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Working Paper No. 18/90

November 1990

DEPARTMENT OF ECONOMETRICS

ISSN 1032-3813

ISBN 0 86746 948 X

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ESTIMATING AGGREGATE CONSUMPTION FUNCTION USING RANDOM COEFFICIENT APPROACH : THE AUSTRALIAN CASE

by

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July 1989

ABSTRACT

We estimate a Friedman type consumption function incorporating varying coefficient approach to investigate the changing pattern of consumer responses in Australia using quarterly data from 1959IV to 1988IV. The methodology used was that of Hildreth and Houck (1968), Singh et al (1976) and Hoque (1988b). The Lagrange multiplier test conducted supports the hypothesis of randomness in the response coefficients, suggesting the use of a random coefficient technique rather than an OLS method in estimating our model. We also extended the model by considering separate treatment for both random and the systematic changes in the structural parameters. Our study clearly indicates a strong stickiness in consumer habits and the results also imply that the consumers tend to adapt to changes in income more and more quickly.

The author is grateful to Kim S. See for excellent computational assistance. He also thanks Professor Maxwell King and Grant Hillier for some helpful comments.

I. INTRODUCTION

As far as consumption studies in Australia are concerned, there are a number of empirical works that have generated useful results by considering a variety of explanatory variables. For example, Arndt and Cameron (1975), using annual data, have found a better fit between consumption and non-farm disposable income than between consumption and total disposable income.

Studies by Evans and Higgins (1972), Taylor (1975), Davy (1976) and Bonyhady and Caton (1976) have revealed that there is a significant negative relationship between consumption expenditure and price inflation. It has also been pointed out that liquid assets and interest rates have good explanatory power for the consumption expenditure as well.

For models where the underlying causal relationship involves the notion of permanent income and of habit persistence or inertia, we have studies by Smyth and McMahon (1972), Higgins and Fitzgerald (1973), Norton and Broadbent (1970) and Freebairn (1976). These studies have found that the inclusion of a lagged consumption variable improved the explanatory power of the consumption function significantly. However, all but one of the studies mentioned above[1] are based on the standard multiple regression model with constant coefficients which implies that the response of a unit change in the regressors to the dependent variable remains unchanged over observations.

The assumption of constancy of the coefficients seems rather restrictive and may be replaced by varying coefficient approach which could be useful and more realistic in applied economic research. For

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1 Freebairn (1976) is the only exception who performed two tests to see whether the parameters of the model are constant over the sample period. He found no evidence of significant variation in the true parameters of the quarterly model over the sample period considered.

example, we often approximate functional forms by linear equations and use aggregate data by assuming representative micro unit. In the case of consumption function, sometimes unobservable variables (for example, permanent income) appear in the model and hence some proxy variables are used instead. Also, the government policy variables affect both consumption expenditures and disposable income over time. All these factors are expected to cause some changes in the coefficients as time passes by. Moreover, consumers often react differently to external factors under different conditions of temporal, psychological or demographic variations. Differing reactions of this kind provide poor support for stable econometric relationships since a 'correct' equation under one set of conditions becomes 'incorrect' when the conditions change. In Australia, many of the early estimated relationships did not stand the test of time, and under rapidly changing conditions became unstable and untenable in any practical sense. This has led to a concentration on intuitive and ad hoc applications of consumer survey data (See McDonnell, 1985).

However, a great deal of attention has focussed recently on random coefficient models applying to different economic problems [for example, see Akkina (1974), Singh et al (1976), Hoque (1988) among others]. Despite some use of this technique in several countries, no study so far has been undertaken using Australian data. It is, therefore, the aim of this paper to provide an alternative estimation of the consumption function using random coefficient approach and then compare with the OLS approach.

Plan of the paper: We describe the model in section II. We consider both constant mean response (CMR) model and the variable mean response (VMR) model. Section III deals with the estimation procedure while the testing for a random coefficient model is discussed in section IV. Section V analyses the empirical results based on Tables 1 and 2. Section VI provides a conclusion. Finally, we present tables 3 through 12 to enable the readers to calculate the response coefficients for each observation.

II. THE MODEL

The major feature of the random coefficient model (RCM) is that it allows the coefficients of the explanatory variables to vary randomly over observations. Besides being a more sensible approach in utilizing available information, the RCM has the ability to capture the effects of omitted variables like tastes, attitudes and other qualitative variables. The present paper deals with two versions of the RCM. We will first consider the Hildreth-Houck (H-H) model where the actual response β_{it} is subject to a random fluctation that causes it to deviate from its average value or the mean response coefficient, $\bar{\beta}_i$ (for the i^{th} explanatory variable). Since we are using time series data, it is likely that some systematic variations may appear in the sample. For instance, the peak or the trough of a business cycle may indicate systematic fall or rise of some parameters. Hence, a more general approach in which the actual response coefficient fluctuates not only about the average value $\bar{\beta}_i$, but also around some trend, is examined. We shall call these models constant mean response (CMR) model and variable mean response (VMR) model respectively.

These approaches will be illustrated with Friedman's permanent income hypothesis where personal consumption expenditure is a function of personal disposable income and lagged personal consumption expenditure. That is,[2]

$$C_t = \beta_1 + \beta_2 Y_t + \beta_3 C_{t-1} \tag{1}$$

where Y_t = personal disposable income at time t

C_t = personal consumption expenditure at time t.

If it is assumed that permanent income is a weighted average of present and past values of measured income such that the weights decline geometrically according to

$$C_t = a + b_0 Y_t + b_1 Y_{t-1} + b_2 Y_{t-2} + \dots \tag{2}$$

where $b_i = (1 - \lambda)\lambda^i b$ and $0 < \lambda < 1$,

then a consumption function of the following form is obtained:

$$C_t = a(1 - \lambda) + (1 - \lambda)\, b\, Y_t + \lambda\, C_{t-1} \tag{3}$$

The short term marginal propensity to consume (MPC) is thus simply the coefficient of Y_t or $(1 - \lambda)b$ in the case of (3) where b is taken to be the long run MPC. Given all the estimates for the coefficients in (1), the long run MPC can be easily evaluated by taking the ratio $\beta_2/(1-\beta_3)$ where β_2 and β_3 are analogues of $(1 - \lambda)b$ and λ respectively.[3]

Now, let the random coefficient consumption function be

$$C_t = \beta_{1t} + \beta_{2t} Y_t + \beta_{3t}\, C_{t-1} \qquad t=2,\dots,T. \tag{4}$$

It can be observed from (4) that the actual responses vary across time and so do the intercept terms. Model (4) can also be written as

$$C_t = \sum_{i=1}^{3} \beta_{it}\, X_{it} \tag{5}$$

where X_{it} represents the ith explanatory variable. It should be noted X_{1t} is an $n \times 1$ vector of ones to represent the intercept term here.

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2 Disturbance term in equation (1) will be added later through random coefficients.

3 Equations (1) and (3) are observationally equivalent.

We exclude the disturbance term from (5) primarily for the sake of convenience. We recognise that while the inclusion of an additive disturbance term together with random intercept term creates an identification problem, its exclusion in some cases may amount to losing part of the structure of the model [see Amemiya (1971) and Akkina (1974)].

The number of coefficients to be estimated in the model is $3 \times n$ ($n = T-1$) but we have only n observations. Thus, straightforward estimation of (5) is not possible. We need certain assumptions regarding the distribution of the random coefficients before we proceed to estimate the model. We specify now these assumptions regarding CMR and VMR models.

A. <u>CMR Model</u>

We consider the following specification which says that the actual response coefficients are random but fluctuate around its mean value, that is,

$$\beta_{it} = \bar{\beta}_i + \varepsilon_{it} \tag{6}$$

where $\bar{\beta}_i$ is the mean response coefficient and ε_{it} is the usual random component (which serves as the disturbance term of the model), having the following properties:

$$E(\varepsilon_{it}) = 0 \; ; \; \mathrm{var}(\varepsilon_{it}) = \sigma^2_{ii}$$

$$E[\varepsilon_{it}, \varepsilon_{i't'}] = 0 \quad \text{for} \quad i \neq i', \; t \neq t'$$

and hence

$$E(\beta_{it}) = \bar{\beta}_i \qquad \text{and}$$

$$\mathrm{var}(\beta_{it}) = \mathrm{var}(\varepsilon_{it}) = \sigma^2_{ii} \tag{7}$$

This implies that the random coefficients β_{it} are independently and identically distributed with fixed means $\bar{\beta}_i$ and variance σ^2_{ii}. In this case, model (5) can be expressed as:

$$\begin{aligned} C_t &= \sum_{i=1}^{3} (\bar{\beta}_i + \varepsilon_{it})\, X_{it} \\ &= \Sigma\, \bar{\beta}_i\, X_{it} + W_t \end{aligned} \qquad (8)$$

where

$$W_t = \Sigma\, \varepsilon_{it}\, X_{it}$$

It can be easily verified that

$$\begin{aligned} E(W_t) &= 0 \qquad \text{for all } t \\ E(W_t, W_{t'}) &= \Sigma\, \sigma^2_{ii}\, X^2_{it} \quad \text{for} \quad t = t' \\ &= 0 \quad \text{for} \quad t \neq t'. \end{aligned}$$

Thus, CMR model reduces to a linear regression model with fixed coefficients and heteroscedastic errors.[4]

We note that one of the X's in our illustration is C_{t-1} which cannot be assumed non-stochastic. The problems associated with the use of a lagged dependent variable in time series models, namely the bias in and the inconsistency of the estimators are too well-known and too widely understood to need an elaboration here. However, it should be mentioned that the use of C_{t-1} in (8) may be free from such problems in the present case. To be more specific, the bias in and the inconsistency of the estimators in such models are dependent upon the autoregressive nature of the residual term and its relationship with the lagged dependent variable (see Griliches, 1961). But the disturbance terms W_t in (8) are clearly serially independent because ε_i's are so assumed. Further, Y_t and C_{t-1} are also assumed to be independent of ε's.

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4 One might notice that this is an example where heteroscedasticity is not exclusively a problem related to cross-section data.

B. VMR model

The actual response coefficients in this case are assumed to be

$$\beta_{it} = \bar{\beta}_i + \bar{\alpha}_i T + \varepsilon_{it} \tag{9}$$

where T is the calender time used to take into account those factors that affect β_{it} systematically. In a consumption function this might yield long run MPC greater than unity. Singh et al (1976) and we have found that this indeed is the case for certain observations which may be true of the modern consumer economy. However, even if one does not consider any version of random coefficient models, long run MPC might exceed unity as is evident from Tables 1 and 2 (the OLS results).

Now

$$E(\beta_{it}) = \bar{\beta}_i + \bar{\alpha}_i T \tag{10}$$

and the assumptions made for ε_{it} hold as well. These assumptions imply that the response coefficients fluctuate not only around a constant value but also around a trend component. Substituting (9) in (5) we get

$$\begin{aligned} C_t &= \sum_{i=1}^{3} (\bar{\beta}_i + \bar{\alpha}_i T + \varepsilon_{it}) X_{it} \\ &= \Sigma \bar{\beta}_i X_{it} + \Sigma \bar{\alpha}_i TX_{it} + W_t \end{aligned} \tag{11}$$

where

$$W_t = \Sigma \varepsilon_{it} X_{it}$$

It should be noted that the error structure for the VMR model is the same as that of CMR model. This simplifies the estimation problem as we shall see in the next section. The VMR model like the CMR reduces to a linear regression model with constant coefficients and heteroschedastic errors.

III. Estimation procedure

Equations (8) and (11) can be written in a general matrix notation as

$$C = Z\beta + W \tag{12}$$

where C and W are $n \times 1$ vectors, β is $k \times 1$ and Z is $n \times k$ of non-stochastic regressors, X_{it}. For the VMR model, we partition Z and β as

$$Z = [X\ X^*] \quad , \quad \beta = [\bar{\beta}\ \bar{\alpha}]'$$

where X and X* are $n \times k$ matrices of X_{it} and TX_{it} respectively with $\bar{\beta}$ and $\bar{\alpha}$ being the column vectors of coefficients for X_{it} and TX_{it} respectively.

Given the assumptions about ε_{it} in (7), the covariance matrix of W is a diagonal matrix given by

$$E(WW') = \text{diag}(d_{11}, d_{22}, \ldots d_{nn}) = D, \text{ let us say}$$

where

$$d_{ii} = \Sigma\, \sigma_{ii}^2 X_{it}^2 .$$

If σ_{ii}^2's and hence D were known, we could use Aitken's procedure to obtain

$$\hat{\beta} = (Z'D^{-1}Z)^{-1} Z' D^{-1}C \tag{13}$$

However, these variances are not known and we must estimate them. One way would be to find the LS residuals to get an initial estimate of the variances as follows:

$$\hat{W} = C - Zb = MC = MW \tag{14}$$

where $M = I - Z(Z'Z)^{-1}Z'$ is an $n \times n$ idempotent matrix and b is the OLS estimator of β. Next, we apply OLS technique to get the estimate of the variances[5] to the following model

$$\dot{\hat{W}} = \dot{M}\dot{Z}\dot{\sigma} + \eta = G\dot{\sigma} + \eta \tag{15}$$

where $\dot{W}$, $\dot{M}$, $\dot{Z}$ and $\dot{\sigma}$ are the squared elements of W, M, Z and σ_{ii} respectively and

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5 See Hoque (1989) for details.

$\eta = \hat{\dot{W}} - E(\hat{\dot{W}})$ is a vector of new disturbances.

Now, from (15)

$$\hat{\dot{\sigma}} = (G'G)^{-1}G'\hat{\dot{W}} \quad (16)$$

Finally, the operational GLS estimator of β is obtained by substituting the $\hat{\sigma}^2_{ii}$'s in D with their respective estimates from (16). Thus, the new estimator of β is

$$\tilde{\beta} = (Z'\hat{D}^{-1}Z)^{-1} Z' \hat{D}^{-1}C \quad (17)$$

where $\hat{D} = \text{diag}(\hat{d}_{11}, \hat{d}_{22}, \ldots \hat{d}_{nn})$

with $\hat{d}_{ii} = \Sigma \hat{\sigma}^2_{ii} X^2_{it}$.

Having estimated β_i's, the individual response coefficients can be obtained from the following[6]

$$\hat{\beta}_{it} = \tilde{\beta}_i + e_{it} \quad , \quad \text{for CMR model}$$

$$\hat{\beta}_{it} = \tilde{\beta}_i + \tilde{\alpha}_i T + e_{it}, \quad \text{for VMR model}$$

Estimates for e_{it} are obtained by applying Griffiths' (1972) method which gives

$$e_{it} = u_t x_{it} \hat{\sigma}^2_{ii} / \Sigma \hat{\sigma}^2_{ii} X^2_{it} \quad (18)$$

where

$$u_t = C_t - \Sigma \tilde{\beta}_i X_{it} \text{ , if CMR model}$$

$$= C_t - \Sigma \tilde{\beta}_i X_{it} - \Sigma \tilde{\alpha}_i TX_{it} \text{ , if VMR model.}$$

IV. Testing for randomness of the coefficients

To determine which model suits our present study best, we conduct the LM test reported in Breusch and Pagan (1979). This test amounts to testing for heteroscedasticity which is the central focus in random

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6 No empirical work using random coefficient model has reported the range and individual values for the actual response coefficients so far. We calculated and reported this to give a fair idea to the reader about the variation in coefficients. For example, Singh et al (1976) report only the mean and variance of the actual response coefficients.

coefficient technique. The effect of introducing stochastic variation in coefficients is that the errors in the reduced model become heteroscedastic. Thus, this test suits our purpose. Basically, we are testing the null hypothesis[7]

$$H_0: \sigma^2_{22} = \sigma^2_{33} = \ldots = \sigma^2_{kk} = 0$$

against the alternative that they are non-zeros.

The test turns out to be simply one-half of the explained sum of squares in the regression of $\dot{g}$ on $\dot{X}$ (we replace $\dot{X}$ by $\dot{Z}$ in VMR model), that is,

$$LM = 1/2\ \dot{g}'\ \dot{X}(\dot{X}'\dot{X})^{-1}\dot{X}'\dot{g} \ \sim\ \chi^2_{(k-1)} \tag{19}$$

where $\dot{g}$ is $n \times 1$ vector whose t^{th} element is given by

$$\dot{g}_t = (\hat{W}^2_t/\hat{\sigma}^2_{11} - 1).$$

This test statistic is distributed asymptotically as a χ^2 with k-1 degrees of freedom.[8] Our calculated LM values for the two consumption functions appear to be much higher than the tabulated values of χ^2 with k-1 degrees of freedom (88.62 for CMR model and 63.46 for VMR model). This suggests rejection of the hypothesis of zero variation in the estimated coefficients. Thus, the random coefficient model should be used to analyse the Australian consumption function.

V. Data and Results

The estimation of the above models are conducted using quarterly data over the period 1959IV - 1988IV obtained from the Australian Bureau of Statistics (ABS). The consumption functions have been estimated both

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7 Note that σ^2_{11} represents the variation in the model as a whole. Therefore, to test for variability of the coefficients, we need only test from σ^2_{22} to σ^2_{kk}.

8 See Hoque (1988a) for a simplified derivation of the test.

by OLS (fixed coefficient) and RC methods and the results are presented in Tables 1 (CMR model) and 2(VMR model). Both models yield very high value of R^2 (.9999) and the Durbin's h-statistic clearly does not indicate serial correlation. As can be seen from Table 1, all the coefficients (with the exception of the constant term in the OLS case) are significant at the 5% level. The mean response coefficients, whether estimated using the OLS or the RC method, appear not to be very different from one another in terms of their magnitude. However, the range of the actual response coefficients turns out to be quite substantial because of the large variation in the error component. This suggests the presence of randomness in the response coefficients. This is reinforced by significant LM value (at 1% level) and significant $\hat{\sigma}_{22}$ and $\hat{\sigma}_{33}$ values (at 5% level).

The results are quite interesting in the sense that they question the findings of existing Australian studies concerning fixity of the marginal propensity to consume. In fact, over the period of estimation the short run MPC is found to vary between .1196 and .2798. The more puzzling but rather interesting result is obtained in connection with long run MPC. The mean long run MPC is calculated to be 1.0178. No such result has been obtained before as far as past Australian studies on consumption function are concerned. The long run MPC varies between .404 and 2.516 during the sample period. However, this result supports Singh's (1976) in connection with Canada. Our results suggest that consumption expenditures might exceed current income for a number of observations in our sample period. Given the excellent credit facilities in a modern consumer economy which is growing, our results are not unexpected. Until recently, interest rates on borrowing such as housing mortgage rate and consumer credit rate did not have any dampening effect on consumption expenditures. Our preliminary regressions with interest rates as additional explanatory variables found them statistically insignificant which has also been found true in many empirical demand for money functions. It is the availability of credit that matters as well as the belief that the expected income will be higher. Both of these factors are true for the Australian consumers. This might explain the higher values of the long run MPC. The lower values may be explained by bad times like recession or absence of government welfare programme or lower MPC for the farm sector as reported by Smyth and McMahon (1972). As regards the mean long run MPC we expect that to be around unity which is normally obtained in the fixed coefficient regression model as can be checked from Table 1.

Regarding $\tilde{\beta}_3$ (coefficient of lagged consumption) we see that it dominates $\tilde{\beta}_2$ in size reflecting strong stickiness in consumer habits. This high dependence of current consumption on past consumption could be due to the introduction of wage-indexation in 1975 designed to stabilize the inflation rate and to the introduction of well-developed credit facilities. Moreover, the persistent nature of the government policy in controlling import and foreign exchange and tariff protection could have increased confidence among the public in maintaining standard of living. This would reinforce stickiness in consumer habits.

When the CMR model is extended to capture the influence of factors that may vary systematically with time, we find that the resulting model fits the data quite well.[9] A number of points are worth making in regard to the results obtained from this extended version. Firstly, as evident from Table 2, there are quite substantial variations in the

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9 It should be noted that the VMR model does not include an intercept term. Our initial estimate shows that this term is statistically insignificant. Its inclusion also leads to a poorer fit. However, the effect of this omission can be taken care of by the trend term included in the model.

error component of the VMR model and hence in the response coefficients. On the other hand, if we consider the statistically insignificant estimates of σ_{22} and σ_{33}, we may be tempted to conclude that there is no random character of the response coefficients in the model. But their joint significance is established by the LM value which is 63.462. Secondly, we note that $\tilde{\alpha}_1$ and $\tilde{\alpha}_2$ are not significant at the 5% level while $\tilde{\beta}_2$ and $\tilde{\beta}_3$ are. This suggests that the response coefficients of both income and lagged consumption fluctuate around a constant value rather than a trend which makes the simpler version (CMR model) more acceptable.

Despite the statistical insignificance of $\tilde{\alpha}$'s, the VMR model possesses some interesting implications. When the coefficients $\tilde{\alpha}_2$ and $\tilde{\alpha}_2$ are compared, it is apparent that they are very close to each other in magnitude but opposite in sign. There is the tendency for $\bar{\alpha}_{1t}$ to rise and $\bar{\alpha}_{2t}$ to fall. One possible interpretation is that the consumers may be gradually decreasing their dependence of current consumption on past consumption and tend to adapt to changes in income. We note that such a finding was obtained by Singh et al (1976) for Japan, Netherlands and U.K. This suggests that there has been structural change in the consumption pattern during the period under study, resulting in increasing dependence on current income. Structural shift in consumption behaviour may have been due, in part, to increasing industrialization with a consequently rising proportion of wage earners in population. On the other hand, there is also a strong evidence of stickiness which may be the result of bad performance of the economy from time to time in terms of recession, inflation, balance of payments difficulties, devaluation and so on. On the whole, the Australian consumers show both backward-looking and forward-looking tendency in their consumption pattern.

Table 1

The CMR Model

Estimates of Mean Response Coefficients and the Ranges for the Actual Response Coefficients and for the Error Component.

Coefficients	OLS Model	RC Model	Range for $\hat{\beta}_{it}$	Range for e_{it}
$\tilde{\beta}_1$	-25.7576	-28.9327*	-141.97 to 118.6	-113 to 147.5
	(-1.5684)	(-1.7609)		
$\tilde{\beta}_2$	.2025**	.1999**	.1196 to .2798	-.08 to .08
	(8.9624)	(8.8426)		
$\tilde{\beta}_3$	.8005**	.8036**	.7044 to .8888	-.099 to .099
	(31.9277)	(32.0379)		
$\hat{\sigma}_{22}$		-.000139*		
		(-1.7057)		
$\hat{\sigma}_{33}$		.000201*		
		(1.9956)		
$R^2 = .999$		h = .2817	LM = 88.6206	

A single star indicates significance at 5% level while a double star at 1% level. The figures in brackets are t values. Further, note that e_{it} displays remarkable symmetry in connection with $\tilde{\beta}_2$ and $\tilde{\beta}_3$.

Table 2

The VMR Model

Estimates of Mean Response Coefficients and the Ranges for the Actual Response Coefficients and for the Error Component.

Coefficients	OLS Model	RC Model	Range for $\hat{\beta}_{it}$	Range for e_{it}
$\tilde{\beta}_2$	.0755	.1752*	.1721 to .2370	-.00008 to .0004
	(.8097)	(1.7528)		
$\tilde{\beta}_3$	.9395**	.8254**	.7255 to .8405	-.0208 to .0284
	(8.5986)	(7.4052)		
$\tilde{\alpha}_1$	.00137	.00055		
	(1.2536)	(.496)		
$\hat{\alpha}_2$	-.00153	-.00053		
	(-1.2391)	(-.4184)		
$\hat{\sigma}_{22}$		-.000001		
		(-.0017)		
$\hat{\sigma}_{33}$		.00008		
		(.1008)		

R^2 = .9999 h = .7641 LM = 63.462

A single star indicates significance at 5% level while a double star at 1% level. The figures in brackets are t values.

VI. Conclusion

Although CMR model appears more sensible in terms of statistical significance and random variation in coefficients, the VMR model also indicates some interesting implications despite the lack of strong statistical significance. On the whole, the Australian consumers exhibit strong dependence on past consumption but this habit is gradually diminishing as consumers tend to adapt to changes in income more and more quickly. This is normal in a growing economy where old standard of living is replaced by a new one in a continual process. People always keep part of the old habits while adapt to new ones in the transition period in a technologically advanced industrialized country.

The fact that consumers are able to spend beyond their means with the help of loan finances should not be taken lightly. High interest rate alone cannot control aggregate demand (consumption being the major part of aggregate demand). The government policy must be directed towards inducing more savings by abolishing tax on interest income and by making real interest rate more attractive. This will increase savings especially private household savings and thus private consumption expenditure will decrease. Although the end of production is consumption, investment must also be a continuous process to maintain and augment consumption for future generations. Without savings this is not possible and the future generations will be presented with debt burdens only both national and international.

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Table 3: CMR Model

Estimates of e_{1t} for the period 1959IV - 1988IV

1	33.79918	40	5.02105	79	-64.61829
2	42.24775	41	23.42192	80	20.90054
3	35.05976	42	4.04700	81	-15.76163
4	10.12766	43	8.59883	82	79.62375
5	-11.15312	44	18.09074	83	-30.08413
6	-20.01367	45	24.77250	84	11.44675
7	-33.25308	46	-23.76343	85	6.68213
8	-12.62538	47	-9.88597	86	4.24746
9	5.67398	48	27.54114	87	32.97166
10	20.64013	49	-53.33640	88	37.84548
11	16.79062	50	-2.31868	89	-8.58528
12	-1.37404	51	-32.23813	90	8.40884
13	6.72727	52	-10.48565	91	59.05992
14	7.54849	53	-26.06797	92	7.52574
15	-0.11098	54	-32.55489	93	22.30850
16	25.26062	55	-11.86285	94	12.98525
17	-27.49999	56	-28.10324	95	-14.65616
18	-11.25729	57	26.21784	96	-10.01832
19	6.35195	58	-24.62669	97	9.89886
20	3.48047	59	19.80067	98	-9.56803
21	-6.27536	60	147.53584	99	-26.35378
22	-8.44237	61	-51.39723	100	-17.47275
23	-8.40386	62	42.95486	101	0.65015
24	-11.56148	63	40.16316	102	21.66310
25	-7.30558	64	28.23397	103	20.09355
26	-10.54044	65	-10.83999	104	18.09161
27	1.84875	66	42.99211	105	13.29179
28	-18.09817	67	27.29949	106	-20.29386
29	-14.66467	68	-113.03699	107	18.64076
30	4.95817	69	2.83130	108	7.05926
31	-25.30933	70	-75.95947	109	-2.24674
32	23.62238	71	-15.38796	110	-2.46434
33	17.61499	72	-53.90295	111	-6.62923
34	31.08604	73	-42.66204	112	14.59098
35	2.88830	74	-100.89952	113	-13.65300
36	-9.12710	75	98.48744	114	5.30793
37	8.28640	76	-37.17895	115	-13.72483
38	11.55790	77	-24.85216	116	-5.29127
39	-3.19862	78	-41.22344	117	-12.65387

Table 4: CMR Model

Estimates of e_{2t} for the period 1959IV - 1988IV

1	-0.00394	40	-0.00122	79	0.05975
2	-0.00500	41	-0.00581	80	-0.01928
3	-0.00436	42	-0.00104	81	0.01506
4	-0.00126	43	-0.00221	82	-0.07808
5	0.00144	44	-0.00472	83	0.03100
6	0.00255	45	-0.00690	84	-0.01213
7	0.00424	46	0.00691	85	-0.00736
8	0.00163	47	0.00292	86	-0.00471
9	-0.00073	48	-0.00840	87	-0.03819
10	-0.00273	49	0.01656	88	-0.04524
11	-0.00230	50	0.00073	89	0.01069
12	0.00019	51	0.01067	90	-0.01055
13	-0.00094	52	0.00356	91	-0.07704
14	-0.00108	53	0.00929	92	-0.01007
15	0.00002	54	0.01220	93	-0.03082
16	-0.00385	55	0.00463	94	-0.01832
17	0.00431	56	0.01172	95	0.02063
18	0.00176	57	-0.01124	96	0.01502
19	-0.00101	58	0.01104	97	-0.01511
20	-0.00057	59	-0.00921	98	0.01504
21	0.00106	60	-0.07434	99	0.04224
22	0.00144	61	0.02701	100	0.02846
23	0.00145	62	-0.02406	101	-0.00108
24	0.00200	63	-0.02303	102	-0.03682
25	0.00126	64	-0.01677	103	-0.03529
26	0.00189	65	0.00667	104	-0.03254
27	-0.00034	66	-0.02721	105	-0.02464
28	0.00345	67	-0.01794	106	0.03822
29	0.00285	68	0.07816	107	-0.03574
30	-0.00098	69	-0.00198	108	-0.01397
31	0.00511	70	0.05392	109	0.00452
32	-0.00473	71	0.01128	110	0.00506
33	-0.00359	72	0.04028	111	0.01423
34	-0.00642	73	0.03254	112	-0.03224
35	-0.00060	74	0.08002	113	0.03063
36	0.00201	75	-0.08028	114	-0.01245
37	-0.00189	76	0.03124	115	0.03237
38	-0.00269	77	0.02137	116	0.01284
39	0.00076	78	0.03713	117	0.03199

Table 5: <u>CMR Model</u>

Estimates of e_{3t} for the period 1959IV - 1988IV

1	0.00516	40	0.00156	79	-0.07410
2	0.00663	41	0.00747	80	0.02461
3	0.00566	42	0.00133	81	-0.01916
4	0.00168	43	0.00289	82	0.09936
5	-0.00188	44	0.00620	83	-0.03921
6	-0.00340	45	0.00869	84	0.01530
7	-0.00564	46	-0.00861	85	0.00923
8	-0.00213	47	-0.00367	86	0.00607
9	0.00097	48	0.01049	87	0.04840
10	0.00356	49	-0.02105	88	0.05760
11	0.00296	50	-0.00093	89	-0.01356
12	-0.00025	51	-0.01323	90	0.01366
13	0.00123	52	-0.00441	91	0.09863
14	0.00140	53	-0.01130	92	0.01310
15	-0.00002	54	-0.01457	93	0.03988
16	0.00485	55	-0.00550	94	0.02397
17	-0.00545	56	-0.01357	95	-0.02780
18	-0.00226	57	0.01325	96	-0.01921
19	0.00129	58	-0.01304	97	0.01948
20	0.00072	59	0.01093	98	-0.01939
21	-0.00134	60	0.08516	99	-0.05470
22	-0.00184	61	-0.03150	100	-0.03691
23	-0.00186	62	0.02750	101	0.00140
24	-0.00260	63	0.02714	102	0.04788
25	-0.00167	64	0.02001	103	0.04587
26	-0.00243	65	-0.00803	104	0.04264
27	0.00043	66	0.03314	105	0.03229
28	-0.00433	67	0.02196	106	-0.05074
29	-0.00358	68	-0.09460	107	0.04712
30	0.00124	69	0.00244	108	0.01839
31	-0.00647	70	-0.06782	109	-0.00600
32	0.00614	71	-0.01401	110	-0.00671
33	0.00470	72	-0.05065	111	-0.01842
34	0.00847	73	-0.04102	112	0.04150
35	0.00081	74	-0.09937	113	-0.04012
36	-0.00259	75	0.09905	114	0.01587
37	0.00239	76	-0.03918	115	-0.04233
38	0.00343	77	-0.02689	116	-0.01660
39	-0.00097	78	-0.04584	117	-0.04068

Table 6: CMR Model

Estimates of $\tilde{\beta}_{1t}$ for the period 1959IV - 1988IV

1	4.86645	40	-23.91169	79	-93.55102
2	13.31501	41	-5.51082	80	-8.03220
3	6.12702	42	-24.88573	81	-44.69437
4	-18.80508	43	-20.33390	82	50.69102
5	-40.08586	44	-10.84199	83	-59.01687
6	-48.94641	45	-4.16023	84	-17.48598
7	-62.18582	46	-52.69616	85	-22.25061
8	-41.55812	47	-38.81870	86	-24.68528
9	-23.25875	48	-1.39160	87	4.03893
10	-8.29261	49	-82.26914	88	8.91274
11	-12.14211	50	-31.25141	89	-37.51801
12	-30.30678	51	-61.17087	90	-20.52390
13	-22.20546	52	-39.41838	91	30.12718
14	-21.38425	53	-55.00071	92	-21.40699
15	-29.04371	54	-61.48763	93	-6.62424
16	-3.67212	55	-40.79559	94	-15.94749
17	-56.43273	56	-57.03598	95	-43.58889
18	-40.19003	57	-2.71490	96	-38.95105
19	-22.58078	58	-53.55942	97	-19.03388
20	-25.45227	59	-9.13206	98	-38.50076
21	-35.20809	60	118.60310	99	-55.28652
22	-37.37511	61	-80.32996	100	-46.40549
23	-37.33660	62	14.02213	101	-28.28258
24	-40.49421	63	11.23042	102	-7.26964
25	-36.23831	64	-0.69876	103	-8.83919
26	-39.47317	65	-39.77272	104	-10.84113
27	-27.08399	66	14.05937	105	-15.64095
28	-47.03091	67	-1.63325	106	-49.22659
29	-43.59740	68	-141.96972	107	-10.29197
30	-23.97456	69	-26.10144	108	-21.87348
31	-54.24207	70	-104.89221	109	-31.17948
32	-5.31036	71	-44.32069	110	-31.39708
33	-11.31774	72	-82.83569	111	-35.56197
34	2.15331	73	-71.59478	112	-14.34175
35	-26.04444	74	-129.83225	113	-42.58573
36	-38.05983	75	69.55470	114	-23.62481
37	-20.64633	76	-66.11169	115	-42.65757
38	-17.37483	77	-53.78490	116	-34.22401
39	-32.13136	78	-70.15617	117	-41.58661

Table 7: <u>CMR Model</u>

Estimates of $\tilde{\beta}_{2t}$ for the period 1959IV - 1988IV

1	0.19591	40	0.19864	79	0.25961
2	0.19486	41	0.19405	80	0.18058
3	0.19549	42	0.19882	81	0.21492
4	0.19860	43	0.19765	82	0.12178
5	0.20130	44	0.19514	83	0.23086
6	0.20240	45	0.19296	84	0.18773
7	0.20410	46	0.20677	85	0.19250
8	0.20149	47	0.20277	86	0.19514
9	0.19913	48	0.19146	87	0.16166
10	0.19713	49	0.21642	88	0.15461
11	0.19756	50	0.20059	89	0.21055
12	0.20005	51	0.21052	90	0.18931
13	0.19892	52	0.20341	91	0.12282
14	0.19878	53	0.20915	92	0.18979
15	0.19987	54	0.21206	93	0.16904
16	0.19601	55	0.20449	94	0.18154
17	0.20417	56	0.21158	95	0.22049
18	0.20161	57	0.18861	96	0.21488
19	0.19884	58	0.21089	97	0.18475
20	0.19928	59	0.19064	98	0.21489
21	0.20091	60	0.12552	99	0.24210
22	0.20130	61	0.22687	100	0.22832
23	0.20131	62	0.17580	101	0.19878
24	0.20186	63	0.17682	102	0.16304
25	0.20112	64	0.18309	103	0.16456
26	0.20175	65	0.20653	104	0.16732
27	0.19952	66	0.17265	105	0.17521
28	0.20331	67	0.18192	106	0.23808
29	0.20270	68	0.27802	107	0.16412
30	0.19888	69	0.19788	108	0.18589
31	0.20497	70	0.25378	109	0.20438
32	0.19513	71	0.21113	110	0.20491
33	0.19627	72	0.24014	111	0.21409
34	0.19344	73	0.23240	112	0.16762
35	0.19925	74	0.27988	113	0.23049
36	0.20187	75	0.11958	114	0.18741
37	0.19797	76	0.23109	115	0.23222
38	0.19717	77	0.22123	116	0.21270
39	0.20062	78	0.23699	117	0.23185

Table 8: CMR Model

Estimates of $\tilde{\beta}_{3t}$ for the period 1959IV - 1988IV

1	0.80876	40	0.80516	79	0.72949
2	0.81023	41	0.81106	80	0.82821
3	0.80926	42	0.80492	81	0.78443
4	0.80528	43	0.80648	82	0.90296
5	0.80172	44	0.80980	83	0.76439
6	0.80020	45	0.81228	84	0.81889
7	0.79795	46	0.79498	85	0.81282
8	0.80146	47	0.79992	86	0.80966
9	0.80456	48	0.81409	87	0.85199
10	0.80715	49	0.78255	88	0.86120
11	0.80655	50	0.80267	89	0.79004
12	0.80335	51	0.79036	90	0.81726
13	0.80482	52	0.79918	91	0.90222
14	0.80500	53	0.79229	92	0.81670
15	0.80357	54	0.78902	93	0.84348
16	0.80845	55	0.79809	94	0.82756
17	0.79814	56	0.79002	95	0.77579
18	0.80134	57	0.81684	96	0.78438
19	0.80489	58	0.79055	97	0.82308
20	0.80432	59	0.81452	98	0.78420
21	0.80226	60	0.88876	99	0.74889
22	0.80176	61	0.77209	100	0.76669
23	0.80173	62	0.83109	101	0.80500
24	0.80099	63	0.83073	102	0.85148
25	0.80193	64	0.82361	103	0.84947
26	0.80116	65	0.79556	104	0.84624
27	0.80403	66	0.83674	105	0.83589
28	0.79926	67	0.82555	106	0.75286
29	0.80001	68	0.70899	107	0.85072
30	0.80483	69	0.80603	108	0.82199
31	0.79713	70	0.73577	109	0.79759
32	0.80973	71	0.78959	110	0.79688
33	0.80829	72	0.75294	111	0.78518
34	0.81207	73	0.76257	112	0.84509
35	0.80440	74	0.70422	113	0.76347
36	0.80101	75	0.90265	114	0.81946
37	0.80599	76	0.76441	115	0.76126
38	0.80702	77	0.77670	116	0.78699
39	0.80262	78	0.75775	117	0.76292

Table 9 : VMR Model

Estimates of e_{1t} for the period 1959IV - 1988IV

1	-0.00019	40	-0.00002	79	0.00022
2	-0.00024	41	-0.00010	80	-0.00012
3	-0.00020	42	-0.00002	81	0.00005
4	-0.00002	43	-0.00004	82	-0.00041
5	0.00011	44	-0.00008	83	0.00013
6	0.00018	45	-0.00011	84	-0.00007
7	0.00026	46	0.00008	85	-0.00004
8	0.00012	47	0.00003	86	-0.00005
9	8.21797D-06	48	-0.00012	87	-0.00020
10	-0.00009	49	0.00020	88	-0.00024
11	-0.00007	50	-2.05186D-06	89	0.00004
12	0.00004	51	0.00011	90	-0.00008
13	-6.84982D-06	52	0.00003	91	-0.00042
14	-0.00001	53	0.00008	92	-0.00008
15	0.00003	54	0.00009	93	-0.00019
16	-0.00013	55	0.00002	94	-0.00013
17	0.00018	56	0.00006	95	0.00010
18	0.00009	57	-0.00009	96	0.00008
19	-0.00002	58	0.00005	97	-0.00010
20	-5.82594D-06	59	-0.00007	98	0.00008
21	0.00005	60	-0.00028	99	0.00025
22	0.00006	61	0.00009	100	0.00017
23	0.00006	62	-0.00007	101	-0.00001
24	0.00008	63	-0.00010	102	-0.00025
25	0.00006	64	-0.00009	103	-0.00024
26	0.00007	65	2.69504D-06	104	-0.00024
27	3.42553D-06	66	-0.00014	105	-0.00018
28	0.00010	67	-0.00010	106	0.00026
29	0.00008	68	0.00025	107	-0.00027
30	-0.00002	69	-0.00003	108	-0.00011
31	0.00013	70	0.00024	109	0.00002
32	-0.00011	71	0.00002	110	0.00003
33	-0.00008	72	0.00017	111	0.00014
34	-0.00014	73	0.00013	112	-0.00024
35	-5.27336D-06	74	0.00032	113	0.00027
36	0.00004	75	-0.00034	114	-0.00003
37	-0.00004	76	0.00012	115	0.00031
38	-0.00005	77	0.00008	116	0.00018
39	0.00001	78	0.00013	117	0.00056

Table 10: <u>VMR Model</u>

Estimates for e_{2t} for the period 1959IV - 1988IV

1	0.01306	40	0.00161	79	-0.01437
2	0.01673	41	0.00706	80	0.00819
3	0.01360	42	0.00147	81	-0.00347
4	0.00132	43	0.00277	82	0.02728
5	-0.00762	44	0.00556	83	-0.00843
6	-0.01228	45	0.00726	84	0.00472
7	-0.01831	46	-0.00556	85	0.00286
8	-0.00850	47	-0.00195	86	0.00322
9	-0.00057	48	0.00782	87	0.01315
10	0.00641	49	-0.01322	88	0.01613
11	0.00503	50	0.00014	89	-0.00271
12	-0.00305	51	-0.00712	90	0.00550
13	0.00047	52	-0.00173	91	0.02839
14	0.00102	53	-0.00507	92	0.00551
15	-0.00210	54	-0.00593	93	0.01315
16	0.00876	55	-0.00146	94	0.00914
17	-0.01182	56	-0.00375	95	-0.00704
18	-0.00584	57	0.00558	96	-0.00540
19	0.00116	58	-0.00314	97	0.00668
20	0.00039	59	0.00444	98	-0.00563
21	-0.00318	60	0.01657	99	-0.01722
22	-0.00399	61	-0.00524	100	-0.01175
23	-0.00398	62	0.00406	101	0.00091
24	-0.00533	63	0.00625	102	0.01709
25	-0.00396	64	0.00542	103	0.01649
26	-0.00461	65	-0.00017	104	0.01621
27	-0.00023	66	0.00903	105	0.01253
28	-0.00651	67	0.00655	106	-0.01783
29	-0.00527	68	-0.01611	107	0.01885
30	0.00125	69	0.00223	108	0.00776
31	-0.00853	70	-0.01576	109	-0.00133
32	0.00724	71	-0.00163	110	-0.00180
33	0.00522	72	-0.01108	111	-0.00964
34	0.00961	73	-0.00878	112	0.01596
35	0.00037	74	-0.02082	113	-0.01837
36	-0.00303	75	0.02175	114	0.00200
37	0.00254	76	-0.00781	115	-0.02116
38	0.00353	77	-0.00503	116	-0.01225
39	-0.00083	78	-0.00814	117	-0.03755

Table 11: VMR Model

Estimates of $\tilde{\beta}_{2t}$ for the period 1959IV - 1988IV

1	0.17207	40	0.19381	79	0.21563
2	0.17258	41	0.19428	80	0.21584
3	0.17317	42	0.19492	81	0.21656
4	0.17390	43	0.19545	82	0.21666
5	0.17459	44	0.19597	83	0.21774
6	0.17520	45	0.19649	84	0.21810
7	0.17584	46	0.19724	85	0.21868
8	0.17626	47	0.19773	86	0.21923
9	0.17670	48	0.19814	87	0.21963
10	0.17715	49	0.19901	88	0.22014
11	0.17772	50	0.19936	89	0.22098
12	0.17839	51	0.20003	90	0.22141
13	0.17889	52	0.20050	91	0.22162
14	0.17944	53	0.20110	92	0.22251
15	0.18004	54	0.20167	93	0.22295
16	0.18043	55	0.20215	94	0.22357
17	0.18129	56	0.20274	95	0.22435
18	0.18175	57	0.20315	96	0.22489
19	0.18220	58	0.20384	97	0.22526
20	0.18277	59	0.20427	98	0.22600
21	0.18337	60	0.20462	99	0.22672
22	0.18394	61	0.20553	100	0.22719
23	0.18449	62	0.20593	101	0.22756
24	0.18506	63	0.20645	102	0.22788
25	0.18559	64	0.20702	103	0.22844
26	0.18616	65	0.20766	104	0.22900
27	0.18665	66	0.20807	105	0.22960
28	0.18729	67	0.20867	106	0.23059
29	0.18783	68	o.20957	107	0.23062
30	0.18828	69	0.20984	108	0.23133
31	0.18898	70	0.21067	109	0.23202
32	0.18930	71	0.21100	110	0.23258
33	0.18989	72	0.21170	111	0.23325
34	0.19038	73	0.21222	112	0.23342
35	0.19106	74	0.21296	113	0.23448
36	0.19167	75	0.21286	114	0.23473
37	0.19214	76	0.21386	115	0.23562
38	0.19267	77	0.21437	116	0.23605
39	0.19329	78	0.21498	117	0.23698

Table 12: VMR Model

Estimates of $\tilde{\beta}_{3t}$ for the periods 1959IV - 1988IV

1	0.83737	40	0.80534	79	0.76876
2	0.84051	41	0.81026	80	0.79080
3	0.83685	42	0.80414	81	0.77861
4	0.82405	43	0.80491	82	0.80883
5	0.81458	44	0.80718	83	0.77259
6	0.80940	45	0.80835	84	0.78522
7	0.80284	46	0.79500	85	0.78283
8	0.81211	47	0.79808	86	0.78266
9	0.81952	48	0.80733	87	0.79206
10	0.82597	49	0.78576	88	0.79451
11	0.82406	50	0.79858	89	0.77514
12	0.81546	51	0.79079	90	0.78282
13	0.81845	52	0.79566	91	0.80519
14	0.81847	53	0.79180	92	0.78178
15	0.81482	54	0.79040	93	0.78889
16	0.82516	55	0.79434	94	0.78435
17	0.80405	56	0.79153	95	0.76765
18	0.80949	57	0.80033	96	0.76876
19	0.81597	58	0.79108	97	0.78032
20	0.81467	59	0.79814	98	0.76748
21	0.81057	60	0.80973	99	0.75536
22	0.80924	61	0.78740	100	0.76030
23	0.80872	62	0.79617	101	0.77243
24	0.80684	63	0.79784	102	0.78809
25	0.80768	64	0.79648	103	0.78695
26	0.80651	65	0.79036	104	0.78615
27	0.81036	66	0.79903	105	0.78194
28	0.80355	67	0.79602	106	0.75105
29	0.80426	68	0.77283	107	0.78720
30	0.81026	69	0.79064	108	0.77559
31	0.79995	70	0.77212	109	0.76596
32	0.81519	71	0.78573	110	0.76497
33	0.81264	72	0.77575	111	0.75661
34	0.81650	73	0.77752	112	0.78167
35	0.80673	74	0.76496	113	0.74681
36	0.80281	75	0.80700	114	0.76666
37	0.80784	76	0.77691	115	0.74297
38	0.80831	77	0.77916	116	0.75136
39	0.80342	78	0.77553	117	0.72553

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