The Relationship between Consumption, Income and Wealth in Australia

Lance A. Fisher
Glenn Otto
School of Economics
University of New South Wales
Sydney, Australia
and
Graham M. Voss
Department of Economics
University of Victoria
Victoria, Canada

Draft: August 2005
Preliminary and Incomplete

Abstract

This paper identifies a long-run relationship between consumption, labour income and wealth in Australian data over the period 1976:4-2004:3. It also finds a long-run relationship between consumption, labour income and the two components of wealth, namely, financial and non-financial wealth. The estimated vector-error correction models show that wealth and, principally non-financial wealth, adjusts the most to restore the long-run cointegrating relation among the variables in response to a transitory shock. The transitory component of wealth, particularly of non-financial wealth, is large relative to the transitory component of consumption and labour income. Since 2003, non-financial wealth has increased dramatically to levels above trend that are unprecedented historically. At the same time consumption has not significantly moved above trend and this implies that a downward adjustment in non-financial wealth (that is, a fall in housing prices) is expected by households in the future to re-establish the long-run relationship among the series.

Lance A. Fisher
Glenn Otto
School of Economics
University of New South Wales
Sydney, NSW, 2053, Australia
Email: L.Fisher@unsw.edu.au
G.Otto@unsw.edu.au

Graham M. Voss
Department of Economics
University of Victoria
PO Box 1700 STN CSC
Victoria, BC V8W 2Y2, Canada
Email: gvoss@uvic.ca

1. Introduction

The recent strong growth in household wealth in many countries motivates a number of studies to examine the relationship between household consumption and wealth. A key concern of such studies is how household consumption is likely to react to variations in household wealth, particularly the possibility of substantial declines in stock market or housing asset values with subsequent repercussions for aggregate consumption. To this end, long run relationships between consumption and wealth are often used as a guide to wealth effects on consumption.[1]

These long run relationships, however, must be used with some care. This point is emphasised in a recent US study, Lettau and Ludvigson (2004), which demonstrates that much of the variation in US household asset wealth, although highly persistent, is transitory in nature eliciting little or no response in household consumption. Long run estimates of wealth effects then overstate the adjustment of consumption to conjectured changes in asset wealth as the possible adjustment to wealth itself is ignored.

In general to understand the relationship between consumption and wealth requires a systems approach: modelling the endogenous behaviour of both consumption and wealth, as well as identifying economically interpretable disturbances. This allows for a coherent data-based assessment of the likely behaviour of consumption and wealth to underlying disturbances. This study re-evaluates the wealth effect on consumption in Australia using a systems approach to modelling, a vector error correction model for consumption, labour income and wealth. It follows Lettau and Ludvigson (2004) by considering the permanent and transitory shocks that underlie the model and the relative importance these shocks have for the series of interest.

Our study makes some additional contributions. As part of the empirical work, we explore in detail the long run relationship between consumption, labour income, and wealth – the underlying relationship for studies such as ours. Previous studies, both for Australia and the US, suggest that the long-run relationship between these series is not particularly robust. As this matters for both the long run and dynamic relationships it is important to have a clear picture of the robustness of this relationship.

We also consider the individual behaviour of the components of household wealth, financial and non-financial (housing) assets. In Australia, the non-financial assets represent about sixty percent of household assets and the steep increase in wealth in recent years is largely explained by increases in housing prices (see for example Tan and Voss, 2003). In contrast, much of the increase in US aggregate household wealth in recent years (specifically the 1990s) is explained by rising values of household equity holdings (Poterba, 2000).[2]

---

[1] Lettau and Ludvigson (2004) provide a summary of recent instances of wealth effects calculated from such long run relationships. Poterba (2000) is an example for the US; Tan and Voss (2003) is an example for Australia. Other recent related studies are Hamburg et al. (2005) for Germany, Pichette and Tremblay (2003) for Canada, and Fernandez-Corugedo et al. (2002) for the UK.

[2] Additional evidence that US household asset wealth is dominated by equity market returns is given in Lettau and Ludvigson (2004), which notes a very high correlation between quarterly fluctuations in household net worth and movements in equity returns. It is possible, however, to overstress the dependence of household wealth in the US on financial assets. While this is certainly true in aggregate, the situation is

The format of the paper is follows. Section 2 briefly reviews related literature and puts our work into context. In section 3, we present the empirical model and sketch its relationship to standard theories of household consumption. Section 4 presents the empirical model estimation including a variety of robustness checks on our principal conclusions. Finally, section 5 summarizes our principal results and implications for policy makers concerning the behaviour of consumption and wealth.

2. Related Literature: Theory and Existing Empirical Work

In two important papers, Lettau and Ludvigson (2001, 2004) have reconsidered the relationship between consumption, labour income and wealth for the United States. They identify the permanent and transitory components in these series and re-evaluate the importance of the wealth effect on consumption. They show that most of the variation in wealth is transitory and quite persistent and that consumption responds very little to transitory wealth fluctuations. As a result, large movements in wealth are estimated to have a small impact on consumption, much smaller than the estimates reported in earlier U.S. studies. They attribute most of the variation in wealth to fluctuations in stock market wealth and correspondingly very little to fluctuations in non-stock market wealth, which is mainly housing wealth. Like consumption, the transitory component of non-stock market wealth is small whereas for stock market wealth it is large.

The importance of the wealth effect on consumption in Australia has recently been investigated by Tan and Voss (2003). They find that the wealth effect on consumption is quantitatively important and that consumption responds more strongly to changes in non-financial wealth than to changes in financial wealth. However, their analysis was conducted in a single-equation framework which, as they note, assumes all of the adjustment to changes in wealth occurs through consumption changes and that is likely to over-estimate the wealth effect on consumption. Rather than focus on the wealth effect on consumption, Fisher and Voss (2004) adopt the approach of Lettau and Ludvigson (2001) and evaluate the predictive content of deviations from the estimated relationship between consumption, labour income and wealth for consumption growth, labour income growth and stock market returns in Australia. They find that deviations from the estimated relationship forecasts next period's return on the aggregate stock market index but not consumption and labour income growth over next period. That implies there is an important transitory component to stock market wealth because stock returns are predictable and an unimportant transitory component to consumption as consumption growth is not predictable, which has implications for the wealth effect on consumption.

The present paper directly estimates the permanent and transitory component in consumption, labour income and wealth, along the lines of Lettau and Ludvigon (2004) and reconsiders the question of how important fluctuations in wealth are for consumption changes in Australia. Moreover, the present paper estimates the permanent and transitory component in both components of wealth, financial and non-financial wealth, and evaluates their separate effect on consumption. Most of the transitory variation in wealth is attributable to transitory variation in non-financial wealth though transitory variation in

---

somewhat distorted by the highly unequal distribution of wealth in the US. For example, less than 10 percent of US households both owned a home and held equity worth more than the value of their home in 1998 (Poterba, 2000). We return to this issue later in the paper.

financial wealth is nevertheless significant. There is little response of consumption and labour income to transitory variation in both components of wealth. Thus, it is expected that the large deviation of wealth above its stochastic trend that is observed in recent Australian data will be corrected by a downward adjustment in wealth, principally non-financial wealth, rather than by any adjustment in consumption and labour income.

The relationship between consumption and wealth has also been investigated for some other countries following the approach of Lettau and Ludvigson (2001, 2004). Fernandez-Corugedo, Price and Blake (2002) find in U.K. data a sizable transitory component to wealth and that most of the adjustment to deviations from the long-run relation occurs through wealth. The results in this paper are quite similar to our own. Pichette and Tremblay (2003) consider the relationship between consumption and wealth in Canada and find an important wealth effect on consumption from fluctuations in housing wealth but not from fluctuations in stock market wealth. Hamburg, Hoffman and Keller (2005) find that changes in wealth have virtually no effect on consumption in Germany and that, unlike for Australia, the U.K. and Canada, the transitory component of wealth is small. In particular, they find that deviations from the long-run relation between consumption, labour income and wealth are corrected through adjustments in labour income and not wealth.

3. Empirical Models

In this section, we lay out the long-run models of consumption and wealth that form the basis of our empirical modelling in the following section. We then discuss how this long-run relationship can be interpreted in the context of a dynamic system relating consumption, wealth and labour income.

3.1 Long run relationship

The basis for our empirical model is a long run relationship between consumption, labour income, and household wealth that arises from a standard budget constraint for a representative agent economy. The relationship is developed in Lettau and Ludvigson (2001, 2004), building on earlier work by Campbell and Mankiw (1989) and is an approximation to the budget constraint evaluated around a steady share of consumption to total wealth. We extend the relationship from these papers in a straightforward manner to include a decomposition of total wealth into three components: human wealth, financial wealth and non-financial wealth. That is, $W_t = H_t + A_{ft} + A_{nt}$, where W_t is total household wealth (beginning of period and in real per capita terms), H_t is human wealth, A_{ft} is financial wealth, and A_{nt} is non-financial wealth. In the following analysis we assume that the shares of wealth for each of these three components have stable steady state values.

We consider two versions of the long run relationship, with and without the decomposition of asset wealth into financial and non-financial wealth. The two relationships are:

$$c_t - \beta_0 - \beta_1 y_t - \beta_2 a_t = u_t \quad (1)$$

$$c_t - \gamma_0 - \gamma_1 y_t - \gamma_2 a_{ft} - \gamma_3 a_{nt} = v_t \quad (2)$$

All variables are in logarithms with c_t total consumption, y_t after tax labour income, a_t total non-human wealth (that is, both financial and non-financial assets), a_{ft} financial wealth, and a_{nt} non-financial wealth. The two error terms u_t and v_t are mean zero stationary variables. The two constant terms arise from the linearization of the budget constraint. The slope coefficients are steady state share of wealth parameters and in principle $\beta_1 + \beta_2 = 1$ and $\gamma_1 + \gamma_2 + \gamma_3 = 1$.[3] So, for example, $\beta_2 = \overline{A/W}$, the steady state ratio of non-human assets in total wealth. Labour income is introduced into the model as a means of measuring human assets; consequently, $\beta_1 = \gamma_1 = \overline{H/W}$.

Under the assumption that c_t, y_t, a_t, a_{ft}, and a_{nt} are all first difference stationary then equations (1) and (2) are cointegrating relationships, which we use as the basis of our empirical models of consumption and wealth. Before proceeding with the estimation, however, it is useful to briefly discuss a number of aspects of equations (1) and (2) that bear on the estimation and interpretation of the empirical results. Both equations are approximations based upon the inter-temporal budget constraint of a representative agent with no explicit behavioural theory modelled other than the imposition of standard transversality conditions and the assumptions that all asset markets are complete and without imperfections. The equations also assume that human wealth can be measured, in logarithms, as the sum of current labour income and a mean zero stationary process; see Lettau and Ludvigson (2001) for details.

The error terms in equations (1) and (2) are assumed to be mean zero stationary random variables. In general terms they consist of expected future log differences of consumption and labour income (discounted) as well as expected future net returns on the different asset components (also discounted). For (1) and (2) to represent cointegrating relationships, these variables must be first difference stationary.

Finally, and most importantly, the log approximations assume a stable steady state ratio of consumption to total wealth and stable steady state shares of wealth components in total wealth. These bear on both the prediction that the errors in equations (1) and (2) are stationary and that the coefficients in equations (1) and (2) are stable. In the empirical work that follows, there is a reasonable suggestion that these assumptions are not valid and contribute to weaknesses in the empirical results. The reason for this is easily anticipated. As discussed earlier, there is some evidence that consumption has not growth as strongly as wealth in the last few years of the sample; moreover, there is evidence that non-financial assets, primarily housing, have increased in value more rapidly than other components of household wealth. Both of these may be sufficient to cause (1) and (2) to fail as cointegrating relationships.

3.2 Dynamic System

If either of the models (1) and (2) are found to represent valid cointegrating relationships then it is common to interpret the coefficients as long run elasticities for consumption relative to labour income and wealth; in a similar manner, they may also be

[3] As noted in Lettau and Ludvigson (2001), however, this only holds exactly if consumption, which includes durables, is properly measured. As our measure of consumption includes expenditure on durables rather than consumption, we can expect the sum of these coefficients to differ from unity.

used to construct long run marginal propensities to consume relative to these variables. Lettau and Ludvigson (2004), however, stress that such interpretations are potentially misleading.

To see this, consider how we might interpret model (1). Suppose we interpret the coefficient on wealth as the long run elasticity of consumption with respect to wealth and argue that a permanent rise in wealth gives rise to a certain percentage increase (in this case β_2) in consumption. While this is true given (1), it is not a particularly interesting interpretation as it implicitly treats wealth, and labour income, as exogenous variables when they are in fact endogenous variables responding to underlying exogenous shocks, as is consumption itself. To put this in slightly different terms, imagine a shock to wealth that raises current wealth by a certain amount and ask what we might infer from equation (1) about the response of consumption. The answer is essentially nothing, both for the short run and long run response of consumption. To determine the response of consumption we need to know how consumption itself initially responds to the underlying shock and how all of consumption, labour income and wealth respond to the shock over time – that is, we require a model of the adjustment paths that restore the long run relationship given in (1). This requires a dynamic system of equations with (1) or (2) providing the long run steady state for the system, which, as is well known, is associated the vector error correction model.

A vector error correction model for equation (1) assuming there are no short-run dynamics is:

$$\Delta c_t = \mu_c + \alpha_c (c_{t-1} - \hat{\beta}_1 y_{t-1} - \hat{\beta}_2 a_{t-1}) + \varepsilon_{ct}$$

$$\Delta y_t = \mu_y + \alpha_y (c_{t-1} - \hat{\beta}_1 y_{t-1} - \hat{\beta}_2 a_{t-1}) + \varepsilon_{yt}$$

$$\Delta a_t = \mu_a + \alpha_a (c_{t-1} - \hat{\beta}_1 y_{t-1} - \hat{\beta}_2 a_{t-1}) + \varepsilon_{at}$$

In this model it is the adjustment coefficients on the error correction mechanism that are of particular interest. They indicate how each of the three variables in the system adjust to restore equilibrium following a shock to the error correction mechanism. Lettau and Ludvigson's work for the US indicates the pattern for the adjustment coefficients is $\alpha_c = \alpha_y = 0$ and $\alpha_a \neq 0$. This implies that when a shock to the economy disturbs the long run equilibrium relationship for consumption, labour income and wealth, it is the stock of wealth (and only the stock of wealth) that adjusts to restore equilibrium.

In this model all of the adjustment to restore equilibrium following a disturbance to the long-run equilibrium is via changes in the stock of wealth. Thus, even if it can be established that equilibrium relationships of the form of (1) or (2) hold for the Australian economy, an understanding of the adjustment process requires that we estimate the full error correction system. Previous studies of consumption for Australia have either not done so or only tentatively.[4]

[4] For example, Tan and Voss (2003) examine the effects of permanent changes in the level of wealth using only a single equation error correction model for consumption. This assumes that all of the adjustment to a change in the level of wealth occurs through consumption, a point the authors note but do not explore. Fisher and Voss (2004) note that in the sample for which they found tentative evidence for cointegration,

4. Estimation

4.1 Data

The data we use are similar to Tan and Voss (2003) and Fisher and Voss (2004). The series used are: total consumption, c_t; total household net wealth a_t, and its components of net financial assets a_{ft} and net non-financial assets a_{nt}; and after-tax labour income y_t. The sample period is 1976:4–2004:3, which represents all of the available data at the time of the study. All variables are quarterly in real per capita terms and in logarithms. The consumption deflator is used to express all series in real terms. For calculation of net assets, household debt is distributed between financial and non-financial assets proportionally (see Tan and Voss, 2003). The series used in estimation are presented in Figure 1.

The discussion in the previous section identified cointegrating relationships between the variables of interest conditional on these variables being first difference stationary. Standard augmented Dickey-Fuller tests establish that all of the variables of interest are first difference stationary at standard significance levels.

4.2 Long Run Estimates

The first task is to establish that the long run relationships in equations (1) and (2) are cointegrating relationships and to estimate the parameters of these relationships. To test for cointegration, we estimate equations (1) and (2) by OLS and apply various tests for a unit root in the residuals; in each case, this is a test of a null hypothesis of no cointegration.[5] The tests we apply to the residuals from cointegrating regressions are the augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) and Phillips-Ouliaris (Z_τ) tests. The ADF regression was estimated with four lags of the first differenced residuals which was sufficient to take account of serial correlation in the residuals. To estimate the parameters of the relationships, we use dynamic ordinary least squares methods (DOLS) due to Stock and Watson (1993). The results for the cointegration tests and the DOLS estimated parameters are reported in Table 1.

For equation (1), all the residual based tests reject the null of no cointegration at the five percent level. For equation (2), the null of no cointegration is rejected by two of the tests at the five percent level; the ADF test rejects the null only at the ten percent level. The evidence for cointegration appears marginally stronger in the case of equation (1) than equation (2) but in both cases the evidence for cointegration is strong. Having established that (1) and (2) are cointegrating relationships, efficient estimates of the cointegrating parameters are obtained from DOLS estimation. The DOLS regressions augment the OLS regressions with *k* leads through to *k* lags of the first difference of the right-hand side variables. The choice of *k* is essentially arbitrary. We reports parameter estimates for *k*=4, although the parameter estimates are broadly similar for *k*=2 and *k*=3.

---

the estimated adjustment coefficients in the vector-error correction model show that wealth and not consumption or labour income adjusted to deviations from the long-run relation as in Lettau and Ludvigson (2001, 2004).

[5] Davidson and MacKinnon (1993) argue that this procedure may have low power to reject the null hypothesis of no cointegration. If this is the case then actually rejecting the null would seem to provide very strong evidence for cointegration.

In addition to finding support for cointegration an important criterion for evaluating models (1) and (2) is whether the parameter estimates reported in Table 1 are sensible. The log-linear approximation to the budget constraint makes a strong prediction concerning the parameter values: they are equal to the shares in total wealth of human wealth (labour income as proxy) and non-human wealth or its components. Unfortunately, these share values are unobservable. We can, however, compare our results to Lettau and Ludvigson (2004) for the US. Moreover, we do know that the share of non-financial assets should be larger than the share of financial assets so this provides a further check. Finally, the coefficients should sum to one.

The estimates in Table 1 are broadly supportive of these predictions. The sum of the coefficients is very close to one for both the three and four variable model and as anticipated the coefficient on non-financial wealth is larger than that on financial wealth, though by not much. The coefficient estimates are also broadly consistent with the US results in Lettau and Ludvigson (2004). We can also compare the coefficients across the two models to see if they are consistent. The sum of the wealth component coefficients in the four variable model should be equal to the coefficient on total wealth in the three variable model (since $A/W = A_f/W + A_n/W$). And the coefficients in Table 1 are broadly supportive of this prediction.

The long run coefficient estimates for models (1) and (2) define long run residuals, the error correction terms that are assumed stationary, based on the tests for cointegration reported in Table 1. As a diagnostic check, we consider the behaviour of these residuals, which are shown in Figure 2. Inspection of these residuals anticipates some of the issues that we examine in the dynamic system in the following section. For both models the end of the sample is characterized by large negative residuals, relatively larger than at other points in the sample. This arises because of the large increase in wealth in the latter part of the sample, primarily but not entirely due to increases in non-financial assets associated with the boom in housing prices. The large residual arises because neither consumption nor labour income adjusts over this period to offset the increases in wealth.

The behavioural implications of the relative responses of consumption and wealth we consider in the next section. For now, we note that this residual may be an indication of specification problems with our estimated long run models. In particular, it may be an artifact of structural change in the long run model of which we have not taken proper account. These are important issues. For the moment, we proceed under the assumption that the full sample estimates are the best way to interpret the data. Subsequently, we consider the issue of parameter stability in greater detail. To foreshadow the results from this robustness analysis, we do find evidence of instability; however the conclusions of main analysis are unchanged.

4.3 Vector Error Correction Models

Associated with the long-run models represented by equations (1) and (2) are vector-error correction (VEC) models which characterize the dynamic adjustment of the variables to deviations from long-run equilibrium. The VEC representation is

$$\Delta X_t = \mu + \Pi X_{t-1} + \Pi_1 \Delta X_{t-1} + \ldots + \Pi_{k-1} \Delta X_{t-k+1} + \varepsilon_t, \tag{3}$$

where $X_t = (c_t \ y_t \ a_t)'$ or $X_t = (c_t \ y_t \ a_{ft} \ a_{nt})'$, Δ is the first difference operator , μ is a vector of intercepts, Π_i is the matrix of coefficients on the *i*th lagged change in X_t and ε_t is a vector of serially uncorrelated random disturbances with mean zero and covariance matrix Ω. The matrix Π provides information about the long-run relationships among the series. In particular, $\Pi = \alpha\beta'$ where the coefficients in the column vector β are the DOLS estimates of the cointegrating parameters and the coefficients in the column vector α are the adjustment coefficients or loadings on the error-correction term $\beta' X_{t-1}$ in each equation of the VEC model. We note for future reference that if the adjustment coefficient or loading on the error correction term in an equation of ΔX_t is zero, then the dependent variable of that equation is said to be weakly exogenous.

Table 2 reports estimates of the VEC models corresponding to equations (1) and (2) for the full sample. Both VEC models were estimated with three lags which was the optimal lag length selected by the AIC criterion and the log-likelihood ratio statistic. Consider first the results for the aggregate wealth model. The error correction term is statistically significant at the 5-percent level in the wealth equation where it enters with a positive sign and is significant at the 10-percent level in the consumption equation where it enters with a negative sign. When private saving is low (that is, the error-correction term is high either because consumption is high or labour income and wealth are low), consumption is predicted to fall and household wealth to rise thereby restoring the long-run relation. Consumption adjusts more slowly than wealth since its adjustment coefficient is considerably smaller (in absolute value) than it is for wealth. Labour income is weakly exogenous as the error-correction term is not statistically significant in the labour income equation. In Australia, adjustment to deviations from the long-run relationship occurs through both consumption and wealth changes whereas, in the U.S., the adjustment occurs only through wealth changes (Lettau and Ludvigson, 2004).

Further, lagged changes in wealth, in addition to the error-correction term, predict current changes in consumption. Thus, the permanent income hypothesis is formally rejected for Australia. Under this hypothesis, current consumption changes are unpredictable on the basis of any lagged information set. The permanent income hypothesis is also strictly rejected for the U.S. as lagged changes in consumption and household wealth contain predictive content for current consumption changes (Lettau and Ludvigson, 2004). Table 1 also shows that current changes in labour income are predictable on the basis of lagged changes in labour income and wealth, which is also the finding of Lettau and Ludvigson (2004) in U.S. data. Thus there is a transitory component in labour income even though it is weakly exogenous in the VEC model.

Turning to the disaggregated wealth model, the error-correction term is not statistically significant in either of the wealth equations, although its coefficient in the non-financial wealth equation is very similar to that in the aggregate wealth equation. It is statistically significant at the 10-percent level in the consumption equation and enters with a negative sign as before and is not significant in the labour income equation. Also, lagged changes in non-financial wealth have predictive power for current changes in consumption, labour income and non-financial wealth whereas current changes in financial wealth appear unpredictable. The disaggregate wealth model appears to be less precisely estimated than the aggregate one. Nevertheless, we can tentatively conclude that the adjustment process is the same and of the two components of wealth it is non-financial wealth that adjusts to deviations from the cointegrating relation.

4.4 Dynamic interactions

Dynamic interactions among the variables can also be evaluated in terms of the moving average representation of the VEC model. As shown in Johansen (1991), the VEC model (3) can be inverted to obtain the moving average representation for ΔX_t :

$$\Delta X_t = \rho + C(L)\varepsilon_t \qquad (4)$$

where $\rho = C(1)\mu$, L is the lag operator and $C(1) = I + \sum_{i=1}^{\infty} C_i L^i = \beta_\perp \gamma \alpha_\perp'$. Here $\gamma = (\alpha_\perp' \Psi \beta_\perp)^{-1}$, $\Psi = I - \sum_{i=1}^{k-1} \Pi_i$ and the subscript ($\perp$) denotes a matrix orthogonal to the original matrix. In the context of model (1), there is one shock which has transitory effects on the levels of the variables and two stocks which have potentially permanent effects. This follows because there is one cointegrating relation among three variables (Stock and Watson, 1988). Similarly for model (2) there is one shock which has transitory effects and three which have potentially permanent effects on the levels of the series.

There are several ways to transform the shocks from the VEC model into shocks which have permanent and transitory effects. Following Gonzalo and Ng (2001), define

$$G = \begin{bmatrix} \alpha_\perp' \\ \beta' \end{bmatrix}.$$

The first step is to transform the errors from the VEC model to obtain $u_t = G\varepsilon_t$. It is straightforward to show that the shocks constructed as $\alpha_\perp' \varepsilon_t$ have permanent effects on the levels of the series while, in our case, the single shock $\beta' \varepsilon_t$ has only a transitory effect.[6] However, the permanent and transitory shocks are not necessarily orthogonal to one another. The second step is to orthogonalize the permanent and transitory shocks by applying the transformation $v_t = H^{-1} u_t = H^{-1} G \varepsilon_t$ where H is the lower triangular matrix such that $HH' = G\Omega G'$. Once the permanent and transitory shocks are made orthogonal, it is meaningful to show the response of each series to the shocks v_t and to calculate forecast-error variance decompositions. Gonzalo and Ng (2001) recommend constraining statistically insignificant adjustment coefficients in estimated α to zero before constructing $\alpha_\perp$ because $C(1)$ (which depends on $\alpha_\perp$) can be very sensitive to small variations in estimated α . Thus, in the empirical analysis that follows, the VEC model is estimated under the restriction that labour income is weakly exogenous, a restriction not rejected by the data and it is from this model that we form our estimate of $\alpha_\perp$.

Table 3 shows the decomposition of the jth-step ahead forecast error variance in the series that comprise the two models. As we are not concerned with the interpretation

---

[6] Specifically, the last column of the matrix $C(1)G^{-1}$, which gives the long-run impacts of the shocks u_t , is a column vector of zeros, as required for a permanent-transitory decomposition.

of the permanent shocks individually, the table reports the percent contribution of the permanent shocks combined to the forecast error variance together with the contribution of the single transitory shock. Consider the results of model (1) first. The transitory shock accounts for about 37 percent of the forecast-error variance in consumption at the one-quarter horizon and declines to about 10 percent at the four-quarter horizon. The two permanent shocks together correspondingly account for over 90 percent of the forecast-error variance in consumption at horizons of four quarters and more. Almost all of the variability in labour income is attributable to the two permanent shocks which account for over 93 percent of the forecast-error variance at all horizons. The transitory shock is more important here for consumption over short horizons than it is in U.S. and U.K. data (Lettau and Ludvigson, 2004, Fernandez-Corugedo et al, 2002, respectively) and in all three countries the transitory shock explains a negligible amount of the variability in labour income.

The findings are quite different for household wealth. The transitory shock accounts for about 42 percent of the forecast error variance in wealth at an horizon of one quarter, 34 percent at four quarters and 25 percent at eight quarters. Thus, the contribution of the transitory shock to the forecast-error variance in wealth is larger and more persistent than it is in consumption. Its contribution is also much smaller here than in U.S. data where it accounts for over 90 percent of the variability in wealth (Lettau and Ludvigson, 2004) but is of the same order of magnitude as in U.K. data (Fernandez-Corugedo et al, 2002).

Turning to the results for model (2), the transitory shock is just as important in explaining consumption variability at short horizons as it is in model (1). It also accounts for a negligible amount of the variability in labour income at all horizons. The most interesting feature of the results is that transitory shock accounts for a considerably larger portion of the forecast-error variance in non-financial wealth than in financial wealth at all forecast horizons and, taken together, the transitory shock accounts for as much variability in wealth as in model (1). It appears that most of the adjustment in wealth to the transitory shock occurs through non-financial wealth.

Figure 3 shows the responses of the levels of the series in each model to a one-standard error transitory shock along with the responses of the estimated cointegrating residual or error-correction term. Focusing on the responses in model (1) shown in part (a) of the figure, the transitory shock leads to a sharp increase in wealth which gradually dissipates over the next 10 quarters. Thus the transitory increase in wealth is quite persistent and is eliminated only after two and a half years. By comparison, the consumption and labour income responses are small. The response of labour income is somewhat larger than consumption to the transitory shock but both responses are small by comparison to the wealth response. The response of the error correction term predominantly reflects the response of wealth to the transitory shock since it is wealth that responds the most and thus adjusts the most to eliminate deviations from the long-run relationship.

The responses to the transitory shock in model (2) are shown in part (b) of the figure. The response of non-financial wealth is large and persistent being eliminated only after about three years. The response of financial wealth is less than half of that of non-financial wealth and is less persistent dissipating after about two years. The responses of consumption and labour income are small and practically identical to their responses in part (a). The adjustment path of the error correction term primarily reflects the response of non-financial wealth and, to a lesser extent, financial wealth to the transitory shock. Of the two components of wealth, it is non-financial wealth that adjusts the most to restore the long-run relation following a transitory shock.

4.5 Permanent and transitory components

The moving average representation (4) can be summed to obtain a representation for the levels of a variable as the sum of a permanent and transitory component. Specifically, $X_t = X_t^p + X_t^s$ where the *i*th element of the vectors X_t^p and X_t^s is the permanent and transitory component of the *i*th variable at time t, respectively. The vector of permanent components is given by

$$X_t^p = X_0 + C(1)\sum_{i=1}^{t}(\varepsilon_i + \mu), \qquad (5)$$

(see Johansen, 1991) where X_0 is the vector of initial permanent values and the vector of transitory components X_t^s is stationary by construction.[7] The permanent component of the variable constructed from (5) can be thought of as the long-run forecast or trend component of the variable and the transitory component as stationary deviations of the variable from its trend.

The three panels of Figure 4 plot the permanent component of consumption, labour income and household wealth together with their actual values. The permanent components are calculated from the estimated VEC model according to equation (5).[8] Consumption is a very smooth series and is quite indistinguishable from its trend. Labour income has diverged from its estimated trend at times over the sample but not for prolonged periods. Mostly recently, labour income appears to have moved above its estimated trend. Wealth has diverged considerably at times from its estimated trend and for prolonged periods. Thus wealth appears to revert more slowly to its trend than labour income. Since 2003, wealth has moved substantially above its estimated trend and this divergence is much larger and more pronounced than at any other time in the sample. Because there is very little corresponding upward movement in consumption above trend, it appears that the recent surge in wealth is viewed as transitory and that wealth is expected to revert to back to its trend.

A clearer picture is provided in Figure 5 which shows the transitory component in each series directly as the difference between the actual value of the series and its permanent component. The most striking feature of the figure is that the transitory component of wealth is large, particularly since 2003 and highly persistent: the first-order autocorrelation coefficient of transitory wealth is 0.88 over the sample. The transitory increase in wealth since 2003 is unprecedented historically. By contrast, the transitory

---

[7] The vector of permanent components can also be expressed in terms of the orthogonal permanent-transitory shocks as $X_t^p = X_0 + \Gamma(1)\sum_{i=1}^{t}(v_i + \mu^*)$ where $\Gamma(1) = C(1)G^{-1}H$ and $\mu^* = H^{-1}G\mu$. Both representations are equivalent and yield exactly the same decomposition.

[8] Recall that the VEC model is estimated under the restriction of weak exogeneity of labour income. We estimate each initial permanent component in equation (5) by forecasting 108 periods ahead beginning in 1977:4 from the estimated VEC model and then subtracting off the deterministic portion of the forecast.

component in labour income is smaller and less persistent (the first-order autocorrelation coefficient is 0.55) and the transitory component of consumption is practically negligible. Since 2003 labour income has increased above trend while consumption has increased to be slightly on trend. The lack of a large consumption response to the recent surge in wealth suggests that transitory wealth will fall so that wealth will revert to its trend thereby re-establishing the long-run cointegrating relation.

Figure 6 shows the transitory component of each series in the four variable model. The transitory component in consumption and labour income is very similar across the three and four variable models. Transitory fluctuations in wealth are attributable to the transitory component in both financial and non-financial wealth. However, as figure 6 shows, it is the transitory component in non-financial wealth which is the more important. Increases in the transitory component of non-financial wealth observed in the figure are attributable to the rapid rise in houses prices that occurred in 1983-84 following financial deregulation, 1987-89, 1993-95 and more recently since 2000. However, transitory variation in financial wealth has also been important, particularly over 1999-2003, the period of the recent stock market boom. Nevertheless, the unprecedented surge in wealth since 2003 is chiefly due to the transitory increase in non-financial wealth as a result of a strong housing market.

4.6 Stability

In this section, we consider the possibility that the coefficient estimates in the cointegrating relation show temporal instability. This is of concern since the large residuals we observe since 2003 in figure 2 may either arise from a sequence of unusually large shocks to the variables or be indicative of a changed relationship between consumption, labour income and wealth that invalidates the conclusions from our econometric analysis. We address the issue of parameter instability by reporting the result of the *SupF* test for instability in cointegrated regression models proposed by Hansen (1992). The null hypothesis of the test is that the coefficients in the cointegrating relation are stable and the alternative is that there is a single structural break of unknown break date in the coefficients of the cointegrating relation. The test is essentially a sequence of Chow F-tests for structural change in the cointegrating regression conducted for each break date in a rolling window through the sample. The largest F-statistic obtained is then compared to the appropriate critical value tabulated in Hansen (1992). For our sample *SupF* = 47.3 for model (1) which far exceeds the 5 percent critical value of 15.2. Thus, the test rejects the null hypothesis of parameter stability in model (1). The *SupF* statistic occurs at a break date of 1998:3.

While the test suggests instability in the parameter estimates, it is possible that the instability is not sufficiently large enough to invalidate the conclusions that we have already drawn from the econometric analysis. Some instability in the coefficient estimates is expected since in the last two decades Australia has witnessed a great deal of structural reform in financial markets that may have altered the relative importance of non-human assets (and its components) in total wealth. In this case, we should observe changes in the long-run coefficient estimates as well as the constant coefficient, all of which depend upon the relative shares of wealth. To investigate whether our conclusions are robust in view of the finding of instability and a break date of 1998:3, we re-estimate our models for the sample that ends in 1998:3 and see whether we can draw the same conclusions, particularly concerning transitory variation in consumption and wealth, as we did previously.

Table 4 reports the results of the cointegration analysis for the sample 1976:4-1998:3. For the three variable model, there is evidence for cointegration at the 5 percent level on the basis of all the tests. For the four variable model, the ADF test rejects the null of no cointegration only marginally above the 5 percent level while the other two tests clearly reject the null at the 5 percent level. Compared to the full sample results, the evidence for cointegration is somewhat stronger in the sub-sample. The DOLS estimated coefficients in both models are strikingly similar to their corresponding full sample estimates. Thus the estimated long-run coefficients appear remarkably robust, notwithstanding that there was some evidence for a structural break in the cointegrating relation for the aggregate wealth model at 1998:3. Estimates of the adjustment coefficients in the VEC models for the sub-sample are also shown in table 4. For the three variable model, the estimated coefficient on the error correction term in the consumption and wealth equations is highly significant and is about twice as large as that estimated for the full sample. Thus, consumption and wealth both adjust more quickly in the sub-sample than in the full sample to deviations from the long-run cointegrating relation. For the four variable model, the coefficient on the error-correction term appears to be more precisely estimated in the consumption equation and in both wealth equations than in the full sample. The adjustment coefficient for consumption is significant at the 5 percent level and for non-financial and financial wealth, it is significant at the 10 and 11 percent levels, respectively. Thus the evidence is stronger in the sub-sample that consumption and both components of wealth adjust to deviations from the long-run relationship. The error-correction term is not significant in the equation for labour income in both models and, as in the full sample, labour income is weakly exogenous and plays no part in the adjustment process.

Table 5 shows the decomposition of the forecast-error variance in the variables when both VEC models are estimated over the sub-sample.[9] The forecast error variance decompositions for the sub-sample are practically the same as for the full sample. The only notable difference is that the transitory shock accounts for a slightly larger percentage of the forecast-error variance in financial wealth at short horizons. Figure 7 shows the responses of the variables to the transitory shock over the sub-sample. For both the three and four variable models, the responses are qualitatively the same as for the full sample reported in figure 3. The largest response to the transitory shock occurs in wealth and, more specifically, in non-financial wealth. The response of financial wealth is also large up to horizons of four quarters but is somewhat less than half as much as the response of non-financial wealth and dissipates more quickly. The response of consumption and labour income to the transitory shock is small. Thus, as in the full sample, it is the adjustment in wealth that primarily restores the long-run cointegrating relations following a transitory shock.

Up to this point the conclusions we draw from the econometric analysis are essentially the same irrespective of whether the models are estimated over the sub-sample

[9] As for the full sample, the forecast error variance decompositions and the responses to the transitory shock are reported for the VEC models estimated under weakly exogenous labour income and with three lags.

or full sample. However, the question arises as to what the estimated sub-sample models say about the size of the transitory components in the series not only over the estimation period but also for the period 1998:4-2004:3. To address this question, the permanent components in both the three and four variable models are calculated according to equation (5), where the respective VEC models are estimated over the sub-sample under the restriction of weak exogeneity of labour income and with three lags. This gives the permanent component in the series for each model, respectively, from 1977:4-1998:3. To obtain the permanent component in the series for the remainder of the sample, the one-step ahead forecast of the variables from each VEC model is obtained and subtracted from the actual values of the variables to give out of sample residuals from 1998:4-2004:3. Placing these out of sample residuals in equation (5) provides estimates of the permanent component in the series of each VEC model from 1998:4-2004:3. Thus, we can obtain the transitory component in the series for each VEC model over the estimation and out of estimation samples.

Figures 8 and 9 show the transitory component in the series for the three and four variable models, respectively. These plots are remarkably similar to the corresponding plots obtained from full sample estimation shown in figures 5 and 6. In particular, on the basis of the sub-sample estimation, the transitory component in wealth is predicted to be large and positive from 2003 moving wealth above trend to historically unprecedented levels. Labour income is also predicted to increase strongly above trend from 2003 while consumption is relatively unchanged. Figure 9 shows that the predicted transitory increase in wealth from 2003 is mainly attributable to the predicted increase in non-financial wealth, although the transitory increase in financial wealth predicted over 2003 also contributes importantly. We conclude that irrespective of whether the estimation period is for the sub-sample or full sample, the inferences from the estimated VEC models are the same: from 2003 to the end of the sample, wealth, and in particular non-financial wealth, has increased to historically unprecedented levels above trend while consumption remains close to trend necessitating, in the near future, a downward adjustment in wealth and specifically, in non-financial wealth. Because the inferences from the sub-sample models are unchanged from those from the full-sample models, whatever instability in the parameter estimates that tests for structural stability may suggest, parameter instability does not appear to be large enough to alter our inferences.

5. Conclusions

This paper shows that there is a long-run relationship between consumption, labour income and wealth in Australian data. It also shows that there is a long-run relationship between consumption, labour income, financial wealth and non-financial wealth. The long-run relations imply that there is both a permanent and a transitory component in the series. For consumption and labour income, the transitory component is small. However, the transitory component in wealth and, particularly non-financial wealth, is large. Transitory movements in financial and non-financial wealth are largely unrelated to consumption spending because consumption is dominated by permanent components. This is particularly apparent towards the end of the sample where non-financial wealth has increased to unprecedented levels above its trend while at the same time consumption has moved only slightly around its trend resulting in large deviations from the long-run relationships. Thus, to re-establish the long-run relationships, it is wealth and principally non-financial wealth that is expected to adjust downwards, albeit somewhat slowly as its transitory component is quite persistent, so that a downward correction in housing prices is expected. With respect to policy implications, the Reserve Bank should not be unduly concerned about the potential impact on inflation of large swings in asset values since they do not translate into large swings in consumption spending, the largest component of aggregate demand.

6. References

Campbell, J.Y. (1996), "Understanding Risk and Return,"' *Journal of Political Economy* 104, 298–45.

Campbell, J.Y. and N.G. Mankiw (1989), "Consumption, Income and Interest Rates: Reinterpreting the Time Series Evidence," in O.J. Blanchard and S. Fischer, eds., *NBER Macroeconomics Annual: 1989*. Cambridge, MA: MIT Press, 185–216.

Davidson, R. and J.G. MacKinnon (1993), *Estimation and Inference in Econometrics*, Oxford University Press, Oxford.

Fernandez-Corugedo, E., S. Price, and A. Blake (2002), "The Dynamics of Consumer Expenditures: The U.K. Consumption ECM redux," Working paper, Bank of England.

Engle, R.F. and C.W. Granger (1987), "Co-Integration and Error Correction: Representation, Estimation, and Testing," *Econometrica* 55(2), 251–76.

Gonzalo, J. and S. Ng (2001), "A Systematic Framework for Analyzing the Dynamic Effects of Permanent and Transitory Shocks," *Journal of Economic Dynamics and Control* 25, 1527–46.

Fisher, L.A. and G.M. Voss (2004), "Consumption, Wealth and Expected Stock Returns in Australia," *The Economic Record* 80(251), 359–72.

Hamburg, B., Hoffman, M., and J. Keller (2005), "Consumption, Wealth and Business Cycles in Germany," CESIFO Working Paper 1443.

Hansen, B. E. (1992), "Tests for Parameter Instability in Regressions with I(1) Processes" *Journal of Business and Economic Statistics* 10, 45-59.

Johansen S. (1991), "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models," *Econometrica* 59, 1551–80.

Lettau, M. and S.C. Ludvigson (2001), "Consumption, Aggregate Wealth, and Expected Stock Returns," *The Journal of Finance* 66(3) June, 815–49.

Lettau, M. and S.C. Ludvigson (2004), "Understanding the Trend and Cycle in Asset Values: Reevaluating the Wealth Effect on Consumption," *American Economic Review* 94(1), 276–299.

Pichette, L. and D. Tremblay (2003), "Are Wealth Effects Important for Canada?" Bank of Canada Working Paper 2003-30.

Poterba, J.M. (2000), "Stock Market Wealth and Consumption," *Journal of Economic Perspectives* 14(2), 99–118.

Sims, C.A. (1980), "Macroeconomics and Reality," *Econometrica* 48, 1–48.

Stock, J.H. (1987), "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors," *Econometrica* 55, 1035–56.

Stock, J.H. and M. Watson (1993), "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica* 61, 783–820.

Tan, A. and G. Voss (2003), "Consumption and Wealth in Australia," *The Economic Record* 79(244), 39–56.

Table 1

Tests for cointegration and long-run estimates: sample 1976:4-2004:3.

Tests for cointegration	*ADF*(4)	*PP*	Z_τ	5% C.V.	10% C.V.
$c_t - \beta_0 - \beta_1 y_t - \beta_2 a_t$	-3.848	-3.534	-3.519	-3.80	-3.52
$c_t - \gamma_0 - \gamma_1 y_t - \gamma_2 a_{ft} - \gamma_3 a_{nt}$	-3.946	-4.381	-4.362	-4.16	-3.84

DOLS Estimates (k =4)

	β_0	β_1	β_2	*AR*(1)	
$c_t - \beta_0 - \beta_1 y_t - \beta_2 a_t$	-0.8444	0.6637	0.3031	0.763	
	(-40.00)	(14.99)	(19.21)		
	γ_0	γ_1	γ_2	γ_3	*AR*(1)
$c_t - \gamma_0 - \gamma_1 y_t - \gamma_2 a_{ft} - \gamma_3 a_{nt}$	-0.5991	0.6737	0.1323	0.1582	0.753
	(-14.03)	(12.07)	(11.55)	(5.15)	

Notes: This table reports residual based tests for cointegration based on the OLS estimates of the parameters in the cointegrating regressions. *ADF*(4) is the adjusted Dickey-Fuller *t*-statistic from the cointegrating regression, including four lags of the first differences of the OLS residuals. *PP* and Z_τ are the Phillips-Perron and Phillips-Ouliaris *t*-statistics, respectively. In each case, the autocovariance function is truncated at four lags. The critical values are taken from Hamilton (1994), Table B.8. The number of leads and lags of changes in the right-hand side variables in the DOLS regressions is k=4. *AR*(1) is the first-order autocorrelation coefficient of the estimated residuals from the DOLS regressions.

Table 2
Estimates of vector-error correction models conditional on DOLS estimates: estimation period 1977:4-2004:3

Dependent Variable	Equation			Equation			
	Δc_t	Δy_t	Δa_t	Δc_t	Δy_t	Δa_{ft}	Δa_{nt}
Constant	**0.0022**	-0.0003	0.1245	**0.0025**	0.0014	**0.0111**	0.0044
	(2.555)	(-0.138)	(0.449)	(2.623)	(0.608)	(3.498)	(1.257)
$\sum_{i=1}^{3} \Delta c_{t-i}$	0.0929	0.3723	-0.4732	0.1156	0.1145	-0.5151	-0.4965
	(0.517)	(0.846)	(-0.967)	(0.619)	(0.256)	(-0.828)	(-0.720)
$\sum_{i=1}^{3} \Delta y_{t-i}$	-0.0658	-0.5526	0.5415	-0.0885	-0.4152	0.4546	0.3548
	(-0.571)	(-1.956)	(1.723)	(-0.747)	(-1.459)	(1.153)	(0.812)
$\sum_{i=1}^{3} \Delta a_{t-i}$	**0.2091**	**0.5117**	**0.4060**				
	(3.534)	(3.531)	(2.519)				
$\sum_{i=1}^{3} \Delta a_{ft-i}$				0.0575	0.0302	0.1227	0.1136
				(1.163)	(0.254)	(0.746)	(0.623)
$\sum_{i=1}^{3} \Delta a_{nt-i}$				**0.1419**	**0.4329**	-0.1089	**0.5681**
				(3.291)	(4.176)	(-0.758)	(3.568)
ec_{t-1}	-0.0944	0.0333	**0.2734**	-0.1015	0.1527	0.1873	0.2979
	(-1.869)	(0.269)	(1.988)	(-1.807)	(1.131)	(1.001)	(1.436)
	[0.065]	[0.788]	[0.050]	[0.074]	[0.261]	[0.319]	[0.154]
$\overline{R}^2$	0.241	0.181	0.144	0.229	0.192	-0.022	0.163
s.e.	0.006	0.014	0.015	0.006	0.013	0.019	0.021
D.W.	1.954	2.057	1.984	1.945	2.064	1.975	1.995

Notes: In each equation, the sums of the estimated coefficients on the lags of the variables are reported, together with the *t*-statistic for the sum. *t*-statistics are shown in parentheses. Also shown is the associated *p*-value in square brackets for the estimated error-correction coefficient (*ec*) which is constructed from the dynamic ordinary least squares (DOLS) estimates reported in table 1. Significant coefficients at the 5-percent level are highlighted in bold face. Also shown are the adjusted *R*-squared statistic, the standard error of estimate (*s.e.*) and the Durbin-Watson (*D.W.*) statistic.

Table 3
Decomposition of forecast error variance: estimation period 1977:4-2004:3

	Three variable model						Four variable model							
	$c_{t+j} - E_t(c_{t+j})$		$y_{t+j} - E_t(y_{t+j})$		$a_{t+j} - E_t(a_{t+j})$		$c_{t+j} - E_t(c_{t+j})$		$y_{t+j} - E_t(y_{t+j})$		$a_{ft+j} - E_t(a_{ft+j})$		$a_{nt+j} - E_t(a_{nt+j})$	
j	P	T	P	T	P	T	P	T	P	T	P	T	P	T
1	63.08	36.92	100.0	0.00	58.23	41.77	58.17	41.83	100.0	0.00	87.18	12.83	73.64	26.36
2	72.49	27.51	99.92	0.08	64.74	35.26	68.16	31.84	99.92	0.08	89.83	10.17	76.01	23.99
3	83.69	16.31	97.84	2.16	64.73	35.27	50.76	19.24	97.90	2.10	89.38	10.62	75.39	24.61
4	90.21	9.79	96.40	3.60	65.76	34.24	88.11	11.89	96.52	3.48	90.17	9.23	76.05	23.95
6	93.89	6.11	93.31	6.69	70.07	29.93	93.03	6.97	92.77	7.23	93.17	6.83	79.83	20.17
8	95.26	4.74	93.15	6.86	74.77	25.23	94.76	5.24	92.21	7.79	94.84	5.16	83.90	16.10
12	96.76	3.24	94.43	5.57	81.51	18.49	96.44	3.56	93.57	6.43	96.61	3.39	89.17	10.83
16	97.62	2.38	95.43	4.57	85.36	14.64	97.42	2.58	94.78	5.23	97.50	2.50	91.72	8.28
20	98.11	1.89	96.11	3.89	87.89	12.11	97.97	2.03	95.57	4.43	98.02	1.98	93.24	6.76
24	98.44	1.56	96.63	3.37	89.68	10.32	98.33	1.67	96.16	3.84	98.36	1.64	94.30	5.70
60	99.39	0.61	98.47	1.53	95.57	4.43	99.35	0.65	98.28	1.72	99.36	0.64	97.65	2.36

Notes The table reports the percentage contribution of all the permanent shocks together (P) and the transitory shock (T) to the j-step ahead forecast error variance in the series for the three and four variable models. In the estimated VEC models, labour income is weakly exogenous and the number of lags is three.

Table 4

Tests for cointegration and estimates of the coefficients in the long-run relations and adjustment coefficients in the VEC model: sample 1976:4-1998:3.

Tests for cointegration	*ADF*(4)	*PP*	Z_τ	5% C.V.	10% C.V.
$c_t - \beta_0 - \beta_1 y_t - \beta_2 a_t$	-4.778	-4.310	-4.296	-3.80	-3.52
$c_t - \gamma_0 - \gamma_1 y_t - \gamma_2 a_{ft} - \gamma_3 a_{nt}$	-4.069	-4.249	-4.236	-4.16	-3.84

DOLS Estimates (k =4)

	β_0	β_1	β_2	*AR*(1)	
$c_t - \beta_0 - \beta_1 y_t - \beta_2 a_t$	-0.8469	0.6989	0.2921	0.544	
	(-36.69)	(16.85)	(22.97)		
	γ_0	γ_1	γ_2	γ_3	*AR*(1)
$c_t - \gamma_0 - \gamma_1 y_t - \gamma_2 a_{ft} - \gamma_3 a_{nt}$	-0.6164	0.6665	0.1148	0.1795	0.561
	(-8.18)	(10.48)	(6.66)	(4.91)	

Adjustment coefficients

	α_c	α_l	α_w	
ec_{t-1}	-0.1800	0.1956	0.4672	
	(-2.526)	(1.141)	(2.564)	
	[0.014]	[0.257]	[0.012]	
	α_c	α_l	α_{fw}	α_{nf}
ec_{t-1}	-0.1632	0.2340	0.2892	0.2709
	(-2.195)	(1.340)	(1.634)	(1.874)
	[0.032]	[0.185]	[0.107]	[0.065]

Notes: This table reports residual based tests for cointegration based on the OLS estimates of the parameters in the cointegrating regressions. *ADF*(4) is the adjusted Dickey-Fuller *t*-statistic from the cointegrating regression, including four lags of the first differences of the OLS residuals. *PP* and Z_τ are the Phillips-Perron and Phillips-Ouliaris *t*-statistics, respectively. In each case, the autocovariance function is truncated at four lags. The critical values are taken from Hamilton (1994), Table B.8. The number of leads and lags of changes in the right-hand side variables in the DOLS regressions is k=4. *AR*(1) is the first-order autocorrelation coefficient of the estimated residuals from the DOLS regressions. The table also shows estimates of the coefficient on the error-correction term in each equation of the VEC model which is estimated with three lags. *t*-statistics are shown in parenthesis and *p*-values in square brackets.

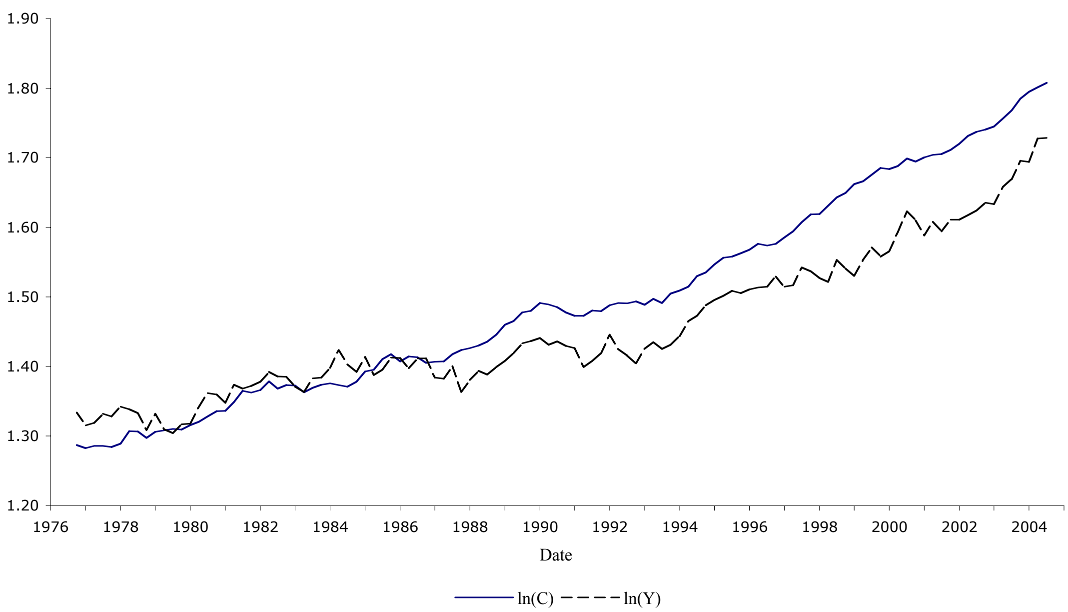
Table 5
Decomposition of forecast error variance: estimation period 1977:4-1998:3

	Three variable model						Four variable model							
	$c_{t+j}-E_t(c_{t+j})$		$y_{t+j}-E_t(y_{t+j})$		$a_{t+j}-E_t(a_{t+j})$		$c_{t+j}-E_t(c_{t+j})$		$y_{t+j}-E_t(y_{t+j})$		$a_{ft+j}-E_t(a_{ft+j})$		$a_{nt+j}-E_t(a_{nt+j})$	
j	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*	*P*	*T*
1	60.51	39.49	100.0	0.00	59.37	40.63	64.33	35.67	100.0	0.00	80.24	19.76	74.01	25.99
2	67.96	32.04	99.76	0.24	66.74	33.26	70.67	29.33	99.70	0.30	85.31	14.69	77.30	22.70
3	80.46	19.54	99.41	0.59	68.23	31.77	81.72	18.28	99.07	0.93	86.96	13.04	76.11	23.89
4	87.90	12.10	98.02	1.98	70.47	29.53	88.42	11.58	97.60	2.40	89.07	10.93	77.26	22.74
6	91.22	8.78	95.69	4.31	78.02	21.98	90.74	9.26	94.53	5.47	92.95	7.05	81.80	18.20
8	92.97	7.03	95.60	4.40	83.73	16.27	92.06	7.94	94.05	5.95	94.67	5.33	86.34	13.66
12	95.39	4.61	96.52	3.48	88.86	11.14	94.71	5.29	95.26	4.74	96.17	3.83	90.83	9.17
16	96.53	3.47	97.07	2.93	91.42	8.58	96.02	3.98	96.02	3.98	97.14	2.86	92.70	7.10
20	97.25	2.75	97.54	2.46	93.05	6.95	96.84	3.16	96.66	3.34	97.70	2.30	94.26	5.74
24	97.22	2.78	97.88	2.12	94.18	5.82	97.39	2.61	97.13	2.87	98.09	1.91	95.20	4.80
60	99.11	0.89	99.06	0.94	97.63	2.37	98.98	1.02	98.73	1.27	99.24	0.76	98.05	1.95

Notes The table reports the percentage contribution of all the permanent shocks together (*P*) and the transitory shock (*T*) to the *j*-step ahead forecast error variance in the series for the three and four variable models. In the estimated VEC models, labour income is weakly exogenous and the number of lags is three.

Figure 1
Consumption, Labour Income, and Wealth for Australian Households:
1976:4 2004:3

(a) Consumption and After Tax Labour Income



(b) Household Net Wealth

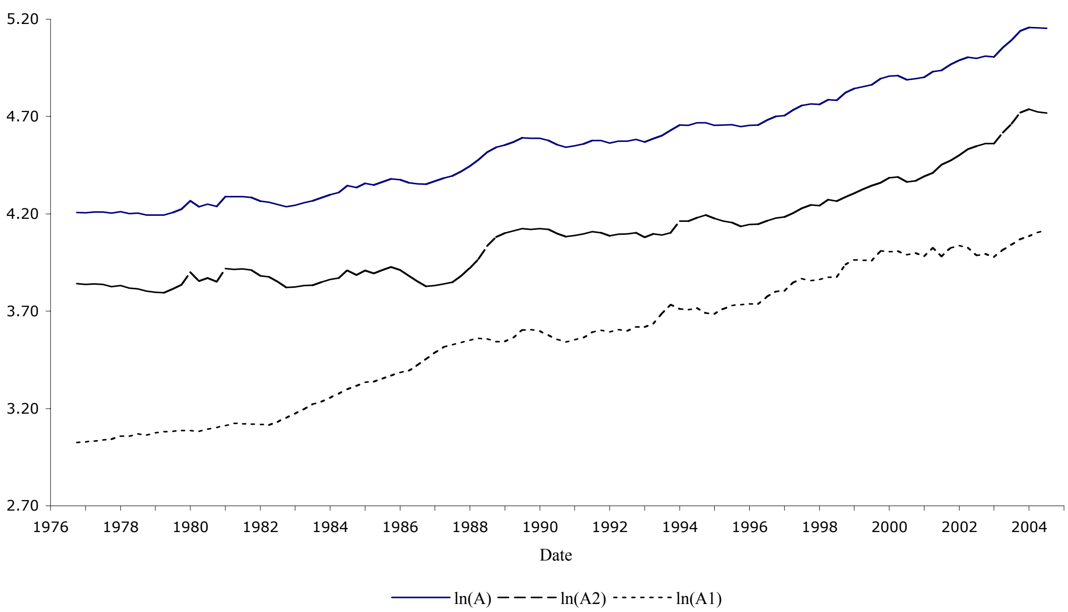


Figure 2
Residuals from DOLS cointegrating regressions for the three and four variable (aggregate and disaggregate wealth) models: 1976:4-2004:3

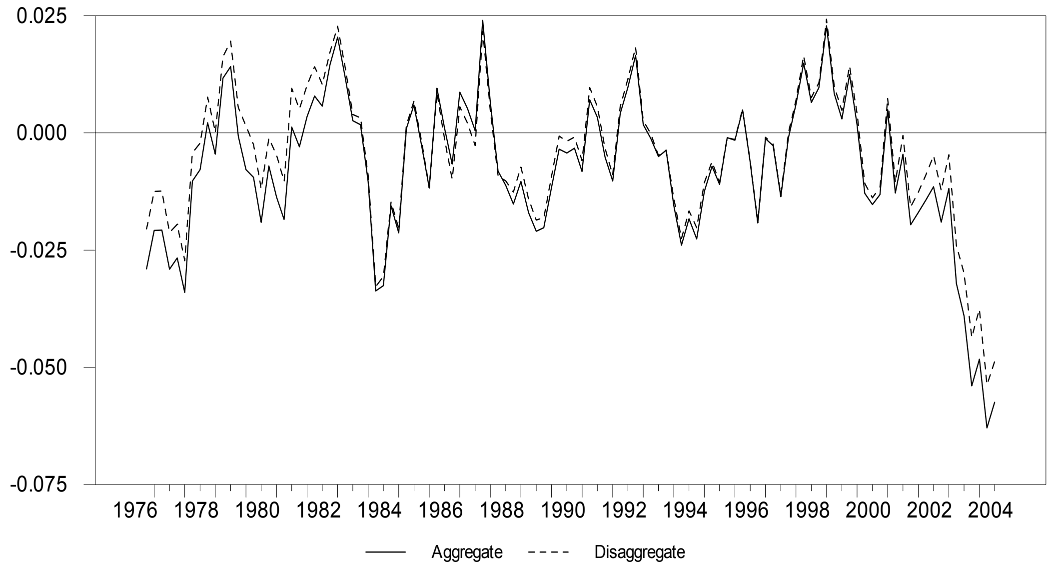
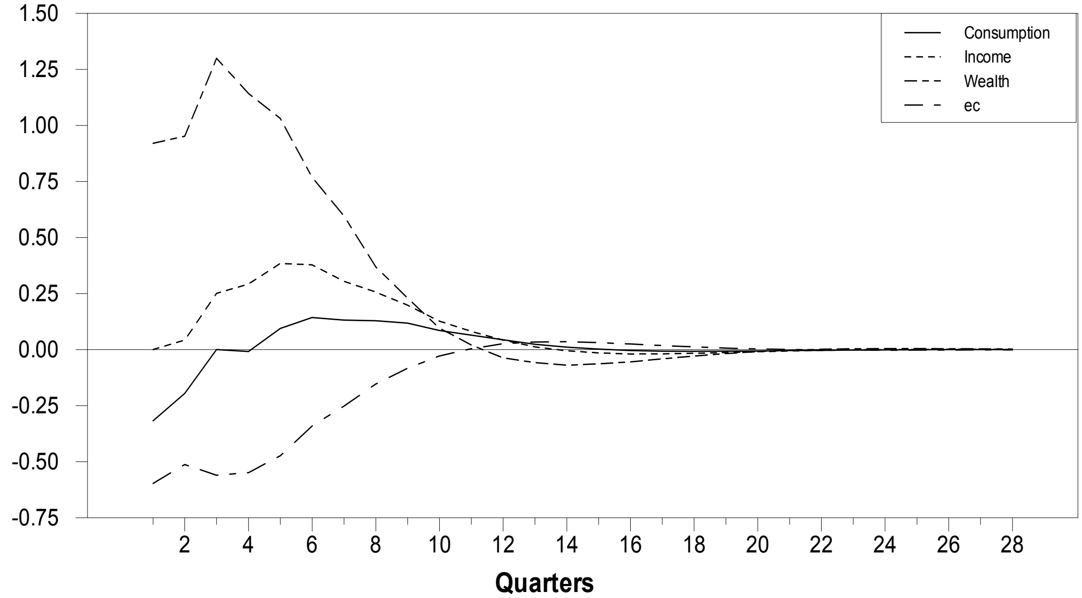
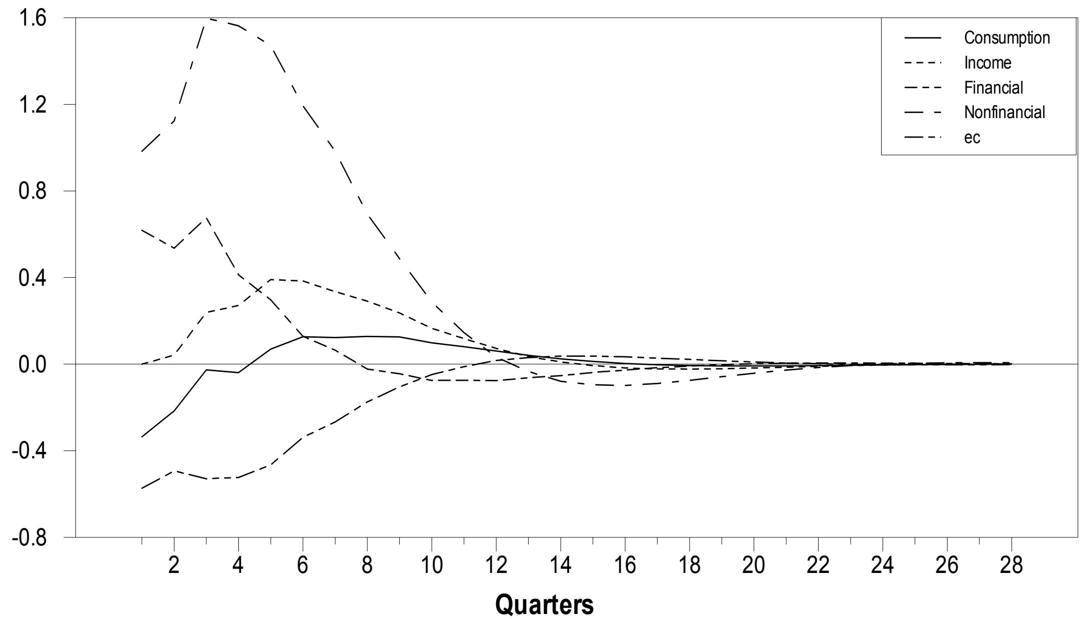


Figure 3
Responses of series to one-standard error transitory shock: 1977:4-2004:3.

(a) Three variable model

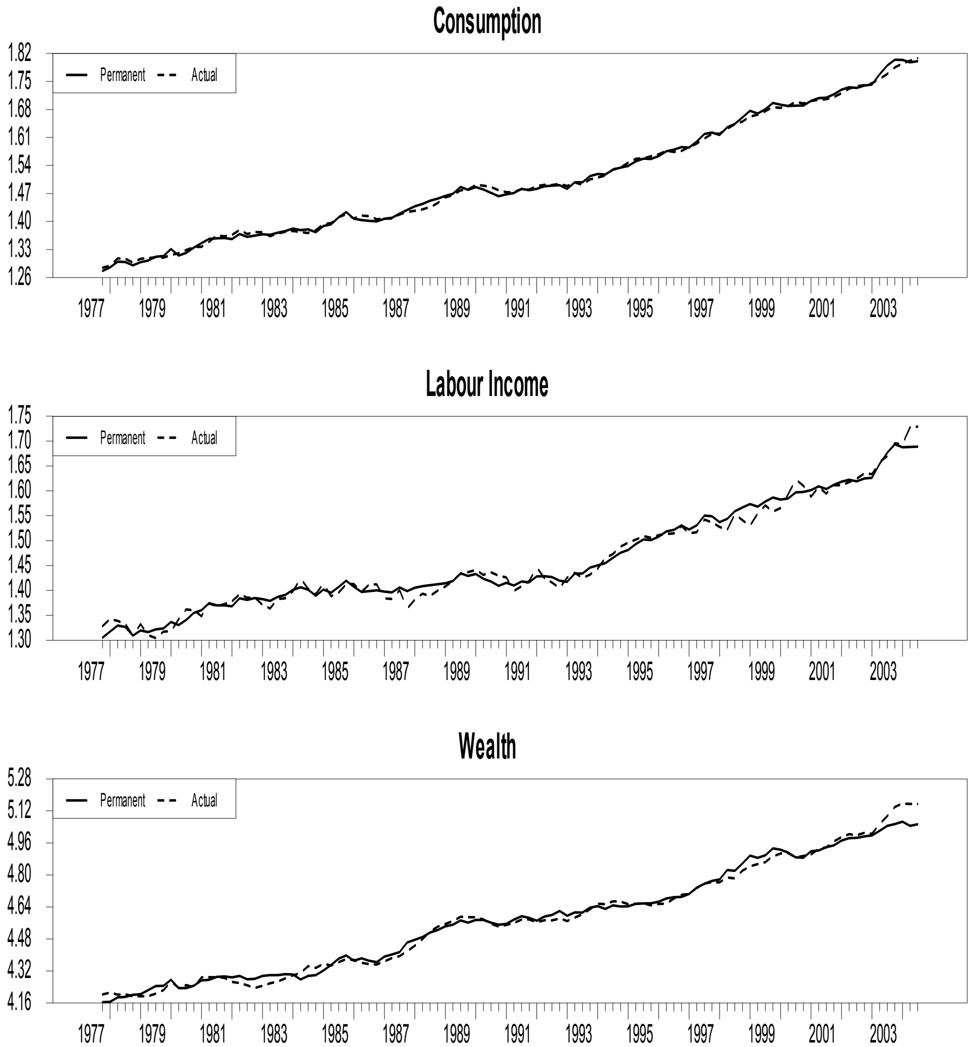


(b) Four variable model



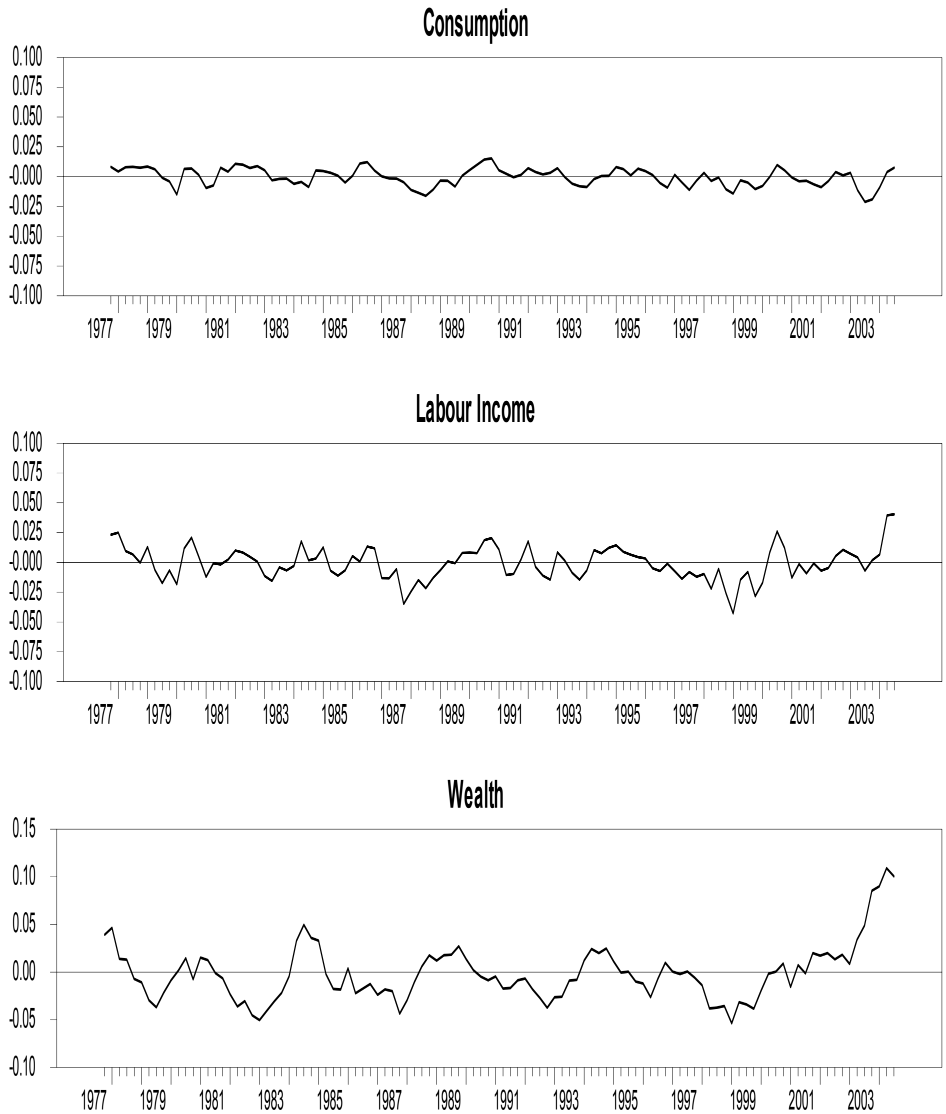
Notes: In the estimated VEC models, labour income is weakly exogenous and the number of lags is three.

Figure 4
Permanent component and actual value of series: 1977:4-2004:3



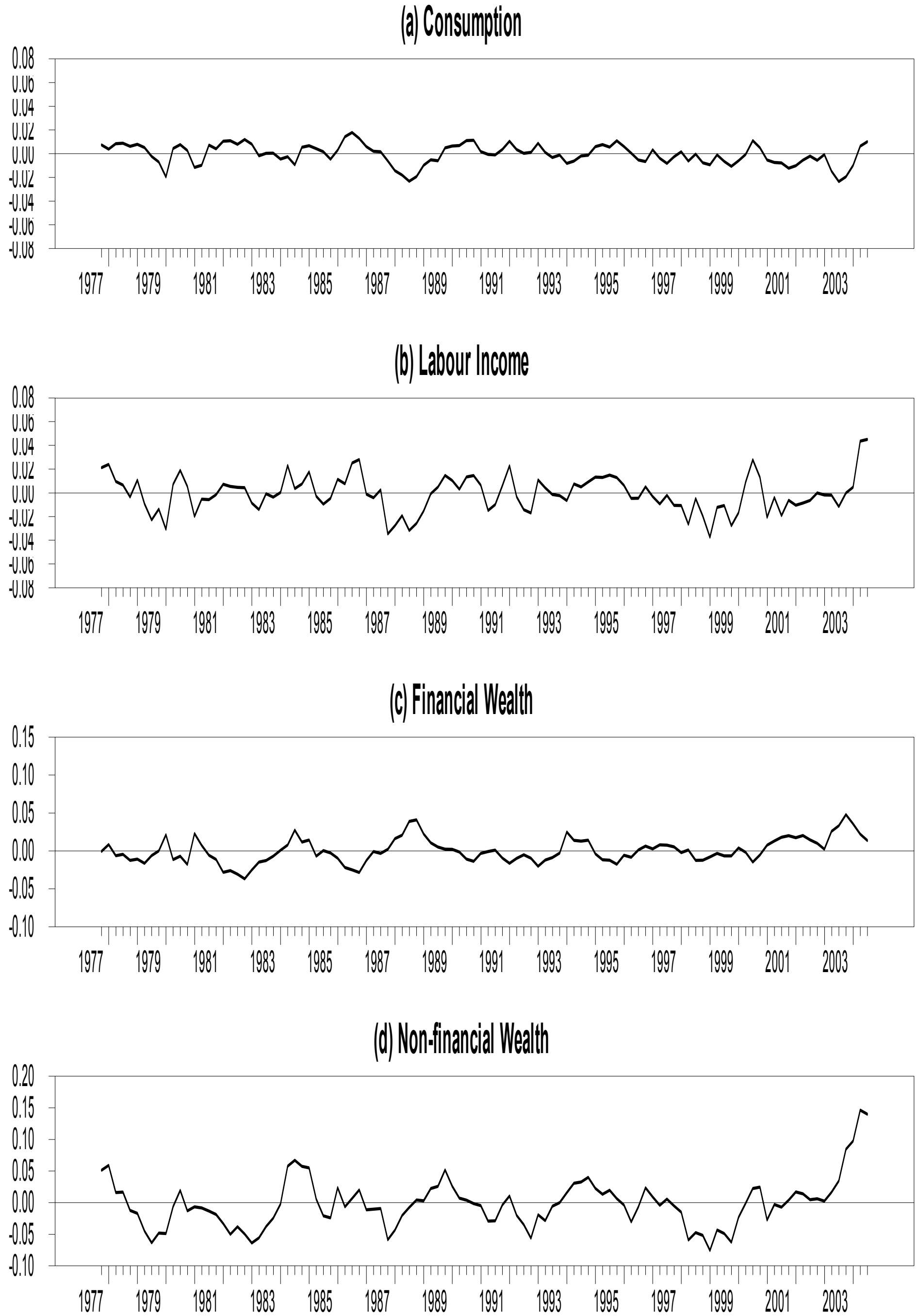
Notes: The permanent component is calculated as the long-run forecast of each variable in a Beveridge-Nelson decomposition of the cointegrated system c_t , y_t and a_t . The variables are measured in log real per capita units.

Figure 5
Transitory component of each series in three variable model: 1977:4-2004:3



Notes: The transitory component in a series is defined as the difference between the actual series and its permanent component.

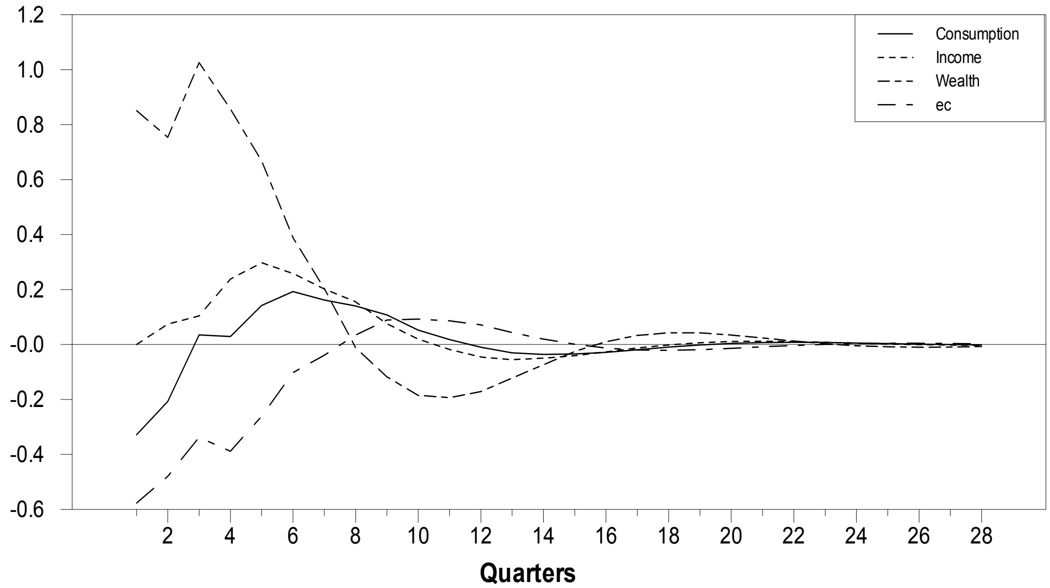
Figure 6
Transitory component of each series in four variable model: 1977:4-2004:3



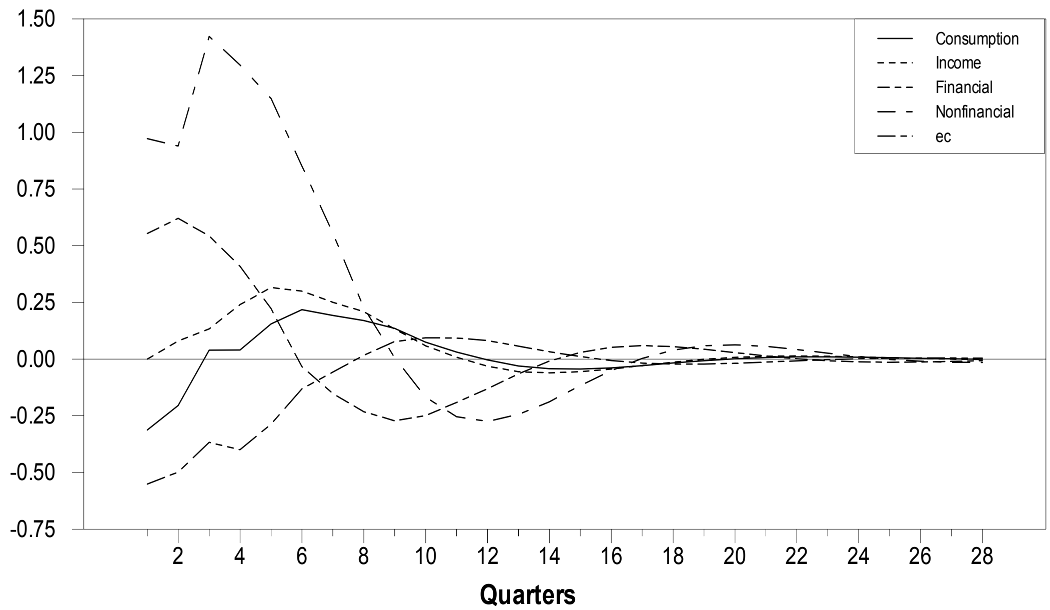
Notes: The transitory component in each series is defined as the difference between the actual series and its permanent component.

Figure 7
Responses of series to one-standard-error transitory shock: 1977:4-1998:3

(a) Three variable model

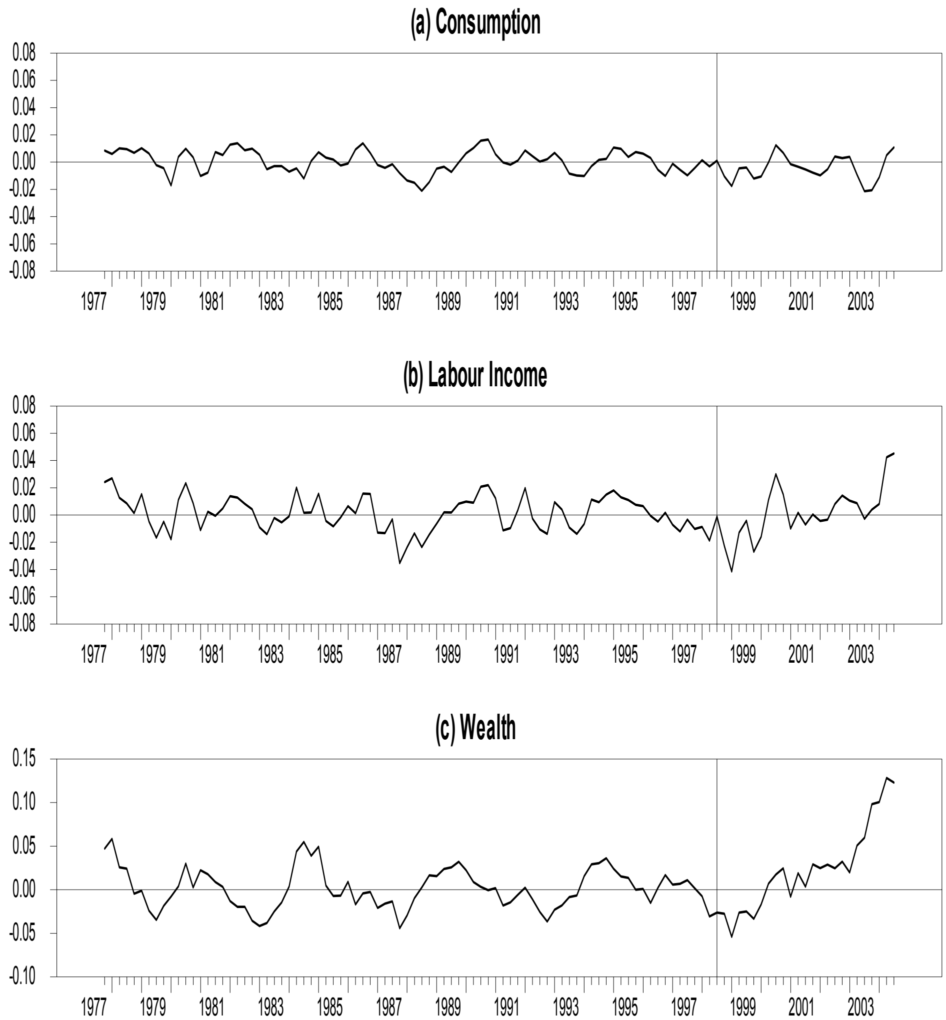


(b) Four variable model



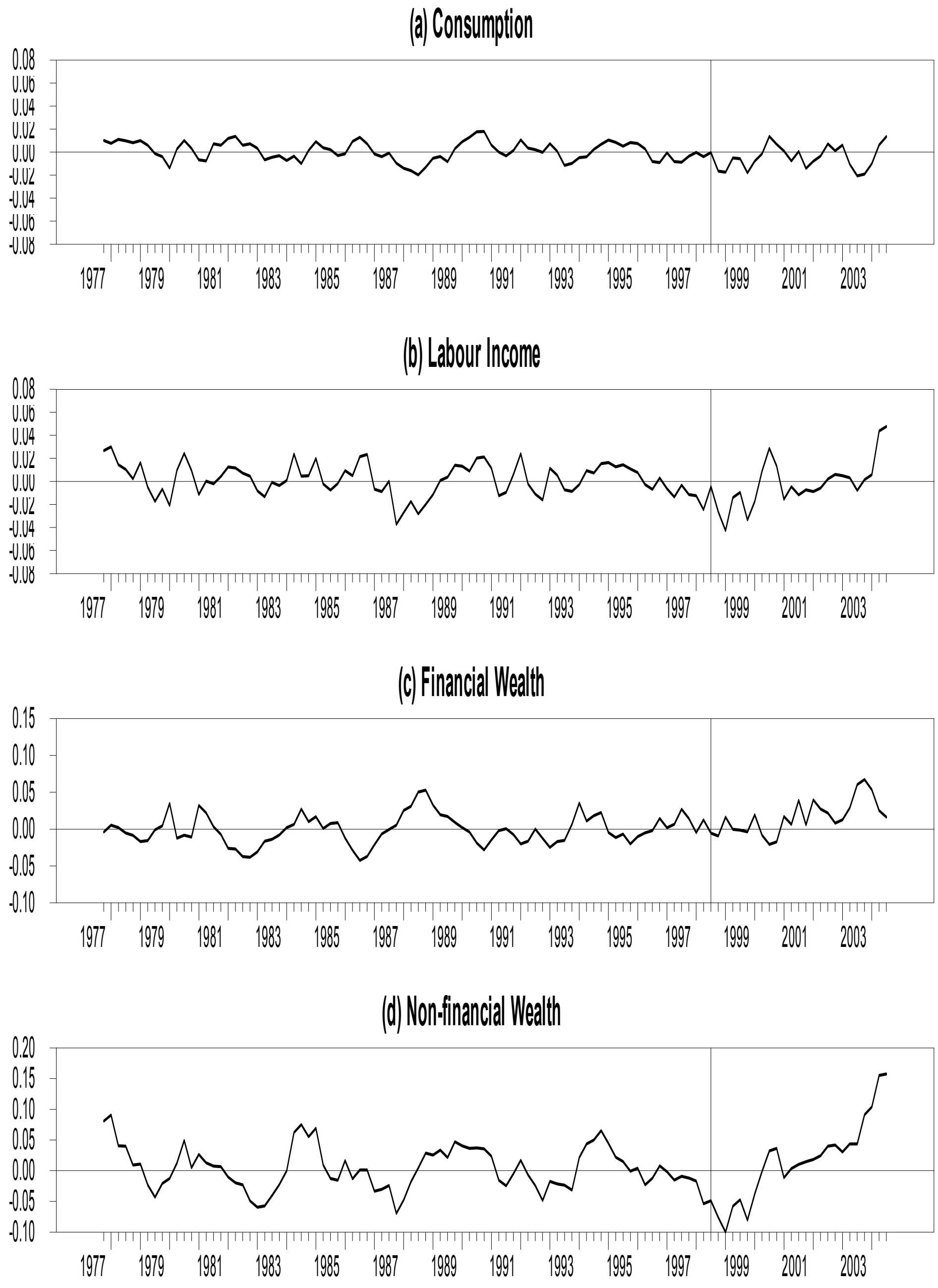
Notes: In the estimated VEC models, labour income is weakly exogenous and the number of lags is three.

Figure 8
Transitory component of each series in three variable model: 1977:4-2004:3
Estimation period 1977:4-1998:3



Notes: The VEC model is estimated with data up to and including 1998:3. The end of the estimation period is shown by the vertical line. In the VEC model, labour income is weakly exogenous and the number of lags is three.

Figure 9
Transitory component of each series in four variable model: 1977:4-2004:3
Estimation period 1977:4-1998:3



Notes: The VEC model is estimated with data up to and including 1998:3. The end of the estimation period is shown by the vertical line. In the VEC model, labour income is weakly exogenous and the number of lags is three.