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Abstract

Recently, the focus has been increasingly on the importance of endogenous time preference and its varying degrees of marginal impatience. Two types of marginal impatience can change the representative household's endogenous discount function: increasing (*Koopmans-Uzawa type*) and decreasing (*Becker-Mulligan type*), which are induced by current consumption and the investment on future-oriented capital, respectively. By modifying the endogenous discount factor in a small-open-economy RBC model, the equilibrium levels of the turnover in future-oriented capital and current consumption are obtained in a reduced form, which overcomes the non-stationarity problem. The relation between current consumption and the turnover in future-oriented capital is consistent with the empirical evidence from Australia.

JEL classification: C62; D90; F43

Keywords: Future-oriented capital; Marginal impatience; Real business cycles; Stationarity; Endogenous time preference

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1 Introduction

Economists have been increasingly paying attention to households' psychological concerns with intertemporal choice of consumption. Samuelson's simplified model (1937), as Frederick, Loewenstein, and O'Donoghue (2002) argue, did compress all these psychological concerns into a single parameter – the exogenous *discount rate*. Das (2003) notes that the "assumption of a constant exogenous rate of time preference is based on analytical convenience rather than strong economic intuition". Recently, the focus has also been more on the importance of *endogenous* time preference and its varying degrees of *marginal impatience*. That is, the intensity of impatience and preference for pleasures (gratifications) from current consumption varies from household to household, and also from time to time for the same household. Koopmans (1960) and Uzawa (1968) had identified *increasing* marginal impatience, implying that richer households tend to discount future consumption more heavily. However, many economists have later on shown theoretically and empirically that the assumption of increasing marginal impatience (*Koopmans-Uzawa type preference*) is counterintuitive because a number of household groups appear to follow *decreasing* marginal impatience.[1]

Becker and Mulligan (1997) (henceforward BM) have provided an analytical framework of decreasing marginal impatience to represent households' time preference (*Becker-Mulligan type*). In their model, individuals can reduce 'the remoteness of future pleasure by spending current *resources* partly as investments on *future-oriented capital*.[2] However, a higher level of such investments leads to a persistently larger stock of future-oriented capital. The traditional business cycle theory generally explains persistence in output movements by appealing to above-average rates of investment. But real business cycle (RBC) theory particularly explains output fluctuation that is completely independent of the monetary policy. In RBC models, output fluctuation originates in shocks to current productivity [See McCafferty (1990), p 431].

To the best of our knowledge, in the existing models of discounting their future utility, households do not incorporate Koopmans-Uzawa and Becker-mulligan types of marginal impatience simultaneously. In our model, we attempt to combine both types of increasing and decreasing marginal impatience induced by current consumption and future-oriented capital, respectively. We intend to have our analysis of endogenous time preference in a small open economy in order to get insights for households' adjustments to their impatience. Because the discount rate is based on an interest rate, it is fixed in a small open economy and determined exogenously by the international

[1] See Koopmans (1986) and Barro and Sala-I-Martin (2003) for intuitive and theoretical discussions, and Atkeson and Ogaki (1996) and Lawrance (1991) for their relevant empirical works.

[2] Examples of future-oriented capital include health, communications, education, insurance, and other financial services. Nakamoto (2009) notes that when individuals expreience jealousy, they become more impatient, leading to a higher level of consumption and a lower level of future-oriented capital.

financial market.

Furthermore, in the standard RBC theory, small-open-economy models usually suffer from the random walk problem in their equilibrium dynamics, i.e., the past history of productivity shocks plus the present one together determine the value of current and future variables. Thus, the equilibrium level of current consumption must depend upon the previous, and eventually, the initial condition, which is known as the problem of *non-stationarity*.[3] This problem has been resolved by endogenizing only the increasing marginal impatience of the Koopmans-Uzawa type as in Schmitt-Grohé and Uribe (2003) (SU). Our model has not only resolved the above problem of non-stationarity in a similar way, but also generlaized the household's consumption behaviour by incorporating both increasing and decreasing types of marginal impatience, as discussed above. Finally, our empirical analysis will test the relation between the turnover of future-oriented capital and current consumption, using the Australian macroeconomic time-series data.

This paper is organized as follows. Section 2 formulates marginal impatience in an RBC model of a small open economy. Its implication to the empirical evidence from Australia is discussed in Section 3, followed by the conclusion in Section 4.

2 The RBC Model

The RBC model analyses short- and medium-run fluctuations of macroeconomic variables by introducing productivity shocks into the production function. According to Mendoza (1991) and the SU model, the use of endogenous discount factor, induced by current consumption, plays a significant role in describing macroeconomic variables of an RBC small-open-economy model, especially, this setting overcomes the unit-root problem where the steady state consumption level does not depend on its initial condition.[4] In a small open economy, we allow households to freely adjust their impatience by altering current consumption and future-oriented capital in households' disposable incomes (resources), simultaneously.[5] Consequently, increasing (Koopmans-Uzawa type) and decreasing (Becker-Mulligan type) marginal impatience caused by these two variables that affect households' behaviours of allocation are included in the endogenous discount factor of the RBC

[3]The problem of non-stationarity is also known as a *unit-root* problem.

[4]The idea to solve this problem is the following: as a small open economy is highly open-oriented, the Euler condition in equilibrium for the key macroeconomic variable (i.e. smoothing consumption intertemporally), $\beta(1+r) = 1$, cannot simply be satisfied. This is because the domestic interest rate in this small open economy is determined by, and thus is equal to, the world interest rate. As a result, the modification of the endogenous discount factor in achieving this condition arises.

[5]The definition of impatience following Koopmans (1960) is that: "If $u_1 = u(x_1) > u_2 = u(x_2)$, ..., interchange of the first-period consumption vector x_1 and thus its corresponding utility level with the *less desirable* second-period vector x_2 and its utility level, decreases aggregate utility". This means that impatient households reduce their aggregate utility over time if they postpone their consumption to the future by valuing the current consumption and utility more than the counterparts in the future.

model.

2.1 The Model

The model environment focuses on the consumer side (decisions); the budget constraint allows foreign debt to accumulate and there are productivity shocks in the production function. The representative household maximizes its discounted infinite-horizon utility subject to the budget constraint. In addition, we extend the first model in Schmitt-Grohé and Uribe (2003) by adopting the concept of *service flow* introduced in Ogaki and Reinhart (1998) to the discount factor. Thus, the law of future-oriented capital accumulation is defined as:

$$s_t = \sum_{n=0}^{t} \delta_s^{t-n} q_n, \tag{1}$$

i.e.,

$$s_t = q_t + \delta_s s_{t-1},$$

where t is a non-negative integer. s_t represents the stock of future-oriented capital in period t (which we call service flow interchangeably), and q_t is the corresponding turnover in the same period (turnover henceforth). Also, $(1 - \delta_s) \in (0, 1)$ is the depreciation rate of the future-oriented capital. Next, the representative household has preferences described by the following utility functions:

$$E_0 \sum_{t=0}^{\infty} \theta_t u(c_t, h_t, s_t); \tag{2}$$

$$\theta_0 = 1; \tag{3}$$

$$\theta_{t+1} = \beta(c_t, h_t, s_t)\theta_t, \tag{4}$$

where c_t, h_t are consumption and productive labour, respectively, with first-order partial derivatives $\beta_c < 0$, $\beta_h > 0$, and $\beta_s > 0$. The foreign debt d_t is accumulated as:

$$d_t = (1 + r_{t-1})d_{t-1} - y_t + c_t + i_t + q_t + \Psi(k_{t+1} - k_t) + \mu(s_{t+1} - s_t), \tag{5}$$

where r_t is the interest rate at period t, y_t is the domestic GDP, i_t is the investment in physical capital, and $\Psi(.)$ represents the adjustment cost of physical capital stock. Similarly, it is also costly for the household to change their stock of future-oriented capital because it requires extra resources to adjust the imagination of future pleasure, and $\mu(.)$ represents the related adjustment cost. For convenience, we assume that $\mu(.)$ follows a linear form so that $\mu \equiv \delta_s^{-1} > 1$; that is, higher

durability of future-oriented capital requires less marginal cost of adjustment. The reason that s_t is included in u_t will be explained later and become obvious in Lemma 1. In these conditions, there is one main difference against the SU model: the endogenous discount factor is induced by two parts: s_t (future-oriented capital) and c_t (current consumption), which have distinguished effects on the monotonicity of the rate of time preference. That is, $\beta_s > 0$ represents decreasing marginal impatience (Becker-Mulligan type), whereas $\beta_c < 0$ stands for increasing marginal impatience (Koopmans-Uzawa type).[6]

Output (y_t) is produced by the input factors of physical capital k_t and productive labour h_t with the technological level A_t:

$$y_t = A_t F(k_t, h_t), \tag{6}$$

and the capital accumulation follows the usual way of:

$$k_t = i_{t-1} + (1 - \delta_k)k_{t-1}. \tag{7}$$

Note that there are two depreciation rates in this model: the depreciation rate of future-oriented capital $(1 - \delta_s)$ and the depreciation rate of physical capital (δ_k), both of which range between 0 and 1.

As this is an RBC model, the business cycles are mainly induced by the following common technological shocks in an AR(1) process:

$$lnA_{t+1} = \rho\ lnA_t + \epsilon_{t+1}, \tag{8}$$

where ϵ_t is normally and identically distributed, with mean 0 and a constant variance σ_ϵ^2. Furthermore, the equilibrium interest rate is exogenously adopted from overseas, i.e.,

$$r_t = r. \tag{9}$$

Lastly, the transversality condition, as the one in the first SU model, is required to ensure an interior solution:

$$\lim_{j\to\infty} E_t \frac{d_{t+j}}{\prod_{i=1}^{j}(1 + r_i)} \leq 0, \tag{10}$$

so that this economy will not borrow any debts in the infinite horizon. Therefore, all the above

[6]Notice that productive labour also plays a role of decreasing marginal impatience. However, it is not the Becker-Mulligan type because h is not a resource variable that can be captured by the household's budget. In fact, according to Mendoza (1991), the implication to include h in (2) and (4) induces that "the marginal rate of substitution between consumption and labour depends on the latter only, and employment becomes independent of the dynamics of consumption". This setting will be more obvious in Lemma 1 and be crucial to establish the endogenous supply of labour.

equations allow us to characterize the equilibrium of this RBC model, which determines the steady state values of c_t, q_t, s_t and h_t.

2.2 The Equilibrium

Given the initial values of A_0, d_{-1} and k_0, the household maximizes its utility function (2) by choosing the values of the variable bundle:

$$\{c_t, h_t, y_t, i_t, k_{t+1}, d_t, \theta_t, q_t, s_{t+1}\}_{t=0}^{\infty}$$

satisfying the constraints of (1),(3)-(9) and the transversality condition. The same Lagrange multipliers as in the SU model, namely, θ_t, η_t and λ_t, are used here for (4) and (5). Hence, the first order conditions (FOCs) of the household maximization problem are equalities of (4)-(8) and the following:

$$\lambda_t = \beta(c_t, h_t, s_t)(1 + r_t)E_t\lambda_{t+1}; \tag{11}$$

$$\lambda_t = u_c(c_t, h_t, s_t) - \eta_t\beta_c(c_t, h_t, s_t); \tag{12}$$

$$\eta_t = -E_t u(c_{t+1}, h_{t+1}, s_{t+1}) + E_t\eta_{t+1}\beta(c_{t+1}, h_{t+1}, s_{t+1}); \tag{13}$$

$$-u_h(c_t, h_t, s_t) + \eta_t\beta_h(c_t, h_t, s_t) = \lambda_t A_t F_h(k_t, h_t); \tag{14}$$

$$\lambda_t[1 + \Psi'(k_{t+1} - k_t)] = \beta(c_t, h_t, s_t)E_t\lambda_{t+1}\left[A_{t+1}F_k(k_t, h_t) + 1 - \delta_k + \Psi'(k_{t+2} - k_{t+1})\right]. \tag{15}$$

As the turnover (q_t) is new, the first order conditions in this model have one more requirement compared to those in the SU model in order to calculate the steady state value for the future-oriented capital in period t. Recalling that the utility function is a combined function of future-oriented capital in the form of turnover, the new FOC with respect to q_t can be written as (See Appendix A for the derivation of this equation):

$$\begin{aligned}&\lambda_t + (\delta_s^{-1} - 1)\sum_{m=t}^{\infty}\lambda_m\left(\prod_{n=t}^{m-1}\delta_s^{n-t}\beta(c_n, h_n, s_n)\right)\\ &= \sum_{m=t}^{\infty}\left[\left(\prod_{n=t}^{m-1}\delta_s^{n-t}\beta(c_n, h_n, s_n)\right)[u_s(c_m, h_m, s_m) - \eta_m\beta_s(c_m, h_m, s_m)]\right].\end{aligned} \tag{16}$$

Notice that this first order condition can be interpreted in two parts: The part $[u_s(c_m, h_m, s_m) - \eta_m\beta_s(c_m, h_m, s_m)]$ implies that the marginal utility of turnover in period m is in the same form as the current consumption in each period. However, the remaining part of this equation represents the discounting of durability and/or depreciation for the future-oriented capital invested in period

m, in terms of service flow, to the current period.[7] This reasoning also applies to the shadow price on the left hand side. Suppose that the economy is in the steady state, and the depreciation of the future-oriented capital is sufficiently large so that $\delta_s < 1 + r - \sqrt{r(1+r)}$. The marginal utility with respect to turnover can now be rewritten as:

$$\begin{aligned}
\lambda =& \lambda(\delta_s^{-1} - 1) + \lambda(\delta_s^{-1} - 1)\left(\delta_s \beta(c,h,s)\right) + \lambda(\delta_s^{-1} - 1)\left(\delta_s^2 \beta(c,h,s)^2\right) + \cdots \\
=& u_s(c,h,s) - \eta\beta_s(c,h,s) + \delta_s\beta(c,h,s)[u_s(c,h,s) - \eta\beta_s(c,h,s)] \\
&+ \delta_s^2\beta(c,h,s)^2[u_s(c,h,s) - \eta\beta_s(c,h,s)] + \cdots \\
=& \frac{u_s(c,h,s) - \eta\beta_s(c,h,s)}{\left[1 - \frac{(\delta_s^{-1}-1)}{1-\delta_s/(1+r)}\right]\left[1 - \delta_s\beta(c,h,s)\right]}.
\end{aligned}$$

It can be seen that the marginal utility of turnover is not equal to the usual value of marginal utility λ, but is discounted by the depreciation rate of future-oriented capital and the discount factor due to its accumulation and durability. Let the steady state value of λ in the above equation equal to the counterpart of the current consumption in (12), so that the household is indifferent to purchase between consumption and the turnover of future-oriented capital in equilibrium, which yields the marginal rate of substitution between c and q:

$$MRS_{c,q} = \frac{u_s(c,h,s) - \eta\beta_s(c,h,s)}{u_c(c,h,s) - \eta\beta_c(c,h,s)} = \left[1 - \frac{(\delta_s^{-1} - 1)}{1 - \delta_s/(1+r)}\right]\left[1 - \delta_s\beta(c,h,s)\right]. \tag{17}$$

Because the utility function is in constant relative risk aversion (CRRA) and the technology function is Cobb-Douglas, as in Mendoza (1991) and the SU model, and the future-oriented capital (s_t) is embedded into the utility and discount functions, we obtain:

$$u(c,h,s) = \frac{\left[c - \omega^{-1}h^{\omega} - s^{\phi}\right]^{1-\gamma} - 1}{1-\gamma};$$

$$\beta(c,h,s) = \left[1 + c - \omega^{-1}h^{\omega} - s^{\phi}\right]^{-\psi};$$

$$F(k,h) = k^{\alpha}h^{1-\alpha}; \qquad \Phi(x) = \frac{\varphi}{2}x^2,$$

where $u(.) > 0$, $\varphi > 0$, ω is the competitive wage paid to the productive labour, and $\phi > 1$ is a constant affecting the marginal rate of substitution between turnover and current consumption. s^{ϕ} enters into the utility function with a negative sign because we assume that future-oriented capital

[7] Because (16) discounts all the future utility brought by consumption to the present, this equation becomes difficult to be represented by the original programming in SU that only contains the relation between two periods; this makes it difficult for the model to generate simulation results to match the real data of small open economies.

cannot be consumed but only be accumulated for discounting.[8] Thus, there are two opposite effects of investing this capital. First, the turnover of future-oriented capital depletes the household's disposal resources in each period, which decreases its *current* and *future* utility. This effect reflects the characteristic of *information gathering* in BM. That is, the gathering of more information about imagining the future lets one learn that future available resources (consumption) will be less effective for generating utility than one had believed. Second, the investment of future-oriented capital can make the household become more patient in valuing the future; thus, it effectively increases the endogenous discount factor.

Then, the following task is to find out the steady state values of future-oriented capital (s), its turnover (q), and productive labour (h). Further, it will be shown that the steady state value of consumption (c) does not depends on its initial condition, but only depends on the worldwide interest rate and the parameters determining s (or q) and h. Therefore, the non-stationarity problem is solved. Firstly, in order to obtain the reduced form of these variables, we need the following lemma:

Lemma 1. *The marginal rate of substitution between current consumption (c) and turnover (q) depends only on q if the utility and discount functional forms satisfy the following condition:*

$$\frac{u_s(c,h,s)}{u_c(c,h,s)} = \frac{\beta_s(c,h,s)}{\beta_c(c,h,s)} = \frac{u_s(c,h,s) - \eta\beta_s(c,h,s)}{u_c(c,h,s) - \eta\beta_c(c,h,s)}. \tag{18}$$

Proof. See Appendix A. □

Given that the steady state Euler equation is $1/(1+r) = \beta(c,h,s)$, using (15), (16) and the functional forms of the utility and the discount factor, the steady state value of turnover (q) can be obtained in a reduced form by some of the parameters:

$$q^* = \left[\frac{1}{\phi}\left(\frac{1}{\delta_s} + \frac{\delta_s}{1+r} - 2\right)\right]^{1/(\phi-1)}.$$

Therefore, a proposition follows:

Proposition 1. *The steady state value of q is decreasing in δ_s and r.*

Proof. Denote $\Lambda(\delta_s) \equiv \frac{1}{\delta_s} + \frac{\delta_s}{1+r}$. Then, $\frac{\partial\Lambda(\delta_s)}{\partial\delta_s} = \frac{\delta_s^2-(1+r)}{(1+r)\delta_s^2} < 0$. Thus, q^* is decreasing in δ_s. q^* is also decreasing in r in a straightforward way and hence omitted. □

This proposition is consistent with usual intuition: the steady state value of the investment of future-oriented capital would be less if it had a longer effect in the future for adjusting the

[8] See Footnote 5 in the BM model for a two-period-lived-consumer case.

household's marginal patience, or if the interest rate were higher (i.e. a lower level of discount factor). Moreover, in the steady state, the stock of future-oriented capital is just the geometric summation of its turnover in all periods. Hence, the steady state value of the stock is obtained as:

$$s^* = \left(\frac{1}{1-\delta_s}\right)\left[\frac{1}{\phi}\left(\frac{1}{\delta_s}+\frac{\delta_s}{1+r}-2\right)\right]^{1/(\phi-1)}.$$

Once again, r has the same effect on s^* as on q^*. In particular, the effect of δ_s on s^* is ambiguous, depending on the magnitude of ϕ. The reason is two-fold: (i) as discussed before, higher δ_s implies a longer effect of the turnover on the future for the adjustment of the household's marginal patience, which is likely to decrease q^* and hence s^*; (ii) higher δ_s means more stock of future-oriented capital will be durable, which tends to increase s^*. Moreover, the steady state value of productive labour is endogenously determined by:

$$h^* = \left[(1-\alpha)\left(\frac{\alpha}{r+\delta_k}\right)^{\alpha/1-\alpha}\right]^{1/(\omega-1)}.$$

This implies that the marginal rate of substitution between c^* and h^* is unaffected by that between q^* and h^*.

Lastly, the steady state Euler equation becomes $\beta(c,h,s)(1+r)=1$. Therefore, c^* becomes constant, depending on only a series of parameters, h^* and s^*. Hence, the steady state value of c does not depend on its initial condition c_0, and the unit root problem (non-stationarity) is solved. Moreover, as this is an RBC model, c should be positively correlated with q for the household (pro-cyclicality) due to positive technological shocks, which is the relation that we will empirically test. Furthermore, the exogenously determined interest rate (r) does affect the household's allocation of c and q; therefore, in addition to c and q, r will be a crucial factor in the empirical analysis of the following section.

3 Empirical Analysis

In this section, we will estimate the relation among q, c and r using Australian time series data. This fits our RBC model setting, because Australia is a typical small open economy.[9] The purpose of this empirical analysis is to test whether the correlation between q and c, and that between q and

[9] In their model of overlapping generations, Chakrabarty, Katayama, and Maslen (2008) also consider the effect of *health goods* consumed by Australian households on the relation between permanent income and the propensity to save, where health goods play a similar role as future-oriented capital to reduce households' degree of impatience. However, they use microdata from The Household, Income and Labour Dynamics in Australia (HILDA) for analysis because their model consists of a continuum of households over generations, whereas our model deals with a representative household in the economy, and therefore uses the aggregate Australian macroeconomic data for the discussion.

r, are consistent with the implication of the RBC model, given that the simulation programming is not computable (see Footnote 7).

3.1 Data Description and the Sources

The three relevant macroeconomic variables–current consumption (c_t), turnover of future-oriented capital (q_t), and the interest rate (r_t)–are directly collected from the websites of the Australian Bureau of Statistics (ABS) and the Reserve Bank of Australia (RBA). Due to the fact that there are no specific categorical definitions and records of future-oriented capital, the only available data are various components of households' final consumption expenditures. Thus, according to the definition of future-oriented capital in the BM model, the types of consumption that are considered to alter households' impatience are classified into q_t in each period.[10] The remaining types are hence defined as c_t.[11]The details of the data of c_t and q_t are given in Appendix B.[12]

In the following analysis, all data are in log forms, converted to be based on the price level of the year 2000, and detrended by the Hodrick-Prescott (HP) filter.[13] All variables range from September 1959 to March 2011 in a quarterly pattern, amounting to 207 periods totally.

3.2 The Results

To estimate the relationship between q_t and c_t, we firstly run a simple OLS regression of q_t on c_t and r_t, and the result is shown in Column 1 of Table 1. We find that the estimators for both c_t and r_t are significant at 1% level, and are consistent with the implication of an RBC model, where one log point increase in c_t raises 1.547 log points of q_t, and one log point increase in r_t is associated with 0.129 log points decline in q_t. This result implies that in the steady state, if there is a positive aggregate productivity shock that increases output, current consumption will be likely to increase, which reduces the household's degree of patience. The positive correlation (procyclicality) between c and q will raise the expenditure of future-oriented capital, adjusting the households' patience to a high level given $\phi > 1$. Further, the higher level of discount factor should be accompanied with a lower level of interest rate (r) to satisfy the Euler equation in the steady state. This may be reflected by the negative correlation between q and r. Moreover, a decline in

[10]The types of consumption that are available in ABS statistics and are characterized to coincide with the definition of turnover of future-oriented capital are shown in Footnote 2.

[11]The remaining types of consumption include food, cigarettes and tobacco, alcoholic beverages, clothing and footwear, rent and other dwelling services, electricity and other fuel, furnishings and household equipment, purchase and operation of vehicles, transport services, recreation and culture, hotels and restaurants, and other goods and services.

[12]The data are available upon request.

[13]See the procedure of detrending comovements of the cyclical components of a series of macroeconomic variables in Hodrick and Prescott (1997).

the interest rate is likely to decrease the steady state productive labour (h), consequently capital investment (i) and debts (d) in the next period; then, a low level of output and disposal income will be expected, which reduces the proportion of resources that households spend on future-oriented capital and current consumption. In Column 2 of Table 1, we include quarterly dummies and a time trend in the regression. The estimator between q_t and c_t reduce only around 0.5 log points without significant qualitative changes, but the counterpart between q_t and r_t decreases by 0.05 log points and becomes insignificant.

Following our model where the current turnover of future-oriented capital may be strongly affected by the turnover decisions and consumption levels in the previous periods, we include the three lags of q_t and c_t to the above regressions. Moreover, in reality, it may take some time for households to realize the influence from the changes of the interest rate on future-oriented capital; hence, some period lags of r_t are also included. Column 3 of Table 1 represents the result of this dynamical specification. The estimation in Column 3 does not considerably differ from the one in Column 1 with all coefficients being significant, but the effect of c_t becomes less as its estimator is reduced to 1.002%. Regarding the interest rate, the estimator of r_t becomes positive. This problem may be explained by the time delay for households to realize fully the change of the interest rate; they need time to adjust their spendings, which is reflected in the significantly negative coefficient of r_{t-1}. Including quarterly dummies and a time trend in Column 4 does not change significantly the absolute values of the estimators.

We redo the above regressions by including 7 lags of the variables in Column 5, and with quarterly dummies and consideration of the time trend in Column 6. The reason to include three lags before and seven lags in the regressions will become more obvious later. The resulting estimators between q_t and c_t still stay at around 1 log point, and the major effects of signs and statistical significance remain, as previously mentioned, although the coefficients involving the interest rate and their lags become insignificant. Notice that since the estimation tends to include autocorrelation in the error terms, the above regressions in Columns 1-6 adopt the *Newey-West* standard errors for the coefficients, which is often used to correct the correlation in the disturbances for time series data.[14]

Although the steady state values of the variables (c^* and q^*) can be stationary in our model, they are valid only locally around a given equilibrium path. Nevertheless, we cannot rule out the possibility that the variables of the whole time series involved in the regressions (without and with lags) may still be in a *nonstationary process*, which makes the results in Table 5.1 difficult to interpret, leading the estimators to be biased. Moreover, including lags of variables leads the instantaneous response of q_t to r_t becomes positive, which is not consistent with the prediction of

[14]See Chapter 12 in Wooldridge (2009) for more details.

our model. In this case, we need other models to learn about the potential relation between q_t, c_t and r_t.

Before we proceed, it is useful to examine whether the variables q_t, c_t and r_t are *integrated of order one* [I(1)]. We use an *Augmented Dickey-Fuller* test (DF-GLS) for the test of unit root.[15] The results reveal that q_t, c_t and r_t are likely to be I(1) variables because we fail to reject the null hypotheses of the DF-GLS tests (See Table 4 for details). Consequently, we use *error correction models* (ECMs) to estimate the coefficients and then to investigate whether these variables are *cointegrated*.

Before we apply the ECMs, we need to test if the variables involved in the regression are *cointegrated*, and we apply the *Johansen's test* for this purpose. With three lags and seven lags respectively, the test fails to reject the critical value at 5% significance level where the null hypothesis is given by a maximum rank of one, which implies that these variables are likely to be cointegrated of order one. Hence, we can use the ECMs for the following analysis.

First of all, we apply the *unrestricted* error correction model to examine the short-run *disequilibrium* relation and the cointegration among q_t, c_t and r_t, using the following specification with three lags of the variables:

$$\begin{aligned} q_t = b_0 &+ b_0^c c_t + b_1^c c_{t-1} + b_2^c c_{t-2} + b_3^c c_{t-3} + b_0^r r_t + b_1^r r_{t-1} + b_2^r r_{t-2} + b_3^r r_{t-3} \\ &+ b_1^q q_{t-1} + b_2^q q_{t-2} + b_3^q q_{t-3} + b_i^d D_i + b^t time + \epsilon_t, \end{aligned}$$

where D_i represents the quarterly dummies with $i = 1, 2, 3, 4$, and *time* is the trend time. According to the standard derivation for the unrestricted error correction model, the above can be reparameterized as the following specification:

$$\begin{aligned} \Delta q_t = b_0^c \Delta c_t &- (b_2^c + b_3^c)\Delta c_{t-1} - b_3^c \Delta c_{t-2} + b_0^r \Delta r_t - (b_2^r + b_3^r)\Delta r_{t-1} - b_3^r \Delta r_{t-2} \\ &- (b_2^q + b_3^q)\Delta q_{t-1} - b_3^q \Delta q_{t-2} \\ &+ \tau\beta_0 - \tau q_{t-1} + \tau\beta_1 c_{t-1} + \tau\beta_2 r_{t-1} + b_i^d D_i + b^t time + \epsilon_t, \end{aligned} \tag{19}$$

where $\tau = 1 - b_1^q - b_2^q - b_3^q$, $\beta_0 = b_0/\tau$, $\beta_1 = (b_0^c + b_1^c + b_2^c + b_3^c)/\tau$, and $\beta_2 = (b_0^r + b_1^r + b_2^r + b_3^r)/\tau$. The estimation of (20) is reported in Column 1 of Table 2. As is shown, all the coefficients for the explanatory variables except Δr_t have the expected signs and significance as explained in the previous specifications, where the effect of Δc_t on Δq_t equals 1.002 log points. In particular, the coefficient of q_{t-1} represents the speed of adjustment of this system, but unfortunately, this estimator is insignificant but negative. The result in Column 2 does not change considerably from the counterpart in Column 1 when we include the quarterly dummies and the time trend.

[15] See Elliott, Rothenberg, and Stock (1996) for more details.

In order to correct the insignificant coefficient of q_{t-1}, we redo the above analysis by including seven lags in the ECM for another specification, which also passes the Johansen's test of rank one. The new specification is given by:

$$\begin{aligned} q_t = b_0 &+ b_0^c c_t + b_1^c c_{t-1} + b_2^c c_{t-2} + b_3^c c_{t-3} + b_4^c c_{t-4} + b_5^c c_{t-5} + b_6^c c_{t-6} + b_7^c c_{t-7} \\ &+ b_0^r r_t + b_1^r r_{t-1} + b_2^r r_{t-2} + b_3^r r_{t-3} + b_4^r r_{t-4} + b_5^r r_{t-5} + b_6^r r_{t-6} + b_7^r r_{t-7} \\ &+ b_1^q q_{t-1} + b_2^q q_{t-2} + b_3^q q_{t-3} + b_4^q q_{t-4} + b_5^q q_{t-5} + b_6^q q_{t-6} + b_7^q q_{t-7} + b_i^d D_i + b^t time + \epsilon_t. \end{aligned}$$

Similarly, this unrestricted model can be reparameterized as the following form:

$$\begin{aligned} \Delta q_t = b_0^c \Delta c_t &- (b_2^c + b_3^c + b_4^c + b_5^c + b_6^c + b_7^c)\Delta c_{t-1} - (b_3^c + b_4^c + b_5^c + b_6^c + b_7^c)\Delta c_{t-2} \\ &- (b_4^c + b_5^c + b_6^c + b_7^c)\Delta c_{t-3} - (b_5^c + b_6^c + b_7^c)\Delta c_{t-4} - (b_6^c + b_7^c)\Delta c_{t-5} - b_7^c \Delta c_{t-6} \\ + b_0^r \Delta r_t &- (b_2^r + b_3^r + b_4^r + b_5^r + b_6^r + b_7^r)\Delta r_{t-1} - (b_3^r + b_4^r + b_5^r + b_6^r + b_7^r)\Delta r_{t-2} \\ &- (b_4^r + b_5^r + b_6^r + b_7^r)\Delta r_{t-3} - (b_5^r + b_6^r + b_7^r)\Delta r_{t-4} - (b_6^r + b_7^r)\Delta r_{t-5} - b_7^r \Delta r_{t-6} \\ &- (b_2^q + b_3^q + b_4^q + b_5^q + b_6^q + b_7^q)\Delta q_{t-1} - (b_3^q + b_4^q + b_5^q + b_6^q + b_7^q)\Delta q_{t-2} \\ &- (b_4^q + b_5^q + b_6^q + b_7^q)\Delta q_{t-3} - (b_5^q + b_6^q + b_7^q)\Delta q_{t-4} - (b_6^q + b_7^q)\Delta q_{t-5} - b_7^q \Delta q_{t-6} \\ &+ \tau\beta_0 - \tau q_{t-1} + \tau\beta_1 c_{t-1} + \tau\beta_2 r_{t-1} + b_i^d D_i + b^t time + \epsilon_t, \end{aligned} \tag{20}$$

where $\tau = 1 - \left(\sum_{i=1}^{7} b_i^q\right)$, $\beta_0 = b_0/\tau$, $\beta_1 = \left(\sum_{i=0}^{7} b_i^c\right)/\tau$, and $\beta_2 = \left(\sum_{i=0}^{7} b_i^r\right)/\tau$. Columns 3 and 4 report the results of (20) where the latter includes quarterly dummies and the time trend, although their results do not differ significantly. The estimators of the explanatory variables have the expected signs and are significant at 1% level, where an increase of one log point in Δc_t raises Δq_t by one log point. The coefficient of Δr_t becomes negative as we predicted, but it is still insignificant. Importantly, the system now adjusts it previous disequilbria with a significant negative $b_1^q \in (-1, 0)$ back to the steady state level, although at quite a slow speed (0.01%). This result confirms the household's behaviours discussed above and the results in Table 1, where the turnover and future-oriented capital are positively correlated with current consumption, and the effect of the interest rate on the future-oriented capital and current consumption is likely to be negative. We also conduct a joint test to show that $\tau\beta_1$, $\tau\beta_2$ and τ are jointly different from zero at the 1% significance level, which again demonstrates that c_{t-1}, r_{t-1} and q_{t-1} are likely to be cointegrated and that their (equilibrium) estimators would even be consistent. In other words, our above explanation of the relation between q_t and c_t still holds for the error correction models.

Finally, although the previous specifications indicate that the prediction of our model is rather consistent with the empirical results, the R-squared could be explicitly high, perhaps because many lags have been included. In addition, the speed of adjustment in q_t is quite low and the estimator

of Δr_t is still insignificant, which could also make the equilibrium estimators of the variables in the cointegration inconsistent. Therefore, to solve these problems, in Column 5 of Table 2, the *vector error correction model* (VECM) with a constant trend has been applied. It is assumed that the cointegrating equation is stationary, in which the differences of the variables have a constant trend over time.[16] The signs and significance of the desired coefficients are similar to the ones in Columns 3-4, but the magnitudes increase substantially. Especially, q_t is positively correlated with c_t for 1.455 log points at 1% significance level and q_t is negatively associated with r_t for 2.793 log points at 10% significance level, but they are the equilibrium estimators.[17] The speed of adjustment in q_t rises substantially to 2.8%. Moreover, the R-squared reduces to 0.828.

To summarize, c_t, r_t and q_t are likely to be cointegrated of order one, and their (equilibrium) estimators would be consistent, especially in the VECM. In other words, the cointegration implies that in equilibrium, q_t is positively associated with c_t and negatively associated with r_t, which would also be true for the disequilibrium relation among the variables given the results of the ECMs with 3 and 7 lags. However, the above empirical analysis provides evidence only on the correlations but does not specify the causality effect between these variables.

3.3 Robustness

To test whether our results are subject to specific selection of the sample, a robustness check is conducted as follows. We redefine the turnover of future-oriented capital to include only consumption expenditure on *health*, and the remaining other categories of future-oriented capital are added to current consumption.

Firstly, regarding the new variables of current consumption and health, we still fail to reject the null hypothesis using the DF-GLS test at 10% significance levels, implying that these variables are still likely to be integrated of order one (See Table 5 for the details). Secondly, using the Johansen's test, it is likely that current consumption, health, and the interest rate would still be cointegrated of order one with only three period lags. Then, we redo the regressions as Tables 1 and 2 and report the result in Table 3. As can be seen, although the selection of the sample for turnover has been changed, the result for the relation between q_t and c_t remains positive and significant across all specifications. The magnitude of this relation ranges between 1.145 to 1.561 log points in the OLS, around 1 log point in ECM, and around 2.203 log points in VECM. Moreover, the effect of r_t on q_t is still significantly negative. Lastly, q_t still adjusts itself to previous disequilibia in the dynamical system, with 0.02% in ECM and 0.8% in VECM. Overall, the above results show that q_t, c_t and r_t are cointegrated, and their (equilibrium) estimators will be consistent in a large sample

[16] See Johansen (1995) for more details about five specifications of VECM.

[17] The disequilibrium relation among the variables are not available in this approach.

size (around 200 observations in our context) due to the property of *superconsistency*. The positive correlation between q_t and c_t and the negative one between q_t and r_t still hold in the robustness check.

4 Conclusion

This paper presents the choice between decreasing and increasing marginal impatience in households' rate of time preference in the form of an endogenous discount factor under the RBC model. The theoretical results illustrate that the introduction of decreasing marginal impatience by future-oriented capital into the household's endogenous discount factor still solves the non-stationarity problem in a small-open-economy RBC model, in which the steady state level of consumption does not depend on its initial condition. It does so because a reduced form for the steady state value of the turnover of future-oriented capital is obtained, and it is negatively correlated with its depreciation rate and the interest rate. Our empirical analysis of Australian households' behaviour shows the positive correlation between the turnover of future-oriented capital and current consumption, and the negative correlation between the turnover and the interest rate, which are consistent with the implication of the RBC model. For the future direction of research, one may apply this RBC model to the empirical data from other small open economies to examine whether the relation between the turnover and current consumption still holds.

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Appendices and Tables

Appendix A

DERIVATION OF EQUATION (16): From the Lagrange equation in the household's maximization problem, we take the F.O.C with respect to q_t, such that:

$$\begin{aligned}
&\theta_t u_s(c_t, h_t, s_t) - \eta_t \theta_t \beta_s(c_t, h_t, s_t) \\
&+\delta_s \Big[\theta_{t+1} u_s(c_{t+1}, h_{t+1}, s_{t+1}) - \eta_{t+1}\theta_{t+1}\beta_s(c_{t+1}, h_{t+1}, s_{t+1})\Big] \\
&+\delta_s^2 \Big[\theta_{t+2} u_s(c_{t+2}, h_{t+2}, s_{t+2}) - \eta_{t+2}\theta_{t+2}\beta_s(c_{t+2}, h_{t+2}, s_{t+2})\Big] + ... \\
&+\theta_t \lambda_t[-1 - \delta_s^{-1}(\delta_s - 1)] + \theta_{t+1}\lambda_{t+1}[-\delta_s^{-1}(\delta_s^2 - \delta_s)] + \theta_{t+2}\lambda_{t+2}[-\delta_s^{-1}(\delta_s^3 - \delta_s^2)] + ... = 0.
\end{aligned} \tag{A.1}$$

Using the law of motion of θ in (1), (A.1) is simplified as:

$$\begin{aligned}
&u_s(c_t, h_t, s_t) - \eta_t \beta_s(c_t, h_t, s_t) \\
&+\delta_s \Big[\beta(c_t, h_t, s_t) u_s(c_{t+1}, h_{t+1}, s_{t+1}) - \eta_{t+1}\beta(c_t, h_t, s_t)\beta_s(c_{t+1}, h_{t+1}, s_{t+1})\Big] \\
&+\delta_s^2 \begin{bmatrix} \beta(c_t, h_t, s_t)\beta(c_{t+1}, h_{t+1}, s_{t+1}) u_s(c_{t+2}, h_{t+2}, s_{t+2}) \\ -\eta_{t+2}\beta(c_t, h_t, s_t)\beta(c_{t+1}, h_{t+1}, s_{t+1})\beta_s(c_{t+2}, h_{t+2}, s_{t+2}) \end{bmatrix} + ... \\
&+\lambda_t[-1 - \delta_s^{-1}(\delta_s - 1)] + \lambda_{t+1}\beta_s(c_t, h_t, s_t)[-\delta_s^{-1}(\delta_s^2 - \delta_s)] \\
&+\lambda_{t+2}\beta_s(c_t, h_t, s_t)\beta_s(c_{t+1}, h_{t+1}, s_{t+1})[-\delta_s^{-1}(\delta_s^3 - \delta_s^2)] + ... = 0.
\end{aligned} \tag{A.2}$$

Finally, by collecting the common terms for $\beta(c_n, h_n, s_n)$ where $n = 0, 1, ..., \infty$, (16) is immediately obtained. *Q.E.D.*

PROOF OF LEMMA 1: Firstly, according to the utility and discount factor functional forms, it is easy to obtain the marginal rate of substitution of utility and discount between the steady state values of current consumption and turnover, respectively:

$$\frac{u_s(c, h, s)}{u_c(c, h, s)} = \frac{\beta_s(c, h, s)}{\beta_c(c, h, s)} = -\phi q^{\phi - 1}.$$

In addition, this equation yields:

$$u_s(c, h, s)u_c(c, h, s) + \eta u_s(c, h, s)\beta_c(c, h, s) = u_s(c, h, s)u_c(c, h, s) + \eta u_c(c, h, s)\beta_s(c, h, s),$$

which implies:

$$\frac{u_s(c,h,s)}{u_c(c,h,s)} = \frac{u_s(c,h,s) - \eta\beta_s(c,h,s)}{u_c(c,h,s) - \eta\beta_c(c,h,s)}.$$

Therefore, it is straightforward to obtain that $\frac{u_s(c,h,s)-\eta\beta_s(c,h,s)}{u_c(c,h,s)-\eta\beta_c(c,h,s)} = -\phi q^{\phi-1}$. $Q.E.D.$

Appendix B: Data Details

Consumption and Future-oriented Capital

We use Household Final Consumption Expenditure (HFCE) in the Australian National Accounts: National Income, Expenditure and Product, released by the Australian Bureau of Statistics (ABS) for the data of current consumption (c_t) and turnover of future-oriented capital (q_t). The reasons for including specific types of consumption under c_t and q_t have already been explained in Footnotes 11 and 12. We select the quarterly data from September 1959 to March 2011, and make them seasonally adjusted in the unit of millions. Moreover, the data have been detrended using HP-filter, and converted to the price level in the year 2000 by the quarterly consumer price index (CPI) provided by the Reserve Bank of Australia (RBA). The final sample size for both c_t and q_t consists of 207 observations.

Interest Rate

The data of interest rate come from RBA, and are represented by the Standard Variable Housing Loan Interest Rates released by the average rates of large banks in mortgage. To match the data of current consumption and turnover of future-oriented capital, we also select the sample size from September 1959 to March 2011 in a quarterly pattern. The data have been detrended by HP-filter and deflated by the CPI using year 2000 as the base. Finally, the sample size also amounts to 207 observations.

4.1 Appendix C: Tables of the Empirical Evidence

Table 1: Current Consumption and the Turnover of Future-oriented Capital

	1	2	3	4	5	6
c_t	1.547***	1.094***	1.002***	1.001***	1.001***	1.001***
	(0.017)	(0.277)	(0.001)	(0.001)	(0.0002)	(0.0003)
c_{t-1}			-2.955***	-2.940***	-3.507***	-3.479***
			(0.001)	(0.001)	(0.002)	(0.002)
c_{t-2}			2.923***	2.895***	4.309***	4.246***
			(0.0004)	(0.0004)	(0.0002)	(0.0002)
c_{t-3}			-0.969***	-0.957***	-1.901***	-1.862***
				(0.001)	(0.044)	(0.004)
c_{t-4}					(omitted)	(omitted)
c_{t-5}					(omitted)	(omitted)
c_{t-6}					0.099***	0.095***
					(0.002)	(0.002)
c_{t-7}					(omitted)	(omitted)
r_t	-0.129***	-0.065	0.008**	0.011***	0.001	0.002
	(0.033)	(0.051)	(0.003)	(0.004)	(0.015)	(0.002)
r_{t-1}			-0.011**	-0.014***	-0.002	-0.004
			(0.049)	(0.005)	(0.021)	(0.002)
r_{t-2}			-0.002	-0.005	-0.001	0.00002
			(0.004)	(0.005)	(0.001)	(0.001)
r_{t-3}			0.005*	0.008*	0.002	0.002
			(0.003)	(0.004)	(0.002)	(0.002)
r_{t-4}					0.001	0.0002
					(0.001)	(0.001)
r_{t-5}					0.00003	-0.0002
					(0.001)	(0.001)
r_{t-6}					0.0003	0.001
					(0.002)	(0.002)
r_{t-7}					-0.001	-0.001
					(0.002)	(0.001)
q_{t-1}			2.956***	2.941***	3.507***	3.479***
			(0.001)	(0.001)	(0.002)	(0.002)
q_{t-2}			-2.923	-2.900	-4.309	-4.246
			(omitted)	(omitted)	(omitted)	(omitted)
q_{t-3}			0.967***	0.954***	1.901***	1.861***
			(0.001)	(0.001)	(0.004)	(0.004)
q_{t-4}					-0.0003**	-0.0003**
					(0.0001)	(0.0001)
q_{t-5}					0.0002	0.0002
					(0.0002)	(0.0002)
q_{t-6}					-0.099***	-0.095***
					(0.002)	(0.002)
q_{t-7}					0.0003	0.0001
					(0.0003)	(0.0002)
Quarterly Dummy	NO	YES	NO	YES	NO	YES
Time Trend	NO	YES	NO	YES	NO	YES
Number of Observations	207	207	204	204	200	200

Notes: Parentheses report the Newey-West standard errors for coefficients. The dependent variable is the logarithm of turnover of future-oriented capital in period t (q_t), and the independent variables are the logarithm of current and lags of consumption and the interest rate. The corresponding coefficients for the independent variables in the columns are b^x_{t-i}, where $x = c, q, r$ representing current consumption, the turnover and the interest rate, and $i = 0, 1, 2, 3, 4, 5, 6, 7$ representing the lags from period t. Significance at the 1 percent, 5 percent, and 10 percent level is denoted by ***, ** and * respectively.

Table 2: Current Consumption and the Turnover of Future-oriented Capital: ECM

	1	2	3	4	5
Δc_t	1.002***	1.001***	1.000***	1.000***	1.455***
	(0.001)	(0.001)	(0.0001)	(0.0001)	(0.038)
Δc_{t-1}	-1.954***	-1.938***	-3.814***	-3.875***	-166.956***
	(0.010)	(0.010)	(0.122)	(0.122)	(60.240)
Δc_{t-2}	0.969***	0.957***	5.287***	5.103***	489.032**
	(0.011)	(0.011)	(0.493)	(0.483)	(239.594)
Δc_{t-3}			-2.537***	-2.339***	-424.148
			(0.792)	(0.760)	(414.455)
Δc_{t-4}			-0.877	-0.947	-45.334
			(0.632)	(0.598)	(413.482)
Δc_{t-5}			1.301***	1.283***	235.051
			(0.256)	(0.244)	(237.296)
Δc_{t-6}			-0.359***	-0.345***	-88.751
			(0.045)	(0.046)	(58.972)
c_{t-1}	0.00001	-0.0004	0.0001***	0.0001***	
	(0.0003)	(0.0003)	(0.00004)	(0.00002)	
Δr_t	0.008**	0.012**	-0.0007	-0.0005	-0.279*
	(0.003)	(0.004)	(0.0004)	(0.0005)	(0.060)
Δr_{t-1}	-0.003	-0.003	0.0008	0.0004	1.600*
	(0.003)	(0.002)	(0.001)	(0.001)	(0.828)
Δr_{t-2}	-0.005*	-0.008*	0.0006	0.001	-0.967
	(0.003)	(0.004)	(0.0008)	(0.001)	(1.176)
Δr_{t-3}			-0.001	-0.0003	-1.902
			(0.001)	(0.001)	(1.197)
Δr_{t-4}			-0.001	-0.001	-0.727
			(0.001)	(0.001)	(1.200)
Δr_{t-5}			-0.0001	-0.0004	1.841
			(0.0004)	(0.004)	(1.174)
Δr_{t-6}			0.001	0.001	0.198
			(0.001)	(0.001)	(0.830)
r_{t-1}	-1.57E-06	0.00008	-0.00001***	-6.29E-06***	
	(0.00004)	(0.00004)	(2.70E-06)	(1.92E-06)	
Δq_{t-1}	1.956***	1.941***	3.814***	3.753***	166.844***
	(0.010)	(0.011)	(0.122)	(0.122)	(60.232)
Δq_{t-2}	-0.967***	-0.954***	-5.287***	-5.103***	-488.895**
	(0.011)	(0.011)	(0.493)	(0.483)	(239.586)
Δq_{t-3}			2.537***	2.339***	424.382
			(0.792)	(0.760)	(414.459)
Δq_{t-4}			0.877	0.947	45.528
			(0.632)	(0.598)	(413.492)
Δq_{t-5}			-1.301***	-1.282***	-235.292
			(0.256)	(0.244)	(237.296)
Δq_{t-6}			0.359***	0.346***	88.730
			(0.045)	(0.046)	(58.966)
q_{t-1}	-8.76E-07	-0.0002	-0.0001***	-0.0001**	-0.028***
	(0.0002)	(0.0002)	(0.00002)	(0.00002)	(0.009)
Quarterly Dummy	NO	YES	NO	YES	NO
Time Trend	NO	YES	NO	YES	YES
Number of Observations	204	204	200	200	200

Notes: Parentheses in the first 4 columns report the Newey-West standard errors for coefficients. The dependent variable is the difference of logarithm of turnover of future-oriented capital in period t (Δq_t), and the independent variables are the differences of logarithm of current and lags of consumption and the interest rate. The corresponding coefficients for the independent variables in the columns are b^x_{t-i}, where $x = c, q, r$ representing current consumption, the turnover and the interest rate, and $i = 0, 1, 2, 3, 4, 5, 6$ representing the lags from period t. In Column 5, we apply the vector error correction model for estimation and cointegration, where the coefficients for c_{t-1} and r_{t-1} can be obtained by multiplying their coefficients in the cointegrating equation with the coefficient of q_{t-1}. The coefficient of q_{t-1} measures the speed of adjustment of q. Significance at the 1 percent, 5 percent, and 10 percent level is denoted by ***, ** and * respectively.

Table 3: Robustness: Current Consumption and Health

Panel A					Panel B			
	1	2	3	4		5	6	7
c_t	1.145***	1.561***	1.001***	1.001***	Δc_t	1.001***	1.001***	2.203***
	(0.034)	(0.209)	(0.001)	(0.001)		(0.001)	(0.001)	(0.380)
c_{t-1}			-2.956***	-2.956***	Δc_{t-1}	-1.958***	-1.955***	-0.655
			(0.001)	(0.001)		(0.017)	(0.015)	(1.006)
c_{t-2}			2.927***	2.927***	Δc_{t-2}	0.974***	0.972***	0.087
			(0.0002)	(0.0003)		(0.174)	(0.016)	(0.978)
c_{t-3}			-0.972***	-0.972***	c_{t-1}	0.0003*	0.0004*	
			(0.001)	(0.001)		(0.0001)	(0.0002)	
r_t	-0.104**	-0.157***	-0.006**	-0.006***	Δr_t	-0.005	-0.006*	-0.729***
	(0.040)	(0.028)	(0.002)	(0.002)		(0.003)	(0.003)	(0.087)
r_{t-1}			0.006**	0.007**	Δr_{t-1}	-0.0001	0.0005	0.256
			(0.003)	(0.003)		(0.001)	(0.002)	(0.617)
r_{t-2}			0.006*	0.005	Δr_{t-2}	0.005	0.006	-0.276
			(0.004)	(0.004)		(0.004)	(0.004)	(0.619)
r_{t-3}			-0.006**	-0.006**	r_{t-1}	-0.0001***	-0.0002***	
			(0.002)	(0.003)		(0.00003)	(0.00003)	
q_{t-1}			2.957***	2.957***	Δq_{t-1}	1.960***	1.957***	0.747
			(0.001)	(0.001)		(0.017)	(0.015)	(1.000)
q_{t-2}			-2.927	-2.927	Δq_{t-2}	-0.973***	-0.970***	0.073
			(omitted)	(omitted)		(0.017)	(0.015)	(0.965)
q_{t-3}			0.970***	0.970***	q_{t-1}	-0.0002*	-0.0002*	-0.008*
			(0.001)	(0.001)		(0.0001)	(0.0001)	(0.004)
Dummy	NO	YES	NO	YES		NO	YES	NO
Time Trend	NO	YES	NO	YES		NO	YES	YES
Number of Observations	207	207	204	204		204	204	204

Notes: Parentheses in the first 6 columns report the Newey-West standard errors for coefficients. In Panel A, the dependent variable is the logarithm of turnover of future-oriented capital in period t (q_t), and the independent variables are the differences of logarithm of current and lags of consumption and the interest rate. In Panel B, the dependent variable is the difference of logarithm of turnover of future-oriented capital in period t (Δq_t), and the independent variables are the differences of logarithm of current and lags of consumption and the interest rate. The corresponding coefficients for the independent variables in the columns are b^x_{t-i}, where $x = c, q, r$ representing current consumption, the turnover and the interest rate, and $i = 0, 1, 2, 3$ representing the lags from period t. In Column 7, we apply the vector error correction model for estimation and cointegration, where the coefficients for c_{t-1} and r_{t-1} can be obtained by multiplying their coefficients in the cointegrating equation with the coefficient of q_{t-1}. The coefficient of q_{t-1} measures the speed of adjustment of q. Significance at the 1 percent, 5 percent, and 10 percent level is denoted by ***, ** and * respectively.

Table 4: The Unit Root Test – DF-GLS

	1 lag	3 lags	7 lags	14 lags
q_t	-0.482*	-1.042*	-1.194*	-1.568*
c_t	-0.034*	-0.536*	-0.469*	-0.694*
r_t	-4.907	-1.582*	-1.052*	-1.168*

Notes: This is the unit root test for Table 2. It follows a modified Dickey-Fuller t test in which the series has been transformed by a generalized least-squares regression, proposed by Elliott, Rothenberg, and Stock (1996). The 10% significance level is represented by * where the null of a unit root fails to be rejected.

Table 5: The Unit Root Test – DF-GLS (Robustness)

	1 lag	3 lags	7 lags	14 lags
q_t	-0.781*	-1.282*	-1.432*	-1.811*
c_t	-0.130*	-0.609*	-0.546*	-0.780*
r_t	-4.907	-1.582*	-1.052*	-1.168*

Notes: This is the unit root test for Table 3. It follows a modified Dickey-Fuller t test in which the series has been transformed by a generalized least-squares regression, proposed by Elliott, Rothenberg, and Stock (1996). The 10% significance level is represented by * where the null of a unit root fails to be rejected.