese national income, consumption and capital accumulation, through the multiplier-accelerator mechanism is capable of explaining Chinese data very well.

I. A MULTIPLIER-ACCELERATOR MODEL

Economists are familiar with multiplier-accelerator models the significance of which was pointed out by Samuelson (1939). The particular version used in this paper has been estimated empirically using United States data and studied analytically by the present author (1967, 1968). It can be derived from a discrete version of the Harrod-Domar model of economic growth by introducing simple distributed lags (see Harrod, 1948, and Domar, 1957). Let Y_t , C_t , and I_t denote respectively national income, consumption, and investment in year t , all in constant dollars. The Harrod-Domar model consists of two equations. The savings function explains aggregate savings $S_t = Y_t - C_t$ as a fraction σ of national income,

$$(1) \quad S_t = Y_t - C_t = \sigma Y_t$$

implying the consumption function

$$(2) \quad C_t = (1-\sigma)Y_t = \gamma Y_t.$$

Secondly, the ratio of capital stock K_t to output Y_t is assumed to be a constant,

$$(3) \quad K_t = \alpha Y_t.$$

The multiplier-accelerator model used in this paper is derived from equations (2) and (3) by introducing simple distributed lags. Equations (2) and (3) are replaced respectively by

$$(4) \quad C_t = \gamma_0 + \gamma_1 Y_t + \gamma_2 C_{t-1}$$

$$(5) \quad K_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 K_{t-1}.$$

Equation (5) is converted to an investment function by using the identity $I_t = \Delta K_t = (K_t - K_{t-1})$, where I_t stands for net investment, and by first differencing

$$(6) \quad I_t = \alpha_1 \Delta Y_t + \alpha_2 I_{t-1}.$$

The resulting multiplier-accelerator model consists of equations (4) and (6), and the identity

$$(7) \quad Y_t = C_t + I_t.$$

It is the purpose of this paper to examine the empirical validity of this model using Chinese data.

II. CHINESE NATIONAL INCOME DATA

Official Chinese national income data are provided by the State Statistical Bureau of the State Council of the Chinese government in its publications Almanac of China's Economy 1981, 1982, and Statistical Yearbook of China 1981 for selected years, including 1952, 1957, 1962, 1965, 1978-1981. Figures for these selected years are given in Table 1 in italics. Statistical Yearbook of China 1981, p. 509, defines national income, consumption and capital accumulation as follows.

"The term national income used in this Yearbook refers to the sum total of net output, in value terms, created during a year in the following material production sectors: industry, agriculture, construction, transportation and commerce (the catering trades and material supplies and marketing enterprises included)....

"Through the process of distribution and redistribution, the available portion of the national income is further broken down into two parts: the consumption fund and the accumulation fund.

"Consumption fund is that part of the national income represented by expenditure by individuals as private consumption and that by the public as public consumption. Its material formation is the total expenditure on consumer goods by individuals and the public plus the wear and tear of non-productive fixed assets, including residential houses, during a year.

"Accumulation is that part of the national income which is used for expanded reproduction, non-productive construction and increase of productive and non-productive stock. Its material formation is the newly added fixed assets of material and non-material sectors (less depreciation of the total fixed assets) and the newly acquired circulating fund in kind by the material sectors during the year."

To obtain national income in the other years, I have accumulated the increments of national income provided by Zhang (1981, p. 727), beginning with the 1957 figure of 90.8 and going forward and backward. (The increment of 12.0 billion for 1953 provided by Zhang appears to be too large and is not used in our

interpolations backward from 1957 to 1953, leaving the figure 58.9 for 1952 intact. The results of these interpolations agree with the figures for the selected years given in Table 1 in italics.) These national income data are given in column 1 of Table 1. The corresponding data on capital accumulation can be found in Zhang (1981, p. 727) and are given in column 2 of Table 1. Consumption is the difference between national income and capital accumulation.

It is interesting to note the fluctuations in national income, particularly the decreases in the years 1960-1962 and 1967-1968. These data are in current prices whereas the model of section I was formulated for variables in constant prices. To find an appropriate price deflator is a difficult problem which has not been resolved in this paper. Chow (1984, Chapter 6) contains a discussion of Chinese national income in constant prices, but does not provide annual figures. The Chinese State Statistical Bureau gives data on Chinese national income in 1952 prices for selected years, but the use of 1980 prices instead would make a very great difference in the resulting series, as discussed in Chow (1984, Chapter 6). For the purpose of this paper we reformulate all the equations in section I in money terms in order to analyze the available data given in Table 1. To the extent that there was inflation in China, part of the high correlations found can be attributed to the covariations among the variables as a result of inflation. According to Statistical Yearbook of China 1981 (pp. 411-412) the general retail price index, with 1950=100, was 111.8 in 1952, the first year of our sample, and was increased only to 150.4 in 1981, the last year of our sample. The Statistical Yearbook (p. 20) also gives Chinese national income of 1981 in 1952 prices to be 309.4 billion yuan, as compared with 388.7 billion in current prices, implying a price change of 25.59 percent from 1952 to 1981. Thus the spurious correlations due to inflation were probably not serious.

III. STATISTICAL ANALYSIS

If the method of least squares is applied to estimate equations (4) and (6) in money terms using the 29 annual observations from 1953 to 1981 given in Table 1, the consumption function is

$$(8) \quad C_t = -.7323 + .2294 Y_t + .7261 C_{t-1} \quad R^2 = .9910$$

$$(2.8817) \quad (.0724) \quad (.1219) \quad s^2 = 35.299$$

where standard errors of the estimated coefficients are in parentheses and s^2 denotes the variance of regression residuals. Note that the intercept is very small as compared with its standard error. The two coefficients are very large as compared with their standard errors. The R^2 is also very high but this is to be expected when an endogenous variable is explained by its own lagged value.

The investment function is

$$(9) \quad I_t = 2.1744 + .7549(Y_t - Y_{t-1}) + .8496 I_{t-1} \quad R^2 = .9697$$

$$(2.0870) \quad (.0845) \quad (.0376) \quad s^2 = 35.170.$$

If we replace the variable ΔY_t by two separate variables Y_t and Y_{t-1} , the resulting investment function is

$$(10) \quad I_t = 1.0922 + .7359 Y_t - .7059 Y_{t-1} + .7755 I_{t-1} \quad R^2 = .9700$$

$$(2.9789) \quad (.0933) \quad (.1279) \quad (.1484) \quad s^2 = 36.190.$$

The freely estimated coefficient of Y_{t-1} is approximately the negative of the coefficient of Y_t , as implied by the acceleration principle.

To make sure that the acceleration principle does not work for the consumption equation, we regressed C_t on Y_t , Y_{t-1} and C_{t-1} and obtained

$$(11) \quad C_t = -1.0922 + .2641 Y_t - .0696 Y_{t-1} + .7755 C_{t-1} \quad R^2 = .9912$$

$$(2.9789) \quad (.0933) \quad (.1160) \quad (.1484) \quad s^2 = 36.190$$

which shows that the coefficient of lagged income is insignificantly different from zero. In fact, given identity (7), equation (11) can be deduced from equation (10). Let the negative of equation (10) be written as

$$(12) \quad -I_t = -a_0 - a_1 Y_t + a_2 Y_{t-1} - a_3 I_{t-1} .$$

By adding Y_t on both sides of (12) and substituting $Y_{t-1} - C_{t-1}$ for I_{t-1} on the right-hand side we obtain

$$(13) \quad C_t = -a_0 + (1-a_1)Y_t + (a_2-a_3)Y_{t-1} + a_3C_{t-1}$$

which is equation (10). Conversely, starting from the consumption function (11), we take its negative, add Y_t on both sides and substitute $Y_{t-1} - I_{t-1}$ for C_{t-1} to obtain the investment function (10). Therefore, given the identity (7), the investment and consumption functions (10) and (11) imply each other. If these two equations and (7) were used in a model to explain Y_t , C_t and I_t , the system would not have sufficient equations to determine the endogenous variables because these equations are linearly dependent. On the other hand, equations (7), (8) and (9) are linearly independent and can determine Y_t , C_t and I_t .

As we studied the forms of the consumption and investment equations using (10) and (11), we discovered that an investment equation of the form (12), with the coefficient of Y_{t-1} being the negative of the coefficient of Y_t as implied by the acceleration principle, can be derived from a consumption of the form (13) with the coefficient (a_2-a_3) of Y_{t-1} being zero, provided that the coefficient a_3 of C_{t-1} and the coefficient $(1-a_1)$ of Y_t sum to unity. If $a_3=a_2$ and $a_3 + (1-a_1) = 1$, we have $a_2=a_1$ in the investment equation (12). Conversely, a consumption function of the form (13) with the coefficient of Y_{t-1} equal to zero can be derived from the investment function (12), provided that the coefficient $-a_2$ of Y_{t-1} equals in absolute value to the coefficient a_3 of I_{t-1} . In spite of the above

algebraic relationships, however, economists believe that the consumption function and the investment function are two separate structural equations, one based on the relation between consumption and income and the other on the relation between capital stock and output. In a simplified Keynesian model involving equation (7) and a consumption function, an economist would not replace C_t in the consumption function by $Y_t - I_t$ and call the resulting equation an investment function. Investment has to be determined by a different equation for the system to be determinate. In the present model we cannot specify (12) as the investment function and (13) as the consumption function simultaneously because these two equations are indistinguishable or unidentifiable. The original equations (8) and (9) are identifiable. They impose the restrictions that the coefficient of Y_{t-1} in the consumption function is zero and that the coefficient of Y_{t-1} in the investment function equals the negative of the coefficient of Y_t (see Chow, 1983, on identification).

A serious objection to using equations (8) and (9) for a simple econometric model of the Chinese economy is that Y_t on the right-hand sides of these equations are endogenous and accordingly the method of least squares gives inconsistent estimates of the coefficients. This objection could be answered by pointing out that the small-sample properties of the least-squares estimates are not bad, especially when the residuals in the equations are small. To obtain consistent estimates, we have applied the method of two-stage least squares to estimate equations (4) and (6). In the first stage, Y_t is regressed on C_{t-1} and I_{t-1} to obtain the estimated \hat{Y}_t . The regressions obtained in the second stage are

$$(14) \quad C_t = -1.6138 + .1737 \hat{Y}_t + .8185 C_{t-1} \quad R^2 = .9883$$
$$(3.6808) \quad (.1322) \quad (.2224) \quad s^2 = 45.941$$

$$(15) \quad I_t = 1.7968 + .8580 (\hat{Y}_t - Y_{t-1}) + .8336 I_{t-1} \quad R^2 = .8956$$
$$(4.1005) \quad (.3976) \quad (.0901) \quad s^2 = 121.303$$

By substituting $C_t + I_t$ for Y_t on the right-hand sides of (14) and (15) and solving the resulting equations for C_t and I_t , we obtain the reduced-form equations. These reduced-form equations are identical with the reduced-form equations obtained by regressing C_t and I_t on C_{t-1} and I_{t-1} because each of the structural equations (14) and (15) is just identified. We can consider (14) and (15) as two simultaneous structural equations determining the two endogenous variables C_t and I_t by the predetermined variables C_{t-1} and I_{t-1} . Equation (14) is just identified because exactly one predetermined variable I_{t-1} is absent. Equation (15) is just identified because there is exactly one linear restriction on the coefficients, the coefficient of $C_t + I_t$ being the negative of the coefficient of $C_{t-1} + I_{t-1}$. Applying least squares to estimate the reduced-form equations for C_t and I_t we obtained

$$(16) \quad C_t = -2.6165 + 1.0349 C_{t-1} + .1338 I_{t-1} \quad R^2 = .9883$$
$$(3.3009) \quad (.0601) \quad (.1026) \quad s^2 = 45.941$$

$$(17) \quad I_t = -3.1549 + .2106 C_{t-1} + .6363 I_{t-1} \quad R^2 = .8956$$
$$(5.3637) \quad (.0976) \quad (.1667) \quad s^2 = 121.303$$

Note that the estimated values of C_t and I_t from these reduced-form equations are the same as those of the structural equations (14) and (15) because both equations are just identified. Accordingly R^2 and s^2 are the same as in (14) and (15).

It is interesting to examine the residuals of equations (16) and (17) to see how well these equations fit the data for 1960-1962 and 1967-1968. The actual values of C_t and I_t are shown in Table 2 together with the residuals which equal the actual minus the predicted values. Although national income began to decline slightly in 1960, both residuals of the consumption and investment equations are rather small, showing that the model can explain the data in 1960 well. For 1961 and 1962 the consumption equation fits the data well, but the investment equation

overestimates actual investment by very large amounts. Thus the model fails to predict the large reductions in investment resulting from the economic collapse of the Great Leap Forward. The data for consumption which show a continuing rise in 1960-1962 are questionable. We know that millions of people in China were starving during these years. Coale (1981, p. 89) estimates that in the years 1958-1961 there were over 16 million deaths in excess of the trend of deaths estimated from the death rates in the adjacent years 1957 and 1962. A first-person account of the starvation of this period can be found in Liang and Shapiro (1983, Chapter 2). Since prices did not increase significantly in 1960-1962, it is doubtful that consumption in money terms could have kept on increasing during this period. 1963 is known to be a year of improved consumption and yet recorded consumption was slightly lower in 1963 than in 1962. It is recognized by economists in China that in the years 1960-1962 when there was strong political pressure to fulfill unreasonable production targets, false statistical reporting was not uncommon. If the consumption data are really overestimates for these years, then the consumption equation of our model may be worse for these years than Table 2 suggests.

Another period of interest is 1967-1968 when actual investment turned out to be much less than estimated from the model. The consumption equation does well in 1967 but also overestimates in 1968. One may attribute the low investment and consumption figures to the disruption of the Cultural Revolution. In 1976 we have another year when actual consumption and investment were lower than estimated. In 1978 actual investment turned out to be much higher than predicted. That year was marked by very ambitious investment plans which had to be scaled down in 1979.

An examination of the residuals of consumption and investment shows that the model fails to predict these variables closely in years of political disruption, including 1960-1962, 1967-1968, and 1978. In these years the large residuals of the investment equation should be compared with the standard error of regression s of 11 billion yuan and even larger standard errors of prediction which incorporate

Table 2 - RESIDUALS OF CONSUMPTION AND INVESTMENT

Year	Consumption	$C_t - \hat{C}_t$	Investment	$I_t - \hat{I}_t$	$C_t - \tilde{C}_t$	$I_t - \tilde{I}_t$
1953	50.7	4.077	16.8	2.018	1.363	0.722
1954	51.9	-0.198	19.5	1.290	-2.695	-0.044
1955	56.9	3.199	18.5	-1.681	0.749	-3.176
1956	63.1	4.358	21.7	1.103	2.156	0.000
1957	67.5	1.914	23.3	-0.639	0.000	-1.641
1958	73.9	3.546	37.9	12.016	1.840	11.144
1959	66.4	-12.530	55.8	19.279	-13.988	17.527
1960	71.9	-1.663	50.1	3.769	-3.563	0.000
1961	80.1	1.607	19.5	-24.363	0.000	-27.299
1962	82.5	-0.384	9.9	-16.219	-1.461	-15.989
1963	81.7	-2.384	18.3	-2.216	-3.302	-1.004
1964	90.3	5.920	26.3	0.608	4.927	1.040
1965	102.2	7.850	36.5	3.907	7.241	4.168
1966	111.6	3.571	47.0	5.411	3.498	5.512
1967	118.3	-0.862	30.4	-19.849	-0.522	-20.087
1968	111.7	-12.174	29.8	-11.298	-11.437	-9.680
1969	126.0	9.036	35.7	-3.626	9.454	-2.360
1970	130.8	-1.752	61.8	15.708	-0.662	17.335
1971	139.8	-1.211	68.4	4.691	0.000	4.339
1972	149.2	-2.008	64.8	-5.004	-0.387	-5.380
1973	158.5	-1.954	74.1	4.607	0.141	5.120
1974	161.0	-10.322	74.1	-3.268	-7.815	-2.996
1975	167.5	-6.409	83.0	5.105	-3.780	5.530
1976	167.9	-13.927	75.6	-9.326	-11.019	-9.279
1977	182.7	1.450	83.2	2.898	4.408	3.614
1978	192.3	-5.283	108.7	20.446	-1.636	21.406
1979	218.9	7.971	116.1	9.599	11.975	8.927
1980	250.2	10.753	116.5	-0.310	16.022	0.000
1981	279.7	7.809	109.0	-14.655	14.600	-12.465

Note: \tilde{C}_t and \tilde{I}_t are estimated by minimum absolute deviations.

the errors of the regression coefficients. In spite of these large residuals, the model explains the Chinese consumption and investment data very well.

To avoid letting the large residuals generated by political events assert too much influence on our estimates, we have also estimated the reduced-form equations by minimizing the sum of absolute deviations of the residuals. The results are:

$$(18) \quad C_t = 2.2772 + .9862C_{t-1} + .1381I_{t-1}$$

$$(19) \quad I_t = -0.1823 + .1494C_{t-1} + .7233I_{t-1}$$

The regression coefficients of (18) and (19) are similar to the corresponding coefficients of (16) and (17). Furthermore the residuals of (18) and (19) as given in the last two columns of Table 2 are not very different from those obtained by least squares. Hence, the methods of least absolute deviations and least squares give similar results and our conclusions remain valid by either method of analysis.

A significant conclusion of this paper is that the multiplier-accelerator model which can explain national income of developed market economies is also applicable to a less developed planned economy like the Chinese economy. The reason is that the consumption and investment equations are based on the long-run constancy of the consumption-income and capital-output ratios modified by short-run adjustments to equilibrium via distributed lags. These basic relationships are found to transcend economic institutions. Political forces may lead to observed deviations from these relationships in isolated instances which can be individually examined, but the relationships hold for most observations. As a by-product, our study casts doubt on the Chinese official consumption data for the years 1960-1962.

FOOTNOTE

* I would like to thank Loretta Mester for performing the computations, and acknowledge financial support from the National Science Foundation.

REFERENCES

Chow, Gregory C., "Multiplier, Accelerator and Liquidity Preference in the Determination of National Income in the United States," The Review of Economics and Statistics, 49, February 1967, 1-15.

- _____, "The acceleration Principle and the Nature of Business Cycles," Quarterly Journal of Economics, 82, August 1968, 04-418.
- _____, Econometrics. Englewood Cliffs: McGraw-Hill Book Company, 1983.
- _____, The Chinese Economy. New York: Harper & Row, 1984.
- Coale, Ansley J., "Population Trends, Population Policy, and Population Studies in China," Population and Development Review, 7, March 1981, 85-97.
- Domar, Evsey D., Essays in the Theory of Economic Growth. New York: Oxford University Press, 1957.
- Harrod, Ray F., Toward a Dynamic Economics. London: Macmillan & Co., 1948.
- Liang, Heng and Judith Shapiro, Son of the Revolution. New York: Alfred A. Knopf, 1983.
- Samuelson, Paul A., "Interactions between the Multiplier Analysis and the Principle of Acceleration," The Review of Economic Statistics, 21, May 1939, 75-78.
- Zhang Shuguang, "Jingji Jiegou Bienhua de Jingji Xiaoguo Fenxi" (Analysis of the Economic Effects of Change in Economic Structure), in Ma Hong and Sun Shangqing, eds., Zhongguo Jingji Jiegou Wenti Yanjou (Studies in China's Economic Structural Problems), 2 volumes. Beijing: People's Publishing Society, 1981. 724-759.