Time Series Analysis of Aggregate Consumption in China

Baiding Hu and Michael McAleer
Department of Economics, University of Western Australia

Abstract: China's economic reforms have resulted in a significant rise in productivity and the removal of barriers to international trade. Much of the research on China has been preoccupied with issues relating to imports, exports and productivity. An analysis of the time paths of China's macroeconomic variables, such as final demand, has not received adequate attention in the literature. As China embraces the market economy, the short- and long-run relationships among macroeconomic variables will find their way into policy formulation at various levels of government. An investigation of such relationships leads to a time series analysis of macroeconomic variables. Final demand plays a predominant role in driving growth in China, as analysed in Hu and McAleer (2002). Using input-output tables consisting of six broad sectors of the Chinese economy, they decomposed the sources of sectoral output growth for the five-year period from 1992 to 1997, and found that the increase in final demand was the most significant factor determining output growth in all sectors. However, the scarcity of input-output tables and the static nature of such models are not conducive for examining the dynamic behaviour of final demand. In this paper, annual national accounts data for China from 1952 to 1998 are used to examine the most important component of final demand, namely aggregate consumption. The paper estimates the short- and long-run relationships between the final demand component and GDP, and also tests the permanent income hypothesis. While the relatively small sample prevents an investigation of structural breaks in long-run equilibrium relationships, it allows an examination of the possible shifts in short-run dynamic behaviour for consumption.

Keywords: *Final demand, consumption, input-output tables, dynamic behaviour, unit roots, cointegration.*

1. Introduction

China's economic reforms that were launched in the late 1970s have led to an increase in productivity and the removal of barriers to international trade. Much of the research on China has been preoccupied with issues relating to imports, exports and productivity. An analysis of the time paths of China's macroeconomic variables, such as final demand, has not received adequate attention in the literature. In two empirical studies, Li (2000) examined whether annual data for China's GDP and its sectoral components from 1952 to 1998 were stationary, and Wu and Zhang (1998) investigated the time series behaviour of the US bilateral trade deficit with China. As China fully embraces the market economy, the short- and long-run relationships between macroeconomic variables will find their way into policy formulation at various levels of government. Investigation of such relationships leads to a time series analysis of macroeconomic variables.

Final demand plays a predominant role in driving growth in China, as analysed in Hu and McAleer (2002). Using input-output tables consisting of six broad sectors of the Chinese economy, they decomposed the sources of sectoral output growth for the five-year period from 1992 to 1997, and found that the increase in final demand was the most significant factor determining output growth in all sectors. However, the scarcity of input-output tables and the static nature of such models are not conducive to examining the dynamic behaviour of final demand. In this paper, annual national accounts data for China from 1952 to 1998 are used to examine the most important component of final demand, namely aggregate consumption. The paper estimates the short- and long-run relationships between this final demand component and GDP, and also tests the permanent income hypothesis. While the relatively small sample prevents an investigation of structural breaks in long-run equilibrium relationships, it nevertheless permits an examination of the possible shifts in short-run dynamic behaviour for consumption.

The plan of the paper is as follows. Section 2 describes the data used and provides unit root tests for the macroeconomic variables. Section 3 presents a cointegration analysis of the long-run relationships between the variables, and Section 4 examines the short-run dynamics of such relationships using the ECM. Some concluding remarks are given in Section 5.

2. Data and Unit Root Testing

All the data are collected from the China Statistical Yearbook published by the State Statistical Bureau (SSB). Aggregate consumption, aggregate investment and the balance of trade are the three components of final demand. Aggregate consumption is measured as final consumption expenditure (FCE) which, according to SSB, refers to expenditure on goods and services purchased both from domestic and international markets: FCE consists of household consumption expenditure (HCE) and government consumption expenditure (GCE).

Many aggregated macroeconomic time series variables are non-stationary, as evident in the empirical work of Nelson and Plosser (1982). As all the variables used in this paper are aggregated macroeconomic time series, it is necessary to test for stationarity using the ADF test, as follows:

$y_t = \alpha + \beta t + \rho y_{t-1} + \sum_{j=1}^{p-1} \phi_j \Delta y_{t-j} + \varepsilon_t$, where ρ is the autocorrelation coefficient and ε_t the white noise error. The length of the lag, p, is determined by the AIC, SBC and HQC model selection criteria that are reported in the Microfit econometric software package.

Table 1 presents the ADF tests of the variables, using the critical values for the test tabulated in MacKinnon (1991). In what follows, natural logarithms are denoted by ln. The ADF test statistics show that the levels of the variables exhibit non-stationarity, or I(1), as the null hypothesis of a unit root is not rejected, while the ADF tests of the first differences of the variables are stationary.

Li (2000) tested the null hypothesis of a unit root for China's GDP data. Prompted by political upheavals experienced in the PRC, Li cast doubt on a conclusion of unit roots. For example, it is widely acknowledged that the Great Cultural Revolution exerted a devastating impact on the Chinese economy. Using Perron's (1989) testing strategy associated with structural change, Li introduced structural breaks as a possible alternative to describe the time series properties of China's GDP. The outcomes of the Perron test supported such a description and led to the conclusion that China's GDP could be more appropriately modelled by a trend stationary process with structural breaks.

Table 1. ADF Tests of Unit Roots

Variables	Levels		First differences	
	ADF	Lag length	ADF	Lag length
$\ln GDP$	-0.4487	4	-5.3053	3
$\ln FCE$	-2.0199	1	-4.2026	1
$\ln HCE$	-1.5893	1	-3.6805	1
$\ln GCE$	-2.8702	1	-7.1660	3
5% Critical value	-3.5468			

Table 2. Johansen Cointegration Test and Estimation

Variables	H_0	H_1	Statistic	95% Critical value	Normalised cointegrating vector	Eigen values
$(\ln FCE_t, \ln GDP_t)$	$r=0$	$r=1$	34.60	18.33	(-1, 0.9705)	0.5365
	$r\le 1$	$r=2$	2.52	11.54		0.0544
$(\ln HCE_t, \ln GDP_t)$	$r=0$	$r=1$	32.58	18.33	(-1, 0.9973)	0.5152
	$r\le 1$	$r=2$	1.68	11.54		0.0366
$(\ln GCE_t, \ln GDP_t)$	$r=0$	$r=1$	19.00	18.33	(-1, 0.5960)	0.3444
	$r\le 1$	$r=2$	10.00	11.54		0.1993

Table 3. Estimated ECM coefficients (asymptotic t-ratios in parentheses)

ECM	Diagnostics
$\Delta \ln FCE_t = 0.0075 - 0.1636\ \hat{e}_{t-1}{}^{f} + 0.4775\,\Delta \ln GDP_t$ $(0.65)\quad(-2.58)\qquad(8.27)$	$R^2 = 0.62;\ DW = 1.81;$ $F = 34.59.$
$\Delta \ln HCE_t = -0.0305 - 0.1143\ \hat{e}_{t-1}{}^{h} + 0.3758\,\Delta \ln GDP_t$ $(-1.17)\quad(-2.69)\qquad(6.50)$	$R^2 = 0.52;\ DW = 1.55;$ $F = 23.06.$
$\Delta \ln GCE_t = 0.0334 - 0.0176\ \hat{e}_{t-1}{}^{g} + 0.8628\,\Delta \ln GDP_t$ $(0.67)\quad(-0.54)\qquad(5.73)$	$R^2 = 0.43;\ DW = 2.26;$ $F = 16.47.$

Table 4. Tests of Structural Change in Short-run Relationships

Coefficients	1952-1998	1952-1978	1979-1998	Chow test F(3,40, 0.05)=2.84
FCE				
Constant	0.0075	0.019072	-0.010085	2.933828
$\hat{e}_{t-1}$	-0.1636	-0.058932	-0.136512	
$\Delta \ln GDP$	0.4775	0.381649	0.800436	
R^2	0.62	0.55	0.81	
$e'e$	0.044108	0.02998	0.006170	
HCE				
Constant	-0.0305	0.051305	-0.069889	4.804776
$\hat{e}_{t-1}$	-0.1143	0.039328	-0.136618	
$\Delta \ln GDP$	0.3758	0.244949	0.718548	
R^2	0.52	0.43	0.72	
$e'e$	0.045723	0.02477	0.008841	
GCE				
Constant	0.0334	0.110675	0.232924	0.555143
$\hat{e}_{t-1}$	-0.0176	-0.084225	-0.132230	
$\Delta \ln GDP$	0.8628	0.809862	1.137681	
R^2	0.43	0.44	0.50	
$e'e$	0.305693	0.247447	0.046027	

However, Li (2000) failed to identify the Cultural Revolution as a structural break, which suggests a serious limitation in using such an approach to model macroeconomic time series data for China.

3. Cointegration and the ECM

It is hypothesised that there exist long-run relationships between aggregate consumption and GDP. There are three vectors of variables, namely $(\ln FCE_t, \ln GDP_t)$, $(\ln HCE_t, \ln GDP_t)$ and $(\ln GCE_t, \ln GDP_t)$, for which the corresponding cointegrating relationships are to be estimated. The Engle and Granger (1987) two-step procedure for estimating cointegrating vectors is known to have several important defects (Enders, 1995); specifically, whether the variables are cointegrated could depend on the choice of the dependent variable, and only one cointegrating vector is assumed to exist. Johansen's (1988) maximum likelihood estimator circumvents the use of the Engle-Granger two-step estimator in testing for the number of cointegrating vectors and in estimating the cointegrating vector. The Johansen procedure involves Full Information Maximum Likelihood estimation of a VAR(p) model that contains potentially cointegrated variables. In this paper, the lag order, p, of the

VAR model was determined by the AIC model selection criterion to be 2.

Table 2 presents the results from using the Johansen procedure for testing and estimation of cointegrating vectors. The first column lists the sets of variables for which there may exist a long-run relationship, and the second and third columns list, respectively, the null and alternative hypotheses regarding the number of cointegrating vectors, denoted by r . Johansen's LR test statistics calculated from the sample are given in column 4, and the corresponding 95% critical values are given in column 5. For the three pairs of variables, the hypotheses of no cointegrating relationship and of two cointegrating relationships are both rejected, leading to the conclusion that there is one cointegrating relationship, as given in the estimated cointegrating vector in column 6. The last column presents the eigen values on which Johansen's LR test statistics are calculated.

The cointegration regression actually represents the formulation of the absolute income hypothesis (AIH) due to Keynes (1936). AIH states that consumption is positively related to income, and rises proportionately lower than income. This means that the marginal propensity to consume (MPC) lies between 0 and 1. Furthermore, the short-run MPC is smaller than the long-run MPC. The cointegrating vectors for the three pairs of variables, namely $(\ln FCE_t, \ln GDP_t)$, $(\ln HCE_t, \ln GDP_t)$ and $(\ln GCE_t, \ln GDP_t)$, provide the estimates of the long-run MPC associated with the three different consumption-income relationships. These estimates can also be interpreted as income elasticities of consumption for the original data, namely the data prior to being transformed into logarithms. The cointegrating vector for $(\ln FCE_t, \ln GDP_t)$ characterises the relationship between final consumption expenditure and GDP, with a long-run MPC of 0.9705. The final consumption expenditure can be decomposed into two other components, namely household consumption expenditure and government consumption expenditure.

Government consumption responded differently to changes in GDP than did private consumption, and consequently exhibited starkly different long-run MPCs. The MPC associated with government consumption expenditure was significantly lower because public expenditure was estimated to be less sensitive to income constraints than was private expenditure. The estimated cointegrating vectors for the pairs of variables, namely $(\ln HCE_t, \ln GDP_t)$ and $(\ln GCE_t, \ln GDP_t)$, support this interpretation because the long-run MPC of the household consumption expenditure is 0.9973 while that of the government consumption expenditure is 0.596. All of the estimated MPCs are less than 1, which supports Keynes' AIH that the MPC is constrained to lie between 0 and 1. As the multiplier is inversely related to the MPC, expenditure from the household sector has a much greater impact on the economy than that from the government sector.

Engle and Granger (1987) modelled cointegrated variables with an ECM. The bivariate ECM is given by $\Delta y_t = \alpha + \beta \Delta x_t - \gamma \hat{e}_{t-1} + \varepsilon_t$, in which γ characterises the adjustment of y_t to the disequilibrium in the previous period, denoted by $\hat{e}_{t-1} (= y_{t-1} - \hat{\lambda} x_{t-1})$, and β and $\hat{\lambda}$ capture the short- and long-run relationships between x_t $(\ln GDP_t)$ and one of the three elements of y_t $(\ln FCE_t, \ln HCE_t, \ln GCE_t)$, respectively. The ECM formulations corresponding to the long-run relationships are presented in Table 3.

Modelling the relationship between income and consumption using the ECM is an improvement over the AIH specification. In view of the theoretical and empirical inadequacies of the simple Keynesian AIH, the life cycle and permanent income hypotheses were developed (Friedman, 1957). In estimating a consumption function using US quarterly data, Hall (1978) argued that treating income as exogenous in a consumption function severely distorted the estimated model, as argued in Haavelmo (1943) and Friedman and Becker (1957). Hall (1978) demonstrated that the conditional expectation of future marginal utility was solely a function of the current level of consumption. He suggested an alternative econometric approach to examine the life cycle-permanent income hypothesis, namely to model the time path of consumption as a random walk process in which current consumption depends only on its immediate past value. Davidson and Hendry (1981) showed that the UK aggregate consumption function estimated as an ECM (see Davidson et al. (1978)), contained Hall's random walk consumption function as a special case.

Chow (1985) derived an aggregated consumption function for China from the Harrod-Domer model, which assumes that consumption has a fraction of national income. Chow's consumption function was estimated as a simple distributed lag model, which specified current consumption as a function of consumption and investment in the previous period. However, as the t-ratio of the coefficient of the investment variable was insignificant, this also led to Hall's consumption specification which, as mentioned above, is a special case of the ECM.

The estimated short-run MPCs for the three consumption functions are given by the estimated coefficients of the short-run dynamics of GDP, namely 0.4775, 0.3758 and 0.8628 for final consumption expenditure, household consumption expenditure and government consumption expenditure, respectively. The short-run MPCs are clearly smaller than their long-run counterparts, reflecting another aspect of the AIH. As expected, the coefficient of the disequilibrium term is negative in all three consumption functions, showing that there is a force to restore disequilibrium in the previous period to equilibrium in the current period. However, in the government consumption expenditure equation, the estimate of γ is insignificant, albeit negative. Again, this illustrates that government consumption behaviour is not particularly sensitive to market forces. The signs of all the estimated coefficients are correct, and no serial autocorrelation was evident in any of the estimated equations.

4. Short-Run Structural Shifts

With the short-run dynamic behaviour of aggregate consumption depicted by the ECM, this section examines if the short-run behaviour has varied according to different regimes. This amounts to testing if there has been a structural break in short-run consumer behaviour using the Chow (1960) test.

Prior knowledge suggests a structural change after the 1978 economic reforms. In order to accommodate the full impact of the economic reforms, 1979 is used as the beginning of the post-reform period, so that the pre-reform and post-reform periods are 1952-1978 and 1979-1998, respectively.

Table 4 reports the results of testing for structural change for the three components of aggregate consumption. The figures at the intersection of the $\boldsymbol{e}'\boldsymbol{e}$ row and the column headed 1952-1998 represent the sum of squared residuals from the whole sample. Similarly, the figures at the intersection of the $\boldsymbol{e}'\boldsymbol{e}$ row and the columns headed 1952-1978 and 1979-1998 represent the sums of squared residuals from the two sub-samples, as indicated by their respective headings. As mentioned above, the Chow test statistic has an F(3, 40) distribution, with the test statistics presented in the last column. The short-run behaviour of the macroeconomic variables, as compared with their long-run counterparts, is much more responsive to market forces and shocks in the underlying economic fundamentals. At the 5% level of significance, with a critical value of 2.84, the null hypothesis of no structural change is rejected by the Chow test for two of the three short-run consumption specifications.

For household consumption expenditure, a unit increment in GDP growth led to a 0.25 unit increment in consumption expenditure growth during the pre-reform period. Such an outcome was indicative of a shortage of consumer goods and subdued consumption desire due to rationing. This figure increased to about 0.72 in the post-reform period, reflecting a sharp rise in the short-run MPC as greater economic affluence became available. Such an empirical observation is in accord with the consensus that the standard of living in China has been improving dramatically since the reforms.

A significant change has also been observed in the response of consumption expenditure to a disequilibrium in the previous year, which was characterised by the coefficient of $\hat{e}_{t-1}$. This figure changed from 0.04 in the pre-reform period to -0.14 in the post-reform period. As discussed previously, the existence of a stable long-run relationship between the variables necessitates a negative sign for the coefficient of $\hat{e}_{t-1}$, which is the case in the post-reform era. Under the rigid planned economy, whereby market forces were suppressed and economic laws were distorted, most Chinese households faced similar constraints on their budget and on the selection of consumer goods. This situation inevitably led to some aberrant consumer behaviour, which may explain the positive sign associated with the coefficient of $\hat{e}_{t-1}$ in the pre-reform period.

Government consumption expenditure is expected to behave differently from household consumption expenditure as the former is much less subject to budget constraints and market forces than is the latter. Therefore, changes in markets and economic systems as a consequence of the reforms may have negligible effects on the short-run behaviour of government consumption expenditure. The Chow test indicated that there was no structural change over the two sample periods in terms of the relationship between government consumption expenditure and growth in GDP, and the responsiveness to deviations from equilibrium.

5. Concluding Remarks

China's annual national accounts data from 1952 to 1998 were used to investigate the time series properties of aggregate consumption. The consumption time series were found to be non-stationary, or I(1). Consequently, cointegration identified the long-run relationships between three components of consumption and GDP, which amounted to estimating an AIH consumption function. Using the cointegrating relationships, the short-run dynamics of consumption were modelled with an ECM, reflecting the permanent income-life cycle hypothesis. Structural changes in the short-run relationships between consumption and income suggested that economic reforms have had significant impacts on short-run private consumption in China.

Acknowledgements

The first author wishes to acknowledge the financial support of a C.A. Vargovic Memorial Fund Award and an Individual Research Grant, Faculties of Economics & Commerce, Education and Law, University of Western Australia. The second author is most grateful to the Australian Research Council for financial support.

References

Chow, G. (1985), A Model of Chinese National Income Determination, Journal of Political Economy, 93(4), 782-792.

Chow, G. (1960), Tests of Equality Between Sets of Coefficients in Two Linear Regressions, Econometrica, 28, 591-605.

Davidson, J.E.H., D.F. Hendry, F. Srba, and S.J. Yeo (1978), Econometric Modelling of the Aggregate Time Series Relationship Between Consumers' Expenditure and Income in the U.K., Economic Journal, 88, 661-692.

Davidson, J.E.H. and D.F. Hendry (1981), Interpreting Econometric Evidence: The Behaviour of Consumers' Expenditure in the UK, European Economic Review, 16, 177-192.

Enders, W. (1995), Applied Econometric Time Series, Wiley, New York.

Engle, R.F. and C.W.J. Granger (1987), Cointegration and Error-correction: Representation, Estimation, and Testing, Econometrica, 55, 251-276.

Friedman, M. (1957), A Theory of the Consumption Function, NBER, New York.

Friedman, M. and G. Becker (1957), A Statistical Illusion in Judging Keynesian Models, Journal of Political Economy, 65, 64-75.

Haavelmo, T. (1943), The Statistical Implications of a System of Simultaneous Equations, Econometrica, 11, 1-12.

Hall, R.E. (1978), Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence, Journal of Political Economy, 86(6), 971-987.

Hu, B and M. McAleer (2002), Economic Growth and Industry Structure in China, to appear in Mathematics and Computers in Simulation.

Johansen, S. (1988), Statistical Analysis of Cointegration Vectors, Journal of Economic Dynamics & Control, 12 (2/3), 231-254.

Keynes, J.M. (1936), The General Theory of Employment, Interest and Money, McMillan, London.

Li, X.M. (2000), The Great Leap Forward, Economic Reforms, and the Unit Root Hypothesis: Testing for Breaking Trend Functions in China's GDP Data, Journal of Comparative Economics, 28 (4), 814-827.

MacKinnon, J.G. (1991), Critical Values for Cointegration Tests, in R.F. Engle and C.W.J. Granger (eds), Long-run Economic Relationships, Oxford University Press, Oxford.

Nelson, C.R. and C. Plosser (1982), Trends and Random Walks in Macroeconomic Time Series, Journal of Monetary Economics, 10, 139-162.

State Statistical Bureau, Statistical Yearbook of China (various issues), Statistical Publishing House of China, Beijing.

Wu, Y. and J. Zhang (1998), An Empirical Investigation on the Time-Series Behavior of the U.S.-China Trade Deficit, Journal of Asian Economics, 9 (3), 467-485.