

Chen, Jie

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## Housing Wealth and Aggregate Consumption in Sweden

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*Department of Economics*

# Housing Wealth and Aggregate Consumption in Sweden

Jie Chen

Department of Economics  
Uppsala University  
P.O. Box 513  
SE-751 20 Uppsala  
Sweden  
Fax: +46 18 471 14 78

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## HOUSING WEALTH AND AGGREGATE CONSUMPTION IN SWEDEN

JIE CHEN

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# Housing Wealth and Aggregate Consumption in Sweden

*Jie Chen*<sup>1</sup>

June 10, 2006

## **Abstract:**

This paper extends the VECM cointegration model and PT (permanent-transitory) variance decomposition framework proposed by Lettau & Ludvigson (2004) and applies them on the Swedish data spanning from 1980q1 to 2004q4. There are strong statistical evidences that the movements of aggregate consumption, disposable income, housing wealth and financial wealth are tied together. However, it also suggests that the short run variations in the Swedish housing market are largely dissociated with consumer spending. Meanwhile, it is shown that the strength of the linkage between consumption and housing wealth is not sensitive to different model specifications and various measures of key variables.

**JEL classification:** E21, E32, E44, R31

**Key Words:** housing wealth, consumption, wealth effect, VECM, PT decomposition

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<sup>1</sup>Jie Chen: The Institute for Housing and Urban Research, Uppsala University, Box 785, 80129 Gävle, Sweden. Phone: 0046 26 4206539. Fax: 0046 26 4206501. Email: [jie.chen@ibf.uu.se](mailto:jie.chen@ibf.uu.se). I am indebted to Lennart Berg, Viggo Nordvik, Geoffery Meen for their very helpful comments on previous versions of this paper. I also wish to thank Serena Ng for kindly allowing me to use her Gauss code in conducting P-T decomposition and Bruce E. Hansen for sharing the Gauss codes for cointegration analysis. Some PT analyses are based on the SVAR software developed by Anders Warne, who is appreciated too. But all remaining errors are my own.

# 1. Introduction

The association between housing price/wealth and household consumption has attracted increasing interest in recent years. Against the backdrop of the abrupt collapse in the international stock market at the beginning of this century,<sup>2</sup> there was once a widely-spread panic that consumers would respond by cutting their spending sharply and thus drag the global economy into deep recession. However, the years since 2001 have witnessed strong performance of consumer spending in nearly all major economies (OECD Economic Outlook, 2004). In seeking explanations for this puzzle, more and more observers asserted that the continued surge in the housing market is the primary factor for offsetting the negative impact of stock market collapse and upholding the strong performance of household consumption.<sup>3</sup> Probably initiated by the pioneer work of Case et al. (2001), a growing body of research work has been devoted to re-examining the association between movements in housing market and changes in household consumption.

Many economic analysts are of the consensus that any economic stabilization policy that fails to take full account of the connection between the housing market and the real economy is unlikely to be successful (Aoki et al., 2004). For example, Belsky & Prakken (2004) claimed that, had the US Federal Reserve Board not helped maintain the continued buoyancy in the US housing market since the late 1990s, the economic recession in the US would have been much more severe. On the other hand, a widely held view is that even a modest drop in housing prices will trigger a sharp plummet of consumer spending and policymakers would be little capable of fending off an economic downturn in such a case (*The Economist*, Sept. 24, 2004). The policy significance of this issue calls for an urgent and comprehensive understanding of the housing wealth-consumption nexus.

Despite mounting numbers of studies on the association between housing price/wealth and consumption, the existing results can be dubious. In a series of recent papers Lettau and her colleagues called into question the validity of the single-equation ECM (Error Correction Model)

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<sup>2</sup> The aggregate value of US stocks measured by the Wilshire 5000 fell from its peak of 14.3 trillion US dollars in March 2000 to 7.8 US trillion dollars in September 2000, losing 50% of its value. The aggregate value of Swedish stocks fell more heavily, from its peak of 608 billion SEK in the second quarter of 2000 to 242 billion SEK in the third quarter of 2002, losing almost two-thirds of its value.

<sup>3</sup> Among others, the last-term Chairman of US Federal Reserve Board Alan Greenspan is a leading advocate of this view. In a series of public speeches and congress testimonies, he credited the robustness of the US housing market in mitigating the aftermath of falling stock market prices and economic recession. "Among the factors contributing to the strength of spending..., have been developments in housing market and home finance that have spurred rising household wealth and allowed greater access to that wealth" (Greenspan, 2005).

approach commonly used in previous literature to empirically estimate parameters of this nexus (Lettau & Ludvigson, 2001; Lettau & Ludvigson, 2004). They argued that a single-equation ECM preassumes that consumption performs all the adjustments to revert the system back to a new long run equilibrium while wealth and labor income perform none. However, economic theory predicts that either income or wealth or both could contribute to the disequilibrium adjustment. Using US data spanning from 1951q4 to 2003q1, Lettau & Ludvigson (2004) provided evidences that the disequilibria are corrected via adjustments in total asset wealth but not via consumption. Thus, the coefficients of short run dynamics estimated in a single equation ECM are subject to model misspecification bias. For this reason, Lettau & Ludvigson (2004) recommended the VECM (Vector Error Correction Model), which is able to take full account of the dynamic responses of all variables in the cointegrated system and obtain more robust parameter estimates of the wealth-consumption nexus.

Perhaps the most important breakthrough in Lettau & Ludvigson (2004) is their utilization of cointegration restrictions to identify the permanent-transitory components of variations in consumption and asset wealth. They stressed that only permanent shocks have real long run effects on consumption while transitory shocks have zero, a crucial point that has been largely neglected in previous literature. In Lettau & Ludvigson (2004), the authors found that up to 88% of post-war variations in US households' net wealth were transitory.

However, Lettau & Ludvigson (2004) use the total sum of household net asset wealth and did not distinguish housing wealth from financial wealth, and did not investigate whether consumption and income are cointegrated with disaggregate forms of wealth. They did not point out which component of wealth contributes, or which one contributes more in the disequilibria correction. They also did not examine which component of wealth contains more transitory components in the movements. Further, their work was silent in the relative importance of housing wealth and financial wealth on the movements of consumption, both long run and short run. These are the tasks to be taken up in this paper.

This paper extends the VECM and PT variation decomposition framework proposed by Lettau & Ludvigson (2004) to a situation in which total wealth is disaggregated into housing wealth and financial wealth. Housing equity is the largest single component of non-human wealth owned by most households. Because housing is not only an investment asset but is also in the first place a consumption good carrying great socioeconomic significance. It has many unique volatility

features. Thus, it is of great interest to disentangle the sole role of housing wealth on consumption from other forms of wealth.

This paper also distinguishes itself from Lettau & Ludvigson (2004) in the choice of consumption measure. I am more interested in the dynamics of aggregate economies and the interplay between key aggregate variables. Thus, the main body of this paper explores how real total consumption moves together with real disposable income, real net housing wealth and real net non-housing financial wealth. With the purpose of testing specific consumer behavior theories, the consumption variable employed in Lettau & Ludvigson (2004) and many other previous studies is the consumer expenditures on nondurable goods and total services. However, I would like to argue that the consumption of housing services should be excluded from the variable of total services. This proposed measure of consumption of nondurable goods and non-housing services is found to be cointegrated with labour income, housing wealth and financial wealth. Moreover, this paper shows that the statistical linkage between housing wealth and household consumption is neither sensitive to choice of consumption variable nor measure of housing market fluctuation. The statistical linkage is also found not dependent on particular theoretic foundation. Finally, it is shown that there is no evidence that increases in housing prices will lead consumers to substitute non-housing consumption with housing consumption.

The remaining parts of this paper are organized as follows: Section 2 discusses the economics behind the associations between housing wealth and consumption and briefly reviews previous literature; Section 3 establishes the econometric framework; Section 4 describes the data and choices of variables; Section 5 reports the key empirical results and extensions; and Section 6 presents concluding remarks and policy suggestions.

## **2. Housing Wealth and Consumption: the Economics**

The correlation between household wealth and aggregate consumption is a classical and deep-rooted question in economic studies. Dating back at least as early as Keynes's *General Theory* (1936), the roles of equity wealth in economic fluctuation and stabilization have been discussed.

### **2.1. Mechanisms behind Housing-Consumption Linkage**

The permanent income hypothesis (**PIH**) and life-cycle permanent income consumption theory now comprise the standard starting point of discussing the role of wealth on household consumer

spending. Ando & Modigliani (1963) visualized consumption decisions as being integrated in an intertemporal optimization program for a representative consumer. The following consumption equation is proposed in Ando & Modigliani (1963):

$$(1.4) C_t = c_Y Y_t + c_W W_t$$

Here, consumption at time  $t$  is expressed as a linear function of current labour income ( $Y_t$ ) and current net assets ( $W_t$ ). If the total net physical wealth is decomposed into net non-housing financial wealth ( $A_t$ ) and net housing wealth ( $H_t$ ), the following equation is obtained:

$$(1.5) C_t = c_Y Y_t + c_A A_t + c_H H_t$$

In Equation (1.5),  $c_Y$ ,  $c_A$ , and  $c_H$  are the **MPC** (marginal propensity to consume) parameters of  $Y$ ,  $A$  and  $H$ , respectively, and are allowed to differ from each other. This disaggregation of total wealth is warranted as economists increasingly believe that, the two different categories of wealth may affect consumption with different effects. See discussions in Section 2.2.

### 2.1.1. The Wealth Effect of Housing

Starting from PIH, a number of theoretical works have elucidated the transmission mechanisms from changes in housing price/wealth to changes in consumption. An easy channel one can visualize is the “**wealth effect**”: increases in housing price/wealth make homeowners feel richer and willing to spend more.

However, this channel is notoriously controversial and ample with counter-arguments. An obvious doubt concerns difficulties in cashing housing capital gains. For example, Phang (2004) failed to find that changes in private housing prices have any impact on consumption in Singapore, and attributed this failure to institutional difficulties in cashing private housing equity gains in Singapore.<sup>4</sup> Using the US micro household data and allowing for asymmetric responses for house price changes, Engelhardt (1996) found that homeowners do not respond to capital gains in housing but do react to capital losses in housing, suggesting that they are either hindered from cashing housing capital gains or suspicious of the degree of permanency of increases in housing prices.

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<sup>4</sup>However, note that Edelstein & Lum (2004) found that price increases in the Singapore public housing resale sector induce positive and significant responses from aggregate consumption over time.



Even without any real-life obstacle, homeowners may not have strong incentives to cash housing capital gains. Consider the bequest motives to the next generation and many non-pecuniary utilities associated with the ownership of a home. In many societies a home of one's own is regarded as the most standing symbol of social status and is considered “an end in itself” (Case et al., 2001).

But one may believe that the “wealth effect” of housing on consumption does not require homeowners to actually capitalize and spend their housing capital gains. The expansion of spending can simply be due to psychological joys, satisfaction, and optimistic future prospective. As Ludwig & Slok (2002) named, there are two kinds of wealth effect of housing: *realized wealth effect* and *unrealized wealth effect*. The realized wealth effect happens when homeowners spend more after cashing their housing capital gains. The unrealized wealth effect occurs when homeowners spend more today on the belief that they “are” richer than before.

### **2.1.2. The Collateral Effect of Housing**

Another important channel that links housing and consumption is the “**credit channel**”. The house is unique as it is not only a common consumption good but can also be used as collateral for expanding one's consumption credit loans. Iacoviello developed a model to show how changes in housing price can be a true driving force of consumption fluctuations via their effects on borrowing capacity (Iacoviello, 2004). In Ludwig & Slok (2002), this is called *liquidity constraint effect*.

### **2.1.3. The Renter's Reaction**

But reactions of renters to increases in house prices deserve attention. Quite many economists argue that housing equity is regarded as a precautionary buffer against economic adversity, and increases in house price may induce “forced savings” of renters and dampen their consumption. Ludwig & Slok (2002) name this as *budget constraint effect*. See also Skinner (1989; 1993). Meanwhile, as Masnick et al. (2005) commented, although escalating house prices may benefit existing homeowners who are willing to “trade down”, they may also hurt some homebuyers who are eager to “trade up”. In Ludwig & Slok (2002), this is named *substitution effect*.

However, during periods of soaring house prices, renters or those wishing to “trade up” may expedite their home purchase plan in order to avoid the costs of more expensive houses in the next period. See discussions of self-fulfilling and self-amplifying prophecy of housing price dynamics in Stein (1995) and Shiller (2004). There are empirical evidences that *increases* in house prices may induce renters to *reduce* rather than *increase* their savings. See evidences from Japan in Yoshikawa & Ohtake (1989) and from Canada in Engelhardt (1994). Hence the literature has not reached any conclusive predictions regarding renters’ possible reactions.

#### **2.1.4. The Housing-Consumption Linkage---A Mere Statistical Symptom?**

Despite the fact that the co-movement pattern between wealth (including both housing wealth and financial wealth) and consumption has been observed and reported worldwide, many economists have dismissed it as a mere statistical symptom, either due to house and asset prices working as a “leading indicator” of future income growth or credited to the fluctuation in house and asset price triggering changes in consumption through the “consumer confidence” channel. See relevant discussions in Edison & Slok (2001) and Belsky & Prakken (2004). Some other researchers claimed that the observed correlation between wealth and consumption is merely a part of the transmission mechanism from exogenous changes in interest rate to fluctuations in aggregate economy (Aoki et al., 2004).

However, as Poterba (2000) and Edison & Slok (2001) have argued, although we may not exclude the possibility of non-causality transmission mechanism in the observed association between wealth and consumption, there is little reason to believe that a causal relationship from wealth to consumption does not exist or is negligible. For example, as Lyhagen (2001) has shown, when attitudes towards future income were controlled for, the empirical evidence still favors the hypothesis that changes in wealth deliver a direct effect on the movement of consumption. Brodin & Nymoen (1992) also found no evidence of serious simultaneity problems in the empirical relationship between wealth and aggregate consumption in Norway. Finally, as mentioned above, a series of micro data studies have confirmed the existence of the causal relationship from wealth to consumption.

Nonetheless, this paper will not attempt to explicitly distinguish direct and indirect effects of wealth on consumption and isolate their relative contributions. For this paper’s purposes, identifying the existence and strength of association between wealth and consumption is sufficient. What I am concerned with is whether movements in consumption, incomes, and

disaggregate forms of wealth are tied together, and if they are, how this finding can be used to identify the long run relationship between incomes, disaggregate forms of wealth and consumption. Particularly, the permanent-transitory variance decomposition method used in this paper – while allowing us to quantify the fractions of variances in incomes and wealth that are related and unrelated to consumption movement, respectively – does not require us to identify the existence and direction of causality relationships between each variable.

To wrap up discussions in this section, some conclusions can be drawn: the sign and magnitude of the association between housing price/wealth and consumption depend crucially on a number of institutional-cultural factors including the degree of financial market liberalisation, availability of mortgage refinancing tools, culture of bequest and social value of homeownership, homeownership ratio over total population, governmental housing policy, demographic composition, and pattern of income distribution. Thus, for a given economy, it is not feasible to determine *a priori* the relationship between housing and consumption or the strength of this relationship; it must be empirically investigated.

## **2.2. Comparing Housing Wealth and Financial Wealth**

There are increasing evidences suggesting that changes in financial wealth and housing wealth could follow with different types of feedback from consumption and their *MPCs* or elasticities are dissimilar. For example, using a panel data of 14 developed countries during 1975-1996, Case et al. (2001) found the estimated elasticity of consumption with respect to housing wealth is significant and large, ranging from 0.11 to 0.17, while the elasticity for stock market wealth is significantly smaller, only 0.05 to 0.09. A similar conclusion is reached by Ludwig & Slok (2002) for a study of 16 OECD countries. However, using a state-level panel data in Australia, Dvornak & Kohler (2003) found that the marginal propensity to consume from stock market wealth is larger than that with respect to housing wealth, while their elasticities are quite close.

Different types of wealth may have different impacts on consumption, which can be attributed to that they have: 1) differences in the degree of liquidity; 2) differences in the difficulty of cashing capital gains; 3) differences in the distributions of the two types of wealth across income groups. Housing equities are widely and relatively evenly held by households of all income classes, while in contrast stock assets typically concentrate only in the hands of top-income households. The rich people is believed to have a low propensity to spend; 4) different degree of permanency viewed by agents; 5) as mentioned above, there are several counteracting forces for the positive

effects of housing wealth, but seemingly no such as regards financial wealth. See Dvornak & Kohler (2003) for a good discussion of these points.

### **2.3. The Swedish Housing Market and Previous Studies**

The Swedish housing market is comprised by three tenure sectors: an ownership sector, a cooperative sector, and a rental sector. The ownership sector consists of single family houses and in 2002 more than 42% of total 9 million Swedish households live in this sector, while the rental sector is of almost the same share and the cooperative sector is around 15%. The housing wealth concept discussed in this paper refers only to the market value of single family houses, which is commonly used in the Swedish literature (Berg & Bergström, 1995). The rent levels in Sweden are regulated by a “Fair Rent System” and loosely connected to movements in housing sale prices. Hence there are reasons to believe that rises in housing prices would not hurt renters much. For this reason, the Swedish housing market, which allowing us to treat renters’ negative reactions as minor, provides a good case to analyze the housing wealth-consumption nexus.<sup>5</sup>

The cooperative dwellings are generally multi-family buildings and residents are called tenant-owners. From a legal viewpoint, a cooperative estate is collectively owned by all residents living in. But the cooperative sector resembles the ownership sector as the rights to live in a cooperative dwelling can be bought and sold on the market and the prices are mirroring comparable single family housing prices. Therefore one may anticipate that tenant-owners react similarly to price changes in single family houses. Hence, the estimated association between single-family-house market values and household consumption could be a downward-biased estimate of the real association between housing market and consumption. This is an issue one may need caution when interpreting the results. But considering the relative small size of cooperative sector, the downward bias should not be large.

Swedish people live in good accommodation conditions. The per capita living floor space was 45 square meters in 1990. But since 1996, the prices of single family houses in Sweden have rose more than 100%. In 2002, the average purchase price of a single family house is 1,223,000 SEK, which is 6.5 times of the average annual taxable earned income (188,000 SEK). In the same year, the mean ratio of household debt in relation to disposable income is 120% and the ratio of outstanding amount of mortgage loan in relation to GDP is 48% (SCB, 2005). Compared to the Netherlands (88%), Denmark (82%), UK (62%), and Germany (51%) (EU housing statistics,

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<sup>5</sup> It will be really interesting to test whether the wealth effects of housing are asymmetric in Sweden. But this paper did not go into this detail.

2003), the Swedish ratio of mortgage loan to GDP can be regarded as moderate. But the housing finance market in Sweden is a large and liquid market. It grows fast since the financial liberalisation in the middle of 1980s (Turner, 1999). The Swedish mortgage bond market is now the third-largest one in Europe, only after the German and Danish markets (EU housing statistics, 2003).

The issue of housing wealth-consumption linkage has received considerable attention in Sweden (Agell et al. 1995; Barot, 1995; Berg & Bergström, 1995; Ekman, 1997; Johnsson & Kaplan, 1999; Lyhagen, 2001). With exception of Ekman (1997) which used micro household data to test the relationship between housing wealth and consumption, all previous papers used macro data. Furthermore, all previous macro studies found positive and significant effects of housing wealth change on aggregate household consumption. Due to differences in time period examined and econometric techniques used, their results are not directly comparable to each other or to this paper. However, their works still provide good benchmarks for assessing the findings in this paper. The latest Swedish paper in this area, Johnsson & Kaplan (1999), examined Swedish data up to the year 1998. Thus, this paper provides a timely update of literature with recent data.

### **3. Econometric Model**

#### **3.1. VECM vs ECM**

The econometric discussion starts from the concept of *cointegration*. If some series are individually non-stationary, i.e. **I(1)** (integrated of order 1) and drift randomly, but there exists a certain linear combination that make the residuals of their cointegrating equation are stationary, or say **I(0)** (integrated of order 0), we call these series are cointegrated. The finding of a cointegration relationship indicates co-movements among trending variables and therefore is very useful in exploiting whether there exists a long run equilibrium relationship within the system.

The cointegrating relationship between consumption, income and wealth has solid theoretic justifications from economics (cf. Lettau & Ludvigson 2001, 2004; Rudd & Whelan, 2002). Starting from this point, existing consumption studies generally adopt the single equation ECM (error correction model) approach, which is applied in two steps. That is, in the first step a long run consumption-income-wealth relationship is identified from the cointegration equation, and in the second step a short run consumption equation is estimated with residuals from the first-step cointegration equation included as an independent variable in this equation. The cointegration

equation residual is called the **EC** (error correction) term and its coefficient measures the speed at which consumption converts the system back to the new equilibrium path. However, this approach relies heavily on the assumption that only consumption performs the disequilibrium adjustment while neither income nor wealth does. The zero adjustment coefficient restriction for both income and wealth implicitly requires that both income and wealth be weakly exogenous to consumption. But as Lettau & Ludvigson (2004) pointed out, this assumption does not have accepted theoretical foundations.

We know changes in wealth and income influence households' consumption decisions. But it is also well-accepted that the aggregate demand, housing market and financial market are interlinked, implying that all these variables are obviously affected by households' consumption decisions too. Thus it is safer to treat all four variables in this system as endogenous; otherwise, the estimation would suffer potential simultaneity biases. For this reason, I choose to follow Lettau & Ludvigson (2004) and estimate a system of equations using the VECM (Vector Error Correction Model), which does not require the weak exogeneity condition of independent variables as does the single-equation ECM. The VECM estimation also provides a direct test of the exogeneity of one variable to one another.

The reduced-form VECM for a  $m \times 1$  vector of  $I(1)$  process  $Y_t$  with  $r$  ( $m \geq r \geq 1$ ) cointegrated vectors is presented as:

$$(2.1) \Delta Y_t = \mu_t + \gamma \alpha' Y_{t-1} + \Gamma(L) \Delta Y_{t-1} + e_t$$

where  $\Delta Y_t$  is the  $m \times 1$  vector of first difference of  $Y_t$ ,  $\mu_t$  is the vector of deterministic terms in the VAR,  $\gamma$  is the  $m \times r$  vector of adjustment coefficients,  $\Gamma(L)$  is the vector of lag operator, and  $\alpha'$  is the  $r \times m$  *cointegration vector*.

In the context of this paper,  $\Delta Y_t$  is the  $4 \times 1$  vector of first difference of  $\log(C, I, HW, FW)$ , and  $\gamma \equiv (\gamma_c, \gamma_I, \gamma_{hw}, \gamma_{fw})'$ ,  $\alpha' \equiv (1, \alpha_i, \alpha_{hw}, \alpha_{fw})$  after normalized.  $C$ : consumption;  $I$ : income;  $HW$ : net housing wealth;  $FW$ : real net financial wealth.

### 3.2. The Permanent-transitory Decomposition

It has been said that we may never know the true origin of shocks hitting a system (Cochrane, 1994). However, we can distinguish the shocks by their degrees of persistence. A shock, or the innovation to the variable, is said to have permanent effects on the levels of difference-stationary series  $X_t$  if its impact does not vanish in the long run, i.e.  $\lim_{k \rightarrow \infty} \partial E(X_{t+k}) / \partial \tilde{\eta}_t \neq 0$  and is said to have transitory effects on levels of  $X_t$  if otherwise, i.e.  $\lim_{k \rightarrow \infty} \partial E(X_{t+k}) / \partial \tilde{\eta}_t = 0$  (Gonzalo & Ng, 2001). This idea is attractive and has been exploited in Stock and Watson (1988), King et al. (1991), Warne (1993), Gonzalo & Granger (1995), and Proietti (1997). The shares of permanent component in total shocks are important for the interpretation of both long- and short run dynamics of a cointegrated system.

To achieve the permanent-transitory decomposition of shocks, a number of methods have been proposed.<sup>6</sup> All are interested in expressing the  $\Delta Y_t$  in VECM equation in terms of a set of permanent and transitory shocks, as defined above. Here I follow the systematic framework proposed in Gonzalo & Ng (2001). Conditional on  $r$  cointegration relationship found in the system, Gonzalo & Ng (2001) proposes the two-step orthogonalization of the VECM residuals. In the first step, the  $m-r$  permanent shocks are separated from the  $r$  transitory shocks using the prior  $r$  cointegration restrictions on the residuals of VECM. The number of permanent and transitory shocks follows directly from the cointegration restriction of this system. In the second step, Choleski decomposition is implemented to make  $m-r$  permanent shocks mutually uncorrelated with  $r$  transitory shocks.

Formally, it is shown that, for a  $m \times 1$  vector of I(1) process  $Y_t$  with a VECM representation with  $r$  cointegration vectors as defined above and a Wold MA representation  $\Delta Y_t = C(L)e_t$ , it is possible to construct a matrix as follows:

$$(2.2) \quad G = \begin{bmatrix} \gamma_{\perp}' \\ \alpha' \end{bmatrix} \begin{matrix} (m-r) \times m \\ r \times m \end{matrix}$$

$\gamma_{\perp}'$  is the co-feature matrix of  $\gamma$  in the sense that  $\gamma_{\perp}' \gamma' = 0$ .

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<sup>6</sup> Note that the long run effect of permanent (trend) component on levels of  $Y_t$  is not dependent on the approach of permanent-transitory decomposition (Gonzalo and Ng 2001).

The permanent shocks  $u^P$  and transitory shocks  $u^T$  can therefore be isolated by pre-multiply G on VECM residuals  $e_t$ :

$$(2.3) \quad Ge_t = \begin{bmatrix} \gamma'_{\perp} e_t \\ \alpha' e_t \end{bmatrix} : \begin{matrix} u_t^P \\ u_t^T \end{matrix}$$

This is just the first step, however. To make the permanent shocks and transitory shocks mutually orthogonal, the Choleski decomposition is applied to  $\text{cov}(Ge_t)$ :  $H = \text{Chol}(Ge_t)$  and the orthogonalized permanent and transitory shocks are obtained as following:

$$(2.4) \quad \tilde{\eta}_t = H^{-1}Ge_t = \begin{bmatrix} \tilde{\eta}_t^P \\ \tilde{\eta}_t^T \end{bmatrix}$$

Now it comes the expression of  $\Delta Y_t$  in terms of orthogonalized permanent and transitory shocks:

$$(2.5) \quad \Delta Y_t = C(L)e_t = C(L)G^{-1}HH^{-1}Ge_t = D(L)HH^{-1}Ge_t = T(L)\tilde{\eta}_t$$

where  $D(L) = C(L)G^{-1}$  and  $T(L) = D(L)H$ .

## 4. Data and Variable Description

Details on sources of data and variable description are contained in Appendix A. This section just discusses different choice options of consumption and housing wealth series in the empirical analysis.

The choice of consumption series is evidently crucial to studying the consumption function, but no consensus has been reached on this issue. The standard consumption theory concerns the intertemporal optimization of utility derived from the service flow of consumption, and predicts that the rational agents, based on their predictions of own lifetime income, will smooth their life-cycle consumption profile to the extent that the marginal utility of consumption is equalized across different periods. However, the problem regarding durable goods is that service flows from durable goods are unevenly spanned over time periods and are difficult to measure. Observable current expenditures on durable goods are regarded as replacements and additions to



the existing capital stock and therefore not valid indicators of service flows of durable goods consumed in each period. Thus, durable goods are typically omitted from the consumption function.

However, this paper is more interested in how fluctuations in the housing market lead to movements in macro economy where the reaction from aggregate consumer spending is the focus, so total consumer expenditure is used in this paper.<sup>7</sup> Note that Case et al. (2001) and a number of other authors have also adopted this approach. As argued by Rudd & Whelan (2002), to track the intertemporal dynamics of spending, it is not the stream of services but the total consumption expenditure that matters concerning intertemporal budget constraint of spending.<sup>8</sup> Palumbo et al. (2002) also argued that total consumption (including durable goods consumption) comprise the correct consumption variables to use in this case. See Rudd & Whelan (2002) and Koop et al. (2005) for a discussion on how choices of consumption and relevant variables affect model results.

Using total consumption rather than nondurable consumption also allows direct comparability with previous Swedish consumption studies by Berg & Bergström (1995), Johnsson & Kaplan (1999) and Lyhagen (2001), as these authors used total consumption rather than non-durable consumption. When total consumption is modelled, to achieve internal consistency disposable income should be used instead of labour income. Note that in the NA (National Account) system, imputed rents of housing are included in both consumption and disposable income.

Another issue concerns the measurement of housing wealth. Economic theory only predicts the relationship between net wealth and consumption. Using gross measures of wealth can bias up the effect of wealth on consumption. However, to produce the series of net housing wealth data, one needs the series of home mortgage loan data. Restricted by data unavailability, most previous studies simply used total housing wealth data. To facilitate comparison with previous studies conducted in Sweden, I estimate two systems in this paper, whereby System A is comprised of total consumption, disposable income, gross housing wealth and net financial wealth and System B is comprised of total consumption, disposable income, net housing wealth and net non-housing financial wealth. See the definition of each variable in Appendix A.

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<sup>7</sup> Using non-durable consumption will yield a number of other troublesome problems. When the total consumption is broken into durable consumption and non-durable consumption and only the latter is estimated, the durable consumption must be moved to the right hand and the testing becomes highly complex.

<sup>8</sup> Note that Rudd & Whelan (2002) cast doubts on the validity of using consumption of nondurable goods and services to examine the cointegrating relationship implied by the theoretical framework in Lettau and Ludvigson (2004). However, results in this paper are not sensitive to choice of consumption.

Table 1: Variable definition

Symbol	Variable meaning
<i>TC</i>	Total Consumption
<i>NDC</i>	Nondurable Consumption*
<i>DI</i>	Disposable Income
<i>LI</i>	Labour Income
<i>HW</i>	Gross Housing Wealth
<i>NHW</i>	Net Housing Wealth
<i>NFW</i>	Net Financial Wealth
<i>NHFW</i>	Net Financial Wealth, excluding home mortgage loans
<i>HP</i>	Official Constant-quality Housing Price Index

Note: \*This paper's measure, different from common definition. All variables have been deflated by CPI (Year 2000 price=100). Consumption, income, and wealth variables are measured at per capita levels. When the variables appear as lower cases in the equations, their log values are used.

## 5. Empirical Results

### 5.1. Unit Root Tests

The natural starting point of this study is to examine the time series properties of variables used herein. The unit roots in both the log levels and log levels of the first differences of each variable are tested. All variables are measured in real terms and per capita. Since the non-stationary assumption of individual variable plays a crucial role in the modeling strategy, a wide range of standard and newly-developed unit root tests are employed to obtain the most reliable conclusion. It is found that results of different tests can corroborate each other and support the null assumptions that these series contain (long run) unit roots. See details in Appendix B.

One therefore is able to conclude that all variables considered—total consumption/nondurable consumption, disposable income/labour income, gross housing wealth/net housing wealth, and net financial wealth/net non-housing wealth, are individually  $I(1)$ . As seasonal unit roots are found in consumption series, quarterly dummies are included in all models estimated.

### 5.2. Cointegration Analysis

The cointegration relationships for both System A and System B are tested.

Applying the Johansen FLML method (Johansen, 1995), I find that each system contains one and only one cointegration vector. Although this test seems to detect the cointegration rank consistently, there has been discussion on its pitfalls as regards reaching spurious conclusions of

the cointegration relationship (See for example, Gonzalo & Lee, 1998). It is thus a safer strategy to combine both the residual-based and Johansen tests to reach the most robust conclusions on the cointegration relationship.

The standard Engle-Granger cointegration test is known to have little power over structural breaks in the process. That is, it will confuse a stationary process with structural break(s) as a unit root process and is thus not able to reject the unit root null of residuals when the null is actually wrong. Hence, this test may provide the wrong conclusion that there is no cointegration, when there actually is. The data used in this study happen to provide a good illustration of this point.

Applying the standard Engle-Granger cointegration tests (cf. Table C1), one may conclude that no cointegration exists in each system. However, if one applies the tests developed by Gregory & Hansen (1996a) that allows a structural break at an unknown date, the conclusions are completely reversed: each system contains a cointegration relationship (cf. Table C1). One may therefore strongly speculate that there should be a structural break in the cointegration vector.

However, at least from an econometrics viewpoint, the inconsistency between the Engle-Granger and the Gregory & Hansen (1996a) cointegration test results does not necessarily validate the existence of a structural break in the cointegration vector. To accomplish the instability investigation, one needs to use the test of parameter stability for equations containing  $I(1)$  processes that developed by Hansen (1992). See more details of this point in Gregory & Hansen (1996b). Applying the Hansen (1992) test, I find no evidence indicating a structural instability in the cointegration vector for either System A or System B. Check Table C2 and the plotting of stability statistics in Appendix C. Furthermore, I split the data into two sub-periods according to all the potential breakdown time that suspected by Gregory & Hansen (1996a) test results, but in any split experiment no evidences show that the two sub-period data are structurally different in their cointegration relationship, qualitatively and numerically (results not reported but available upon request). I thus interpret the inconsistency between the Engle-Granger and Gregory & Hansen (1996a) test results as the data contain some outlier(s) rather than a structural break in the cointegration vector.

It is true that the 1991 crisis heavily dampened the Swedish housing market. But it does not seem that it seriously disrupted the long run relationship between consumption, income and housing. However, this paper refrains from going into further details of this issue. The following content

proceeds by assuming there is a unique cointegration relationship between consumption, disposable income, housing wealth and financial wealth, regardless of whether the housing wealth is measured at gross or net value.

### 5.3. VECM Results

The identification of cointegration automatically implies that it is feasible to conduct VECM. The *Johansen-type* VECM estimates of the long run consumption function for System A and System B are reported below:

$$\text{System A: } tc = 4.581 + 0.258di + 0.197hw + 0.052nfw$$

$$(0.127) \quad (0.049) \quad (0.016)$$

$$\text{System B: } tc = 3.907 + 0.427di + 0.105nhw + 0.060nfhw$$

$$(0.122) \quad (0.030) \quad (0.026)$$

Note: Asymptotic errors in parentheses.

In both systems, using the lag selection mechanism based on **BIC** (Bayesian Information Criterion) and **HQIC** (Schwarz Information Criterion, cf. Schwert 1989) rule, I include 5 lags in VAR. It may be deserved to mention that **AIC** (Akaike Information Criterion) points to 4 lags in VAR. However, choosing to increase or decrease lag by 1 does not have a large impact on the key results. In both systems, no restrictions are placed on the intercepts in VAR since the restricted constant nulls are rejected at 5% for both cases. Seasonal dummies are always included in VAR.

Comparing System A and System B, I find that measuring housing wealth at gross rather than net value exaggerates the long run association between housing wealth and total consumption, and underestimates the impacts of disposable income on total consumption. The long run association between financial wealth and total consumption is also higher when home mortgage debt is excluded.

To assess the robustness of the estimated long run relationship, I also estimate System A and System B using **OLS** (Ordinary Least Square), **DOLS** (Dynamic OLS), and **FMOLS** (Fully Modified OLS). See Table 2. It is found that these estimates are very close to the VECM estimates, not only qualitatively but also numerically.

Table 2: Different Estimations of long run cointegration relationship

	System A
OLS	$tc=3.653+0.334di+0.191hw+0.070nfw$ (0.495) (0.075) (0.026) (0.008)
OLS	$tc=3.669+0.373di+0.174hw+0.055nfw$ (0.517) (0.083) (0.030) (0.009)
FM-OLS	$tc=3.261+0.450di+0.142hw+0.055nfw$ (0.817) (0.117) (0.049) (0.015)
	System B
OLS	$tc=3.609+0.394di+0.094nhw+0.122nhfw$ (0.493) (0.071) (0.018) (0.013)
DOLS	$tc=3.519+0.473di+0.069nhw+0.091nhfw$ (0.547) (0.081) (0.019) (0.017)
FM-OLS	$tc=3.361+0.475di+0.069nhw+0.097nhfw$ (0.807) (0.111) (0.034) (0.23)

Note: standard errors in parentheses. Quarterly dummy coefficients included in equations but not reported.

But the Johansen-type VECM estimates are preferred since they have controls for endogeneity. The subsequent analysis is based on them if not noted. The associated adjustment parameter vectors are:

System A:  $\gamma=(0, 0, -0.693, 0)$

System B:  $\gamma=(0, 0, -0.998, 0)$

Note that I have restricted the statistically insignificant adjustment coefficient to zero, following the recommendation of Gonzalo & Ng (2001). LR statistics for  $(\gamma_{tc}, \gamma_{di}, \gamma_{hw}, \gamma_{nfw})$  of System A are 2.26, 0.002, 14.95 and 0.055, respectively. For  $(\gamma_{tc}, \gamma_{di}, \gamma_{nhw}, \gamma_{nhfw})$  of System B, the LR statistics are 2.50, 0.34, 16.2 and 0.003, respectively.<sup>9</sup>

The VECM estimate results show that only housing wealth participates in the disequilibrium error correction while total household consumption, disposable income and financial wealth do not. This finding is not affected by whether the housing wealth is measured in gross or net value. Thus, the weak exogeneity assumption of housing wealth with regard to consumption is rejected and the single equation ECM should not be employed, at least in modelling this period's data. Since the period examined in this paper is different from previous Swedish studies, is not readily

<sup>9</sup> Allowing the adjustment coefficients of consumption to be at their point value, -0.162 and -0.117, respectively, dose not have any significant impact on the PT analysis results.

clear why the weak exogeneity assumption of housing wealth is accepted in previous Swedish studies but rejected here. The post-estimation diagnostics in Appendix D indicate that there is excess kurtosis of residuals but no evidence of skewness, autocorrelation or heterogeneity.<sup>10</sup> The stability in long run parameters is confirmed by the LM test.

As all variables are measured at logarithm level, the normalized  $\alpha$  parameter measures the long run elasticity of consumption with respect to each variable. Based on the estimated  $\alpha$  parameter of System B, it is suggested that one percentage point's growth in disposable income will result in a 0.427 percentage point's increase in total consumption, one percentage point's growth in net housing wealth will follow with a 0.105 percentage point's increase in total consumption, and one percentage point's growth in net non-housing financial wealth will follow with a 0.05 percentage point's growth in total consumption. These parameters are consistent with the ranges of Case et al. (2001)'s findings for the US and cross-country data.

The long run elasticity  $\alpha$  parameters ( $1, \alpha_{di}, \alpha_{hw}, \alpha_{nfw}$ ) estimated by Berg & Bergström (1995) for the period 1970q1-1992q4 are (1, 0.642, 0.221, 0.126) via two-step Engle-Granger procedure and (1, 0.866, 0.098, 0.121) via three-step Engle-Yoo procedure. Using almost identical data, the long run consumption function estimated by Lyhagen (2001) is  $tc=3.64+0.34di+0.18hw+0.15nfw-0.27GE$ , where  $GE$  is a variable for measuring the consumer's expectations concerning future economy outlooks. Using yearly data for the period 1970-1998, Johnsson & Kaplan (1999) obtained an estimate of the long run elasticity parameter as (1, 0.80, 0.04, 0.16). However, note that Johnsson & Kaplan (1999) deducted all financial debts from gross housing wealth to yield their "net housing wealth/stock". At the same time, they used gross financial wealth in their models. Hence, the estimates they reported likely underestimated the strength of housing wealth-consumption linkage and overestimated the strength of financial wealth-consumption linkage.

The long run consumption equations estimated in these previous studies are wholly comparable to results here, especially the point estimate of long run gross housing wealth elasticity in this paper is fairly close to what was reported in Berg & Bergström (1995) and Lyhagen (2001). However, this paper shows that if net housing wealth is used rather than gross housing wealth, the point estimate of housing wealth elasticity will be much lower.

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<sup>10</sup> The statistical inference of VECM estimates is said to be sensitive to the violation of non-autocorrelation and skewness assumptions but moderately robust to the degree of kurtosis (Hamilton, 1996).

## 5.4. PT Variance Decompositions

Until now, I have not decomposed the permanent and transitory components in the shocks within this system. Only permanent changes in wealth lead to feedbacks from consumer spending, whereas transitory fluctuations should have no influence. Previous studies neglect to examine the persistence degree of shocks in wealth and income and thus could not have provided sound parameter estimate of the wealth-consumption nexus (Lettau & Ludvigson, 2004). In this paper, the PT shock decomposition methodology follows Gonzalo & Granger (1995) and Gonzalo & Ng (2001).

Table 3a shows how the total variance in the forecast error of movement in total consumption, disposable income, gross housing wealth, and net financial wealth is associated with each of three permanent shocks and one single transitory shock. I refrain from pointing out the source of the four shocks, since it has been said that we may never know the true origin of shocks hitting a system (Cochrane, 1994). To me, the direction and persistence degree of reactions of each variable following the shocks are the key interest.

Table 3b is a more intuitive representation of Table 3a and shows how the total variances of the forecast errors of each variable can be attributed to the combination of the three permanent shocks and the single transitory shock. Table 3b shows that nearly all the shocks in the variance of household consumption are permanent, supporting the random walk hypothesis of household consumption and consistent with the findings in Lettau & Ludvigson (2004).<sup>11</sup> As mentioned previously, the adjustment coefficient of consumption is not statistically significant at 5% in either System A or System B, and has been restricted to zero in both. However, it is significant at 10% in both cases. Nonetheless, when allowing it to be at its point estimate value, -0.16 and -0.12 for System B and System A, respectively, I still find only a tiny proportion of transitory shock component in the variations of consumption (results not reported but available upon request).

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<sup>11</sup> The random walk hypothesis of consumption argues that the best predictor of consumption is its last period value. See, for example, Campbell (1987).

Table 3a: Variance decomposition of forecast error of System B by shocks

Horizon	P1				P2			
	<i>tc</i>	<i>di</i>	<i>nhw</i>	<i>nhfw</i>	<i>tc</i>	<i>di</i>	<i>nhw</i>	<i>nhfw</i>
1	0.02	1	0.004	0.017	0.98	0	0.034	0.001
2	0.019	0.98	0.006	0.019	0.963	0.004	0.099	0.001
3	0.018	0.967	0.033	0.051	0.964	0.007	0.170	0.002
4	0.021	0.969	0.038	0.086	0.949	0.007	0.251	0.002
5	0.054	0.979	0.068	0.103	0.898	0.005	0.300	0.011
6	0.042	0.98	0.096	0.126	0.896	0.007	0.372	0.027
8	0.029	0.983	0.132	0.166	0.886	0.006	0.475	0.034
16	0.015	0.935	0.166	0.282	0.862	0.042	0.692	0.024
24	0.013	0.878	0.146	0.35	0.851	0.082	0.777	0.016
36	0.014	0.83	0.123	0.399	0.844	0.115	0.822	0.018

Horizon	P3				T			
	<i>tc</i>	<i>di</i>	<i>nhw</i>	<i>nhfw</i>	<i>tc</i>	<i>di</i>	<i>nhw</i>	<i>nhfw</i>
1	0	0	0.078	0.982	0	0	0.885	0
2	0.005	0.015	0.136	0.975	0.013	0.002	0.759	0.004
3	0.003	0.012	0.145	0.937	0.015	0.014	0.652	0.010
4	0.018	0.009	0.137	0.902	0.012	0.015	0.573	0.010
5	0.040	0.006	0.112	0.875	0.008	0.010	0.519	0.011
6	0.056	0.005	0.090	0.838	0.007	0.008	0.442	0.009
8	0.081	0.005	0.062	0.793	0.004	0.006	0.332	0.007
16	0.120	0.020	0.020	0.691	0.002	0.002	0.121	0.004
24	0.135	0.038	0.018	0.631	0.001	0.002	0.059	0.003
36	0.142	0.054	0.027	0.581	0.001	0.001	0.028	0.002

Table 3b: Variance decomposition of h-step forecast error of System B by persistence

Period	$\Delta tc_t - E \Delta tc_{t-h}$		$\Delta di_t - E \Delta di_{t-h}$		$\Delta nhw_t - E \Delta nhw_{t-h}$		$\Delta nhfw_t - E \Delta nhfw_{t-h}$	
	P	T	P	T	P	T	P	T
1	1	0	1	0	0.115	0.885	1	0
2	0.987	0.013	0.998	0.002	0.241	0.759	0.996	0.004
3	0.985	0.015	0.986	0.014	0.348	0.652	0.990	0.010
4	0.988	0.012	0.985	0.015	0.426	0.573	0.990	0.010
5	0.992	0.008	0.990	0.010	0.481	0.519	0.989	0.011
8	0.996	0.004	0.994	0.006	0.669	0.332	0.993	0.007
16	0.997	0.002	0.997	0.002	0.878	0.121	0.997	0.004
20	0.999	0.001	0.999	0.002	0.918	0.082	0.997	0.003
36	1	0.000	0.999	0.001	0.972	0.028	0.998	0.002

Notes: *P* represents permanent shock; *T* represents transitory shock. The 95% CI (confidence interval) for both the variance decomposition and impulse response functions have been generated following the bootstrap procedure described in Gonzalo & Ng (2001) but are omitted here.



Table 3b also shows that the movements in disposable income are also characterized predominately by permanent shocks. The share of transitory shocks in the total variances never goes beyond 1.5% in all horizons. This again is consistent with Lettau & Ludvigson (2004). The evolution path of disposable income also looks like a random walk, and its fluctuations are driven mostly by permanent shocks. A large fraction of components in the movements of housing wealth is found to be transitory; for the first five quarter horizons, this fraction is significantly higher than 50%. Meanwhile, the transitory component in the shocks of housing wealth takes a long horizon to elapse. The transitory fraction in the net housing wealth movement is about 30% after 8 quarter horizons and around 8% after 20 quarter horizons (I will elaborate more on this point in the following section). In contrast, it is found that the fraction of transitory components in the shocks of net non-housing financial wealth is very low, at its highest a trivial 1% in all horizons. Thus, this paper shows that the transitory components in wealth come mainly from housing wealth rather than financial wealth.

In Lettau & Ludvigson (2004), the authors claimed that when they disaggregated the total wealth into stock and non-stock wealth, they found that stock wealth is dominated by transitory shocks and non-stock wealth is dominated by permanent shocks. The findings in this paper may not necessarily contradict Lettau & Ludvigson (2004) since I use different disaggregate forms of wealth. In addition, three reasons may also explain the disparity: 1) stock wealth is only a small component of total household financial wealth in Sweden, i.e. the share is around 0.08-0.2 for the entire sample period; 2) As Table A1 suggests, the contemporary correlation between financial wealth growth and Stock market index growth in Sweden is weak, only around 0.24; 3) net housing wealth accounts for around 50-70% of non-stock wealth in Sweden but possibly not as high in the US; 4) the Swedish housing market was particularly turbulent during the period studied. Using gross housing wealth and net financial wealth instead of net housing wealth and net non-housing financial wealth only have minor impacts on these findings. See Table D3 in the Appendix D.

The wealth-consumption linkage literature exhibits great interest in estimating the *MPC* parameter of wealth. The MPC from housing wealth can be obtained by multiplying the  $\alpha_{hw}$  with the average ratio of housing wealth value level relative to total consumption level.<sup>12</sup> If one regard every moment in housing wealth as permanent, the average *MPC* from net housing wealth is 0.119 (0.105×1.131) SEK per-SEK. However, if one takes into account the permanent-transitory

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<sup>12</sup> The average ratio of net housing wealth relative to total consumption for the most recent period (2002-2004) is 1.131. For gross housing wealth it is 1.805. For disposable income, net financial wealth, and net non-housing wealth, the ratios are 1.046, 1.464 and 2.137, respectively.

composition of variances in net housing wealth, this estimate will be significantly lower. For example, when one takes 50% as the mean fraction of transitory shocks in the total variances of net housing wealth, the estimated *MPC* parameter for average rises in net housing wealth should be  $MPC=0+(1-0.532)\times 0.119=0.056$ , only half of its previous value.<sup>13</sup>

This estimate of average *MPC* from net housing wealth, however, is still substantial. For a one-SEK increase in net housing wealth, consumers will on average spend 0.056 SEK more on consumption. Such estimate is fairly close to comparable *MPC* estimates reported in the US and Canada (Belsky & Prakken, 2004; Benjamin et al., 2004; Pichette, 2004). These evidences so far have suggested that housing wealth is undoubtedly a key factor in the dynamics of aggregate economy. Based on the estimates of System B, the implied average *MPC* from disposable income is 0.493 SEK ( $1.046 \times 0.472$ ) per SEK, and the implied average *MPC* from net non-housing financial wealth is 0.128 SEK ( $2.137 \times 0.06$ ) per SEK. However, after adjusting for the difference in the permanent-transitory composition of variance, one will find that the changes in net non-housing financial wealth lead to more feedbacks from consumption than do changes in net housing wealth.

#### 5.4.1. The Interpretation of Permanent and Transitory Shocks

Below is the plotting of the **IRF** (impulse response function) for one transitory shock and three permanent shocks identified in this cointegrated system. It is up to 40 quarter forecast horizons. Again, I did not identify the source of each shock but instead just focus on the reactions and degree of persistence in the reactions of each variable following a shock.

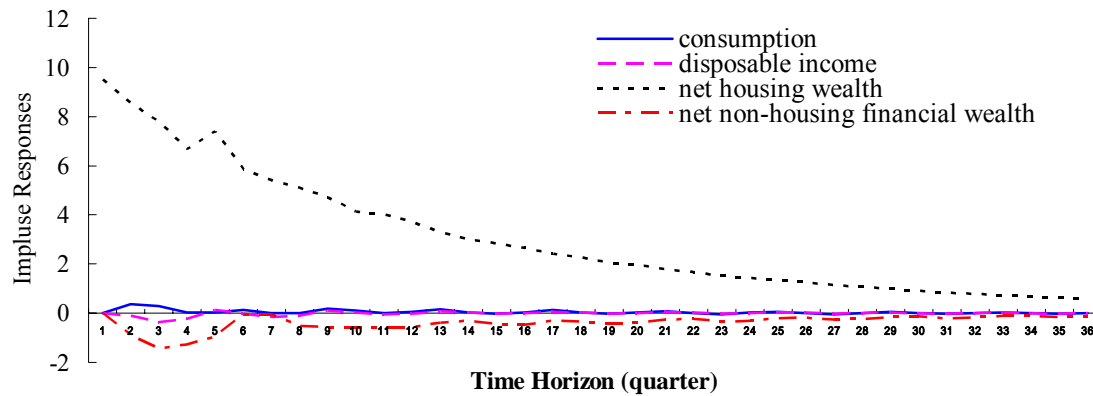
It is shown that, following a transitory shock, there are immediate and substantial changes in net housing wealth, and a large proportion of variations in net housing wealth are actually driven by the transitory shock. Here, it is also suggested that the degree of persistence of this transitory shock is large, which implies that net housing wealth generally adjusts sluggishly to a return to the new equilibrium level. However, it is also shown that small changes in consumption, disposable income and net non-housing financial wealth follow a transitory shock. In other words, variations in the consumption, disposable income and net non-housing financial wealth are virtually dissociated with the transitory shock, or the vast majority of variability in net housing wealth.

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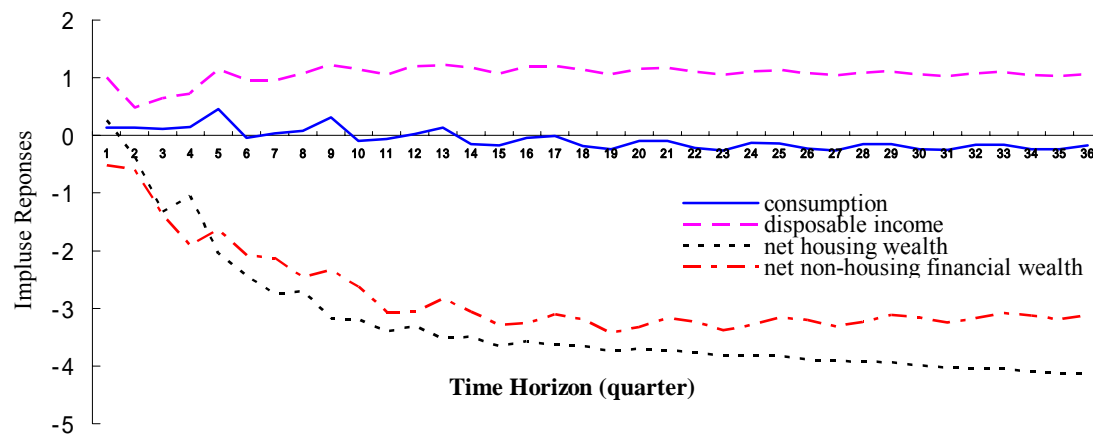
<sup>13</sup> The weighted MPC is computed as  $q \cdot 0 + (1-q) \cdot MPC^p$ , where  $q = \sqrt{sT} / (\sqrt{sT} + \sqrt{sP})$  and  $sT$  is the fraction share of transitory shocks in the total variance of forecast errors (Lettau and Ludvigson 2004). Using the point estimates of model 2b at the 4<sup>th</sup> horizon,  $q$  for net housing wealth is 0.532.

The first permanent shock leads to no feedback from total consumption but to large and negative feedback from net housing wealth and net non-housing financial wealth. Meanwhile, disposable income persistently increases. The second and third permanent shocks lead to persistent rises in both consumption and wealth but without feedbacks from disposable income.

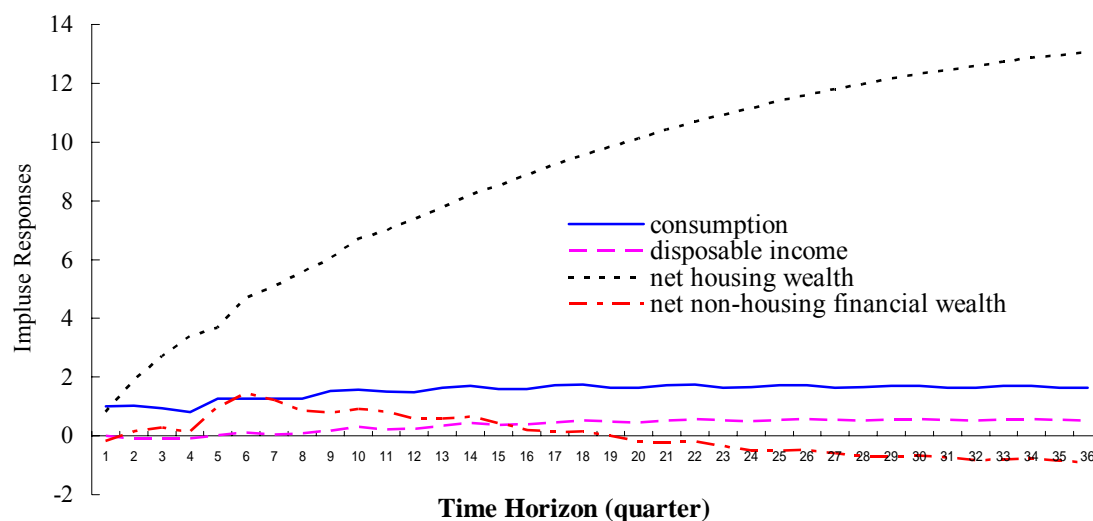
**Figure 1.1 The Impulse Response of Transitory Shock**



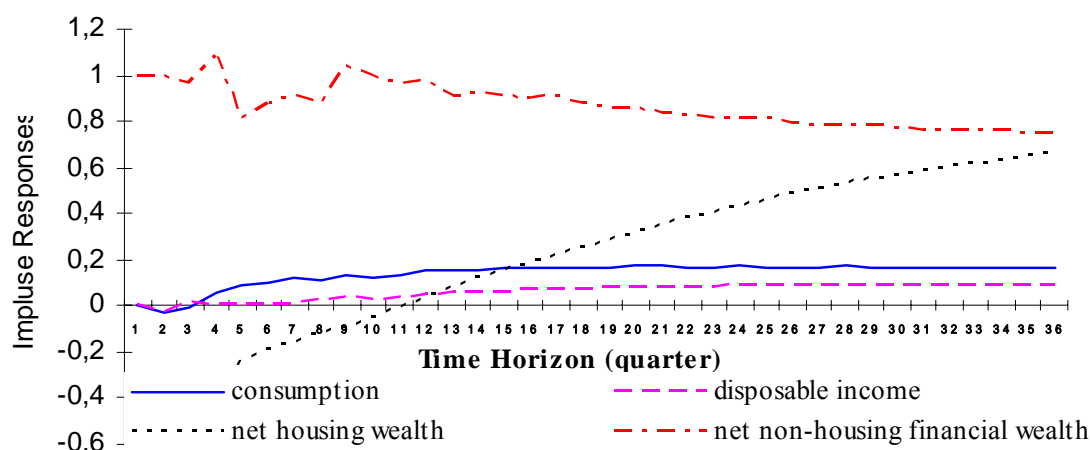
**Figure 1.2 The Impulse Responses of Permanent Shock 1**



**Figure 1.3 The Impulse Responses of Permanent Shock 2**



**Figure 1.4 The Impulse Responses of Permanent Shock 3**



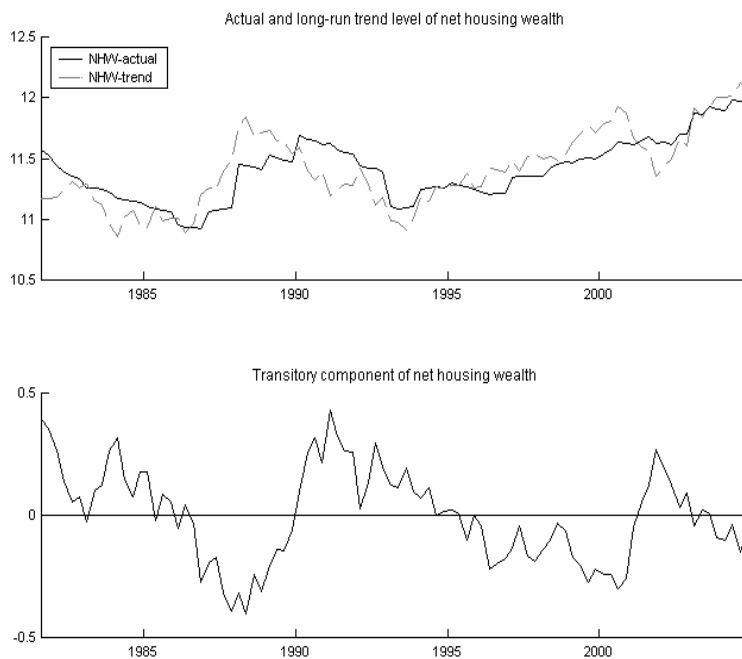
## 5.5. Important Implications of Findings

The VECM estimation and PT variation decomposition result of the consumption-income-wealth system can be used to shed light on a number of important macroeconomic issues. For example, Lettau & Ludvigson (2004) explored the predictability of cointegration residuals to forecast future paths of asset wealth and, particularly, of stock market indexes. However, as stated above, here this paper is more interested in the trend-cyclical development of aggregate economies. The predictability power of cointegration residuals to fluctuations in the housing market is left to future research work.

Employing the trend concept provided in Stock & Watson (1988) and applying Gonzalo-Ng procedure, I decompose the level of each variable studied in the system into a “trend” and “cyclical” component. The trend component of each variable is simply defined by the combination of three permanent components in this cointegrated system, identified previously. The cyclical or transitory component is simply the deviation between the actual level and the implied long run trend level.

To keep a focus on the housing market, the time-series plotting of actual level versus implied long run trend component of housing wealth is depicted below, and the trend plotting of other variables is contained in the three panels of Figure D1 in Appendix D. Leaving housing wealth temporarily, let us first examine the plotting of consumption, income and financial wealth. One will find that total consumption is well described by the implied long run trend component and follows a random walk path. The transitory component of consumption is generally very small, which is also true of disposable income. The distribution of the transitory component of income is even narrower than that of consumption. The transitory component of financial wealth is larger than the former two, but still not large. When we turn to the net housing wealth, however, the figure shows that it tends to maintain large deviations between actual levels and long run trends. In some episodes, the deviations between actual and trend levels of net housing wealth are staggeringly large.

Figure 2: Actual and long run trend levels of net housing wealth



When examining the panel of housing wealth trend-transitory plotting, it is particularly interesting to note that the displayed distribution of estimated transitory components corresponds closely with the extraordinary episodes of Swedish housing market in chronological order. During the early 1980s, housing wealth persisted in exceeding the long run trend level. This shows that although real house prices on the Swedish housing market were continuously declining during this period, the accumulated housing overvaluation in Sweden prior to 1980 had not been completely eliminated until the middle of the 1980s. The transitory component of housing wealth switched to being negative and hit the bottom around 1988, suggesting that the value of housing might be substantially undervalued during this period. This, however, might be a reason for the heating-up of the Swedish housing market in the late 1980s, which continued to rocket until its peak in 1991. After the housing crisis in 1992, it took roughly three years to force housing wealth to return to the long run trend level. However, it appears that the development of the Swedish housing market lagged behind the IT boom in the latter half of 1990s, and that housing value during this period might be undervalued. The surge of Swedish housing prices since 1997 appears to have contained somewhat of an overvaluation component, but the degree of overvaluation seems to be at its highest around 2002 and has declined in the past few years, despite the fact that real house prices continue to soar. In 2004, the value is even below the long run trend level. Thus, it seems that today's Swedish housing market is not in a serious danger of overpricing.

Interested readers can check Figure D1 in Appendix D to see the trend-transitory plotting of financial wealth also closely mirrors the episodes of the Swedish financial market fluctuations during the period studied. These unsurprising coincidences exemplify the explanatory power of models used in this paper.

The noticeable persistence in the swings of the transitory component in both the housing and financial markets strengthens previous observations and provides support for the hypothesis proposed in Lettau & Ludvigson (2004) that wealth adopts long horizons to match the smoothness in consumption and income.

## **5.6. Short Run Dynamics**

Based on the VECM estimates of System B contained in Table D1 of Appendix D, one may get the impression that short run growth in consumption and income is highly predictable. The R-square value for both the consumption growth and income growth equations is above 0.96. This again contradicts Lettau & Ludvigson (2004), who reported low short run predictability of

consumption and income in US data. However, it is also suggested that short run growth in either form of wealth is much more difficult to predict. The R-square value for the housing wealth growth and financial wealth growth equations is much lower, only 0.38 and 0.55, respectively. This is consistent with findings in earlier sections: movements in consumption and income are driven by permanent components and long run trend value, and thus while they are not predictable in the long run, they are highly predictable in the short run; movements in wealth (especially housing wealth) are driven largely by transitory components, and thus appear with mean-reverting features. Thus, *wealth is predictable in the long run but is difficult to predict in the short run.*

Regarding the short run consumption-wealth nexus, it is found that one percentage point's increase in net housing wealth follows with 0.064 percentage point's increase in total consumption, with a one-quarter lag; one percentage point's increase in financial wealth follows with 0.054 percentage point's growth in total consumption, with a three-quarter lag. Thus, evidences show that changes in housing wealth have significant correlations with total consumption, in both the long run and short run.

## **5.7. Discussions and Robustness Check**

### **5.7.1. Housing Prices versus Housing Wealth**

The series of housing wealth used in this paper is produced by author's own calculation and is based on the tax-assessed value of housing stock times a time-varying purchase-price coefficient. This is the method commonly employed by the Swedish literature. To assess whether the estimated parameters are sensitive to potential measurement bias in this computation method of housing wealth, I experiment with an alternative measure of housing market changes – the official quality-controlled housing price index. House price is generally believed to be measured with greater precision than assessed values. But then, one must implicitly assume that the vast majority of volatility in housing wealth can be credited to changes in housing prices and that little is due to the growth of average house size. However, this assumption is valid at least for the period under study. In Sweden, the average useful floor space of completed dwellings was 98.5 m<sup>2</sup> in 1983 and was 99.7 m<sup>2</sup> in 2002, with only very minor growth (UNECE housing statistics, 2005). One may note that a number of authors, e.g. Ludwig & Slok (2002) and Phang (2004), have also employed the price approach in measuring housing wealth effect.

Evidences show that the Swedish housing price index is a I(1) process. The four I(1) variable system that consists of total consumption, disposable income, housing price index and net financial wealth is named as System C. Similar to System A and System B, a unique cointegration vector was found to exist within System C.

From Table 4, the long run estimates of System C are fairly close to those of System A. The adjustment coefficient of gross housing wealth is statistically significant, which again rejects the weak exogeneity assumption of housing wealth with respect to household consumption. Despite some numerical differences, the main conclusions are not affected. Thus, key findings in this paper are not sensitive to how housing wealth is measured. This estimation exercise also demonstrates that housing price can be a good proxy of housing wealth. In the interest of saving space, the VECM estimates for System C are skipped in this paper but available upon request.

Table 4: Estimated long run relationship for System C

	System C
OLS	$tc=3.70+0.459di+0.164hp+0.076nfw$ (0.548) (0.071) (0.028) (0.009)
DOLS	$tc=3.401+0.534di+0.131hp+0.052nfw$ (0.577) (0.077) (0.032) (0.009)
FM-OLS	$tc=2.804+0.621di+0.124hp+0.030nfw$ (0.720) (0.092) (0.044) (0.011)
VCESM (lag=5)	$tc=2.518+0.674di+0.080hp+0.011nfw$ (0.094) (0.038) (0.014)

Note: All variables are measured at log of real and per capita levels. Standard errors in parentheses. Quarterly dummy coefficients included in equations but not reported.

### 5.7.2. Substitution Effect and Non-housing Consumption

As claimed at the beginning, this paper focuses on the association between housing wealth and total household consumption. However, most textbook economic theories concern the long run relationship between the utility service flows derived from the consumption of goods (and services) and wealth variables.

Although I have claimed that I am not planned to test a specific consumer theory, I am, however, interested to test whether increases in housing prices lead to a negative substitution effect on non-housing consumption. As Muellbauer & Lattimore (1995) pointed out, increases in real housing price could possibly have both a positive wealth effect and a negative substitution effect on non-housing consumption for all households whose relative price of housing services is



changed. Negative substitution effect can arise, for example, when many households rush into an overheating housing market and purchase houses at the price of sacrificing their non-housing consumption. The effects of housing price changes on households' non-housing consumption carry significant policy implications, but have rarely been empirically explored in the past.

When existing literature tests PIH or other consumer behaviour theories, however, they unanimously define the nondurable consumption concept as the sum of nondurable goods and total services; see Lettau & Ludvigson (2004), Phang (2004) and many others. In doing so, they ignored the fact that the consumption of housing services itself has been included in total services in the NA (National Account) system. Using this measure of nondurable consumption will bias upward the association between housing wealth and the consumption of non-durable goods and non-housing services.

Fortunately, I have access to the Swedish data of gross rents (item SNA 1210), which is the sum of actual rents paid by tenants and tenant-owners, imputed rents of homeowners (including both permanent and holiday houses), as well as the maintenance and reparation of the dwelling. Excluding the consumption of housing services from total services produces the proper measure of consumption series to answer the question asked in this section. To allow compatibility with this measure, I use labour income instead of durable income, since the imputed rents of housing services are also included in disposable income of NA but not in the series of labour income from the Income Statistics. See Appendix A for more details. The unit root testing of the two series suggests that they are clearly individual  $I(1)$  process (cf. Appendix B).

As an analogy to the analysis of total consumption-housing wealth nexus, I name the system composed of expenditures on nondurable goods and non-housing services, labour income, gross housing wealth and net financial wealth System D1 and the system composed of expenditures on non-durable goods and non-housing services, labour income, net housing wealth and net non-housing financial wealth System D2. Again, it is found that only one cointegration relationship in each system. In the interest of saving space, results are not reported here but are available upon request. The estimated long run relationship for System D1 and System D2 is reported in Table 5:

Table 5: Estimated long run relationship for System D1 and System D2

	System D1	System D2
DOL	$ndc=2.85+0.437li+0.127hw+0.074nfw$	$ndc=2.72+0.504li+0.037nhw+0.117nhfw$
S	(0.340) (0.066) (0.031) (0.008)	(0.353) (0.059) (0.019) (0.013)
FM-	$ndc=3.01+0.439li+0.101hw+0.083nfw$	$ndc=2.97+0.461li+0.033nhw+0.134nhfw$
OLS	(0.585) (0.096) (0.050) (0.013)	(0.557) (0.086) (0.033) (0.019)

Note: All variables are measured at log of real and per capita levels. Standard errors are in parentheses. Quarterly dummy coefficients included in equations.

The estimation results of Systems D1–D2 match very closely with those of Systems A–B. It is shown that the strength of the association between net housing wealth and expenditures on non-durable goods and non-housing services is significantly lower than that between net housing wealth and total consumer expenditures. However, its direction is still positive and the statistical significance is high. Therefore, evidences show that permanent increases in housing price/wealth shifts not only durable consumption but also nondurable consumption. Once again, it is found that using gross housing wealth exaggerates the association strength between housing and non-housing consumption.

## 6. Summary

The contemporary global economy can be characterized by two phenomena: in nearly all countries, the stock market is struggling in feeble recovery since the 2001 plunge; and in most countries, the housing market is continuously booming. Whether it is the upsurge in house prices that counterbalances the falling-down of the stock market and upholds the enduring growth of aggregate demand has therefore become a particularly interesting question in recent years. Mounting inquiries from both economists and policymakers have been inspired. In this paper, using the latest quarterly Swedish data (1980q1-2004q4), I re-examine the association between housing wealth and aggregate household consumption within the framework of VECM and PT shock decomposition.

Applying VECM, following key findings are reached: 1). There is a unique cointegration relationship between aggregate consumption, disposable income, housing wealth and financial wealth. The long run association between housing wealth and aggregate consumption is positive and the strength is strong. The estimated long run elasticity of total consumption with respect to net housing wealth is 0.11. The existence of a unique cointegration relationship and the strength of the housing-consumption association are not contingent on whether gross housing wealth or net housing wealth is used. They are also not affected by whether one uses assessed housing

wealth or real quality-constant housing price index to proxy the movements in the housing market. The cointegration relationship is stable for all these situations. However, it is also suggested that previous studies may have overestimated the association between housing wealth and consumption when using gross wealth value rather than net wealth value; 2). It is found that only housing wealth participates in the disequilibrium adjustment while consumption, disposable income and financial wealth provide little or virtually no contribution to the equilibrium correction. Therefore, VECM should be employed rather than ECM to model this period Swedish data; 3) In the short run, total consumption is expected to rise by 0.064 percentage point following one percentage point's increase in net housing wealth; and 4) There is also evidence suggesting that a permanent increase in housing price/wealth shifts not only durable consumption but nondurable consumption as well.

Applying the PT (permanent-transitory) decomposition analysis to the shocks hitting the system, I reach following conclusions: 1). Nearly all variances in movements of consumption are permanent, supporting the classical random walk hypothesis of consumption behaviour; 2). Variances in the movement of disposable income and financial wealth are also driven almost entirely by permanent shocks; 3). On the other hand, a large proportion of variances in the movements in housing wealth are transitory, no matter how the housing wealth is measured. For net housing wealth, the transitory share is well above 50% for the first five-quarter forecast horizons. Meanwhile, the transitory component in the variances in housing wealth movement elapses slowly. Thus, I reach a policy suggestion quite similar to that of Lettau & Ludvigson (2004): We need not worry a great deal about short run variations in the housing market, as they are largely dissociated with consumer spending. Nonetheless, caution must be exercised in interpreting this remark and using it in policy formulation. *The short-run variations would have little effect on consumption only if they had been correctly anticipated as transitory.* In long run, the estimated average *MPC* from per-SEK increase in net housing wealth was 0.056 SEK after adjusting for the composition of permanent-transitory shocks, in contrast to 0.113 SEK by previous common calculation methods; and 4). The PT models explain well the historical performance of Swedish macroeconomic dynamics. The PT decomposition results also suggest that despite soaring housing prices since 1997, the recent Swedish housing market is not at high risk of overvaluation, as it still evolves around the long run trend level.

In the end, I propose some possible extensions of this study. Future studies may use panel data at regional level to re-assess the strength of the housing wealth-consumption linkage, which may produce more robust estimates. The use of micro-level household data, and particularly panel

data, can be especially useful as it will enable us to distinguish the causal and non-causal relationships between housing price/wealth and consumption. It will also enable easy identification of the substitution effects of housing price/wealth on various components of consumer expenditures. Finally, I believe a study on the asymmetry of the effects of housing wealth on consumption would be a great contribution.

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## 8. Appendix

### 8.1. Appendix A: Data Sources and Variable Description

The raw data used in this paper come from a variety of sources: SCB (Statistics Bureau of Sweden, [www.scb.se](http://www.scb.se)), EuroStat (Official statistics department of EU), and OECD Economic Outlook 2004.

Quarterly data of **total household consumption expenditure** and **disposable income** are obtained directly from the NA (National Account) database at the SCB website.<sup>14</sup> Note that capital gains/losses are not included in the NA data as they are not regarded as the result of productive activity that affects GNP, but only as a change in the value of an asset. This is different from the Income Statistics. The quarterly **nondurable consumption** series used in this paper refers to the sum of nondurable goods and services minus gross rents, which are the actual rents paid by renters and the imputed rents of housing services consumed by homeowners (Item 1210 in SNA 95).<sup>15</sup> The quarterly data of non-durable consumption are available only after 1993. For earlier periods, only yearly data exist. Thus, the earlier yearly data are interpolated to quarterly frequency using the proportional Denton seasonal interpolation method, recommended by IMF and used in their official statistics, where the series of total household consumption expenditure is used as the associated “seasonal indicator series” (Denton, 1971).

There is no direct measure of **labour income** from any official statistics institution. Following the Lettau & Ludvigson (2004), the labour income (non-property income) is defined as: the compensations to employees plus transfer income minus household taxation minus social contribution. The data resource for these series is the OECD Economic Outlook 2004.

The **net household financial wealth** data, which is the difference between total household financial assets and total financial liabilities (both including NPISH), are taken from the FA (Financial Account) of SCB. The assets include cash, sum of savings and deposits, bonds,

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<sup>14</sup>The construction of the Swedish National Accounts follows the European national accounts system legislated by the EU (ESA 95), which in turn is based on the UN recommendation (SNA 93).

<sup>15</sup> Item 1210, gross rents, includes: 0411 - actual rentals paid by tenants exclusive of heating; 0412 - rentals actually paid for secondary residences and tenant-owners; 0421 - imputed rentals of owner-occupiers exclusive of heating; 0422 - imputed rentals for secondary residences exclusive of heating; and 0432 - services for the maintenance and repair of the dwelling. I thank Ylva Petersson at Statistics Sweden for clarifying this for us.



corporate and mutual fund shares, and other forms of financial assets. Quarterly data are available only after 1997, thus the earlier yearly data were interpolated to quarterly frequency using the Denton method with the seasonal profile of the Stockholm stock market index.

The **gross housing wealth**, i.e. the value of housing stock, is based on the tax assessment values of owned permanent and seasonal homes times the purchase-price-coefficient (KB) of each type. The Swedish tax authority conducts general tax assessments of real estate periodically (1981, 1988, 1990, 1992, 1994, 1996, and 2003).<sup>16</sup> The purchase-price-coefficient is the ratio of average purchase price in each time period relative to the assessed value at base year of each interval; this is also called ratio S/A (sale price/assessed value). The quarterly purchase-to-assessed value coefficients were available only after 1998q1, thus the earlier yearly gross housing wealth data were interpolated to quarterly frequency using the Denton method with the seasonal profile of the official housing price index. The **net housing wealth** (home equity) is gross housing wealth minus loans from housing credit institutions to households. In Sweden, housing credit institutions dominate the home mortgage market, selling more than 90% of home mortgage loans. The corresponding **net non-housing wealth** is net financial wealth plus loans from housing credit institutions, since the loans from housing credit institutions have been included in the liability side of the financial account.

The quarterly **house price index** used here is the weighted average of constant-quality **official real estate price index of primary and leisure homes** (1981q1=100) published by SCB. The weight varies by year and is determined by the ratio of permanent housing wealth relative to seasonal housing wealth in each year.

In the empirical analysis, the nominal data of quarterly consumption, income and wealth are deflated by CPI to get constant-price real data (Year 2000=100), and are further divided by total population to be expressed in real per capita measures.

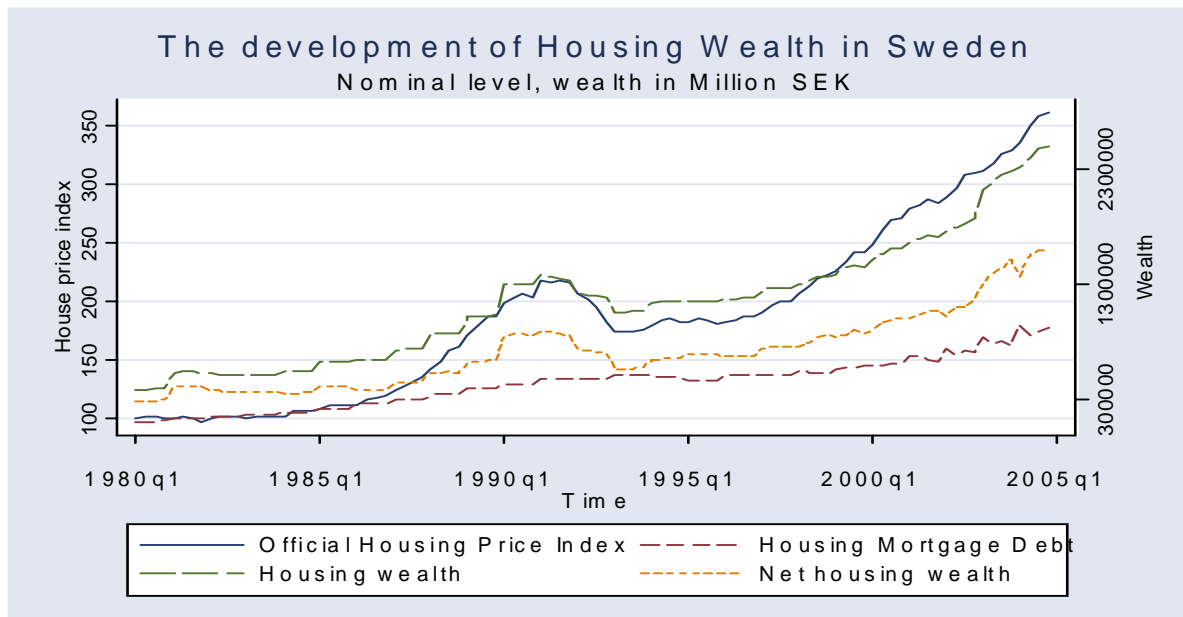
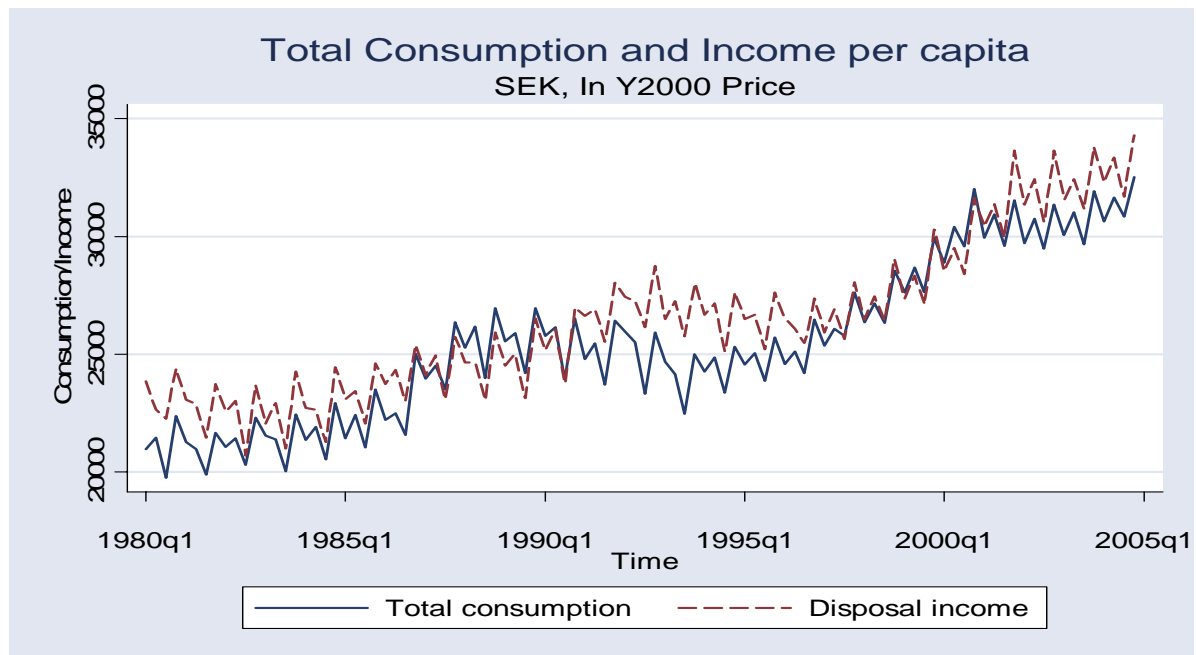
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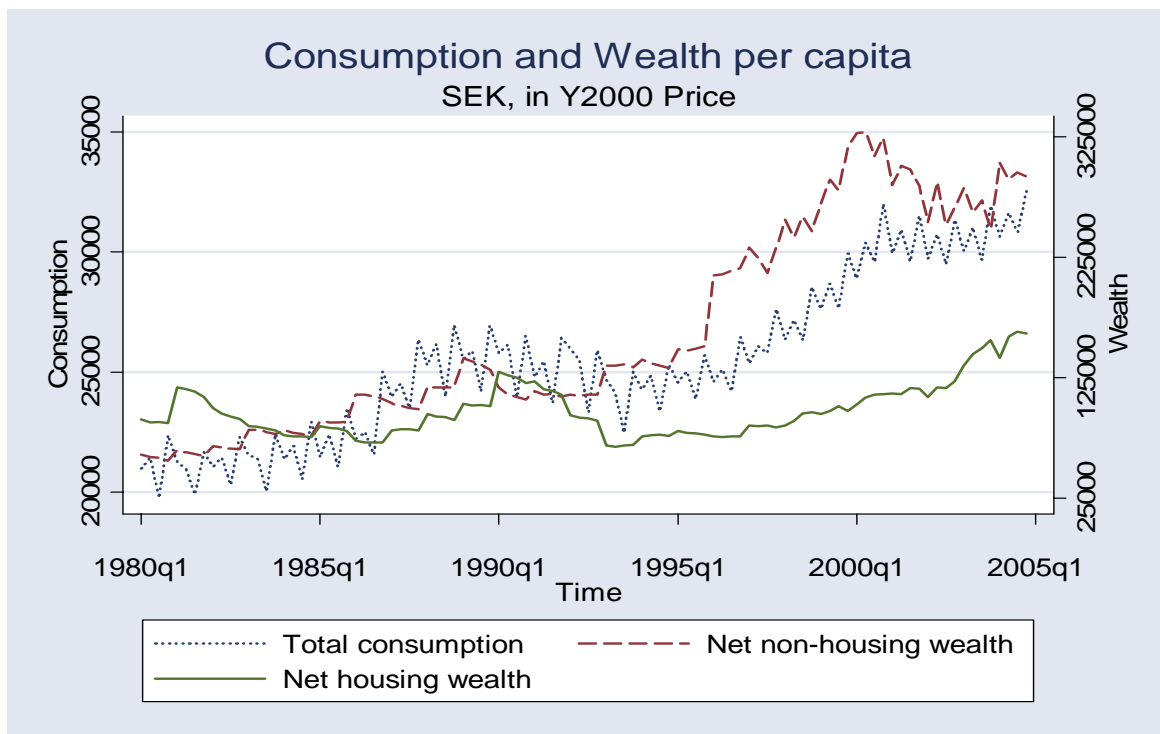
<sup>16</sup> Adjustment has made with regard to the fact that building units with a value less than 50,000 SEK have not been given any taxable value since 1996.

Table A1: correlation between the **growth rates** of key variables

	Total consumption	Disposable income	Gross housing wealth	Net financial wealth	Stock market index*
Total Consumption	1.000				
Disposable Income	0.2757	1.000			
Gross housing wealth	-0.2283	0.0759	1.000		
Net financial wealth	-0.3268	-0.1260	0.0556	1.000	
Stock market index*	0.0951	-0.1537	0.0338	0.2431	1.000

Note: \* the OMX Swedish stock market index





## 8.2. Appendix B: Unit root tests

The lag length selection is a key issue in ADF-type unit root tests. Monte Carlo studies show that the lag length selection has important effects on the power performance of ADF tests in finite sample. Inclusion of surplus lagged dependent regressors tends to reduce the test power systematically. Hayashi (2000, pp397) commented that the general-to-sequential  $t$  rule and AIC (Akaike Information Criterion) rule both have a positive probability of overfitting (lag length used is more than true lag length), but the BIC (Bayesian Information Criterion) rule, also called the SIC (Schwarz Information Criterion, cf. Schwert 1989) rule, is consistent. I therefore select the lag length via BIC throughout unit root tests if not otherwise stated. The unit root tests are sensitive to the deterministic components included—linear time deterministic trend, intercept, both or none. The graph plotting of series can assist us in solving this problem. The series of consumption, income and wealth apparently trend upward, so I test them by imposing a time trend. However, the series of real housing price index is unlikely to have any time trend and is thus tested without time trend.

The ADF-GLS (Generalized Least Square) test developed by Elliott et al. (1996) is assessed to have better overall performance than the standard ADF test in terms of both small sample test size and test power. In the immediate following, I report the results of both standard ADF and ADF-GLS tests. I also perform the ADF unit root test, allowing for additive outliers, following

the method outlined in Vogelsang (1999) and Franses & Haldrup (1994). Here, additive outlier refers to a temporary shock or aberration in the data.

From Tables B1-B2, the results of ADF and ADF-GLS tests are consistent with each other, but the ADF tests allowing outliers report some conflicting conclusions regarding series of income and gross housing wealth. However, the small sample power of the last test is not very good and we should not place great credit on its information. To further assess the robustness of unit root conclusions, the Phillips-Perron test and KPSS test are applied in the following. However, we found that the conclusions of the Phillips-Perron and KPSS test are sensitive to which deterministic terms are included.

Table B1: Standard ADF test statistics (N=100, lag selection via BIC)

Variable	Deterministic terms	lag	ADF t test	Critic (5%)	H0: I(1)
Tc	Time trend	4	-1.972	-3.45	Accepted
Ndc	Time trend	4	-1.817	-3.45	Accepted
Di	Time trend	4	-1.737	-3.45	Accepted
Li	Time trend	4	-2.548	-3.45	Accepted
Hw	Time trend	4	-2.654	-3.45	Accepted
Nhw	Time trend	4	-2.696	-3.45	Accepted
Nfw	Time trend	4	-2.143	-3.45	Accepted
Nhfw	Time trend	4	-2.586	-3.45	Accepted
Hp	Constant	4	-1.728	-2.89	Accepted
$\Delta tc$	Constant	3	-3.912**	-2.89	Rejected
$\Delta ndc$	Constant	3	-6.730**	-2.89	Rejected
$\Delta di$	Constant	3	-4.741**	-2.89	Rejected
$\Delta li$	Constant	3	-3.254*	-2.89	Rejected
$\Delta hw$	Constant	3	-3.634**	-2.89	Rejected
$\Delta nhw$	Constant	3	-4.118**	-2.89	Rejected
$\Delta nfw$	Constant	3	-4.518**	-2.89	Rejected
$\Delta nhfw$	Constant	3	-4.232**	-2.89	Rejected
$\Delta hp$	Nothing	3	-2.109*	-1.950	Rejected

Table B2: ADF-GLS and ADF allowing for outliers

Variable	ADF-GLS t test	Critic (5%)	ADF-for outliers	Outliers	H0: I(1)
tc	-2.006	-3.030	-1.972	No	Accepted
ndc	-1.707	-3.030	-1.817	No	Accepted
di	-1.207	-3.030	-2.789	No	Accepted
li	-2.670	-3.030	-3.750*	No	A/?
hw	-2.526	-3.030	-2.654	No	Accepted
nhw	-1.361	-3.030	-1.479	No	Accepted
nfw	-1.858	-3.030	-2.128	No	Accepted
nhfw	-2.032	-3.030	-3.013	No	Accepted
hp	-1.859	-1.950	-1.728	No	Accepted
$\Delta tc$	-2.073*	-1.950	-3.912**	No	Rejected
$\Delta ndc$	-2.183*	-1.950	-6.730**	No	Rejected
$\Delta di$	-4.579**	-1.950	-2.678	No	R/?
$\Delta li$	-4.577**	-1.950	-3.258*	No	Rejected
$\Delta hw$	-2.614**	-1.950	-2.141	10	R/?
$\Delta nhw$	-5.970**	-1.950	-6.953**	10	Rejected
$\Delta nfw$	-6.139**	-1.950	-12.543**	5	Rejected
$\Delta nhfw$	-3.038**	-1.950	-13.062**	5	Rejected
$\Delta hp$	-2.049*	-1.950	-2.109*	0	Rejected

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; Lag selection always via BIC; The critical values in Table B2 are interpolated according to Elliott et al. (1996), which are obtained from simulations.

Table B3: Phillips-Perron and KPSS ( $H_0: I(0)$ ) test (N=100)

Variable	Z(rho)	Cri(5%)	Z(t)	C(5%)	KPSS	lag	Cri(5%)
Tc	-4.242	-13.692	-1.333	-2.891	1.36**	6	0.463
Ndc	-2.004	-13.684	-1.012	-2.891	1.5**	6	0.463
Di	-7.794	-13.684	-1.804	-2.891	1.23**	7	0.463
Li	-5.058	-13.684	-1.353	-2.891	1.3**	6	0.463
Hw	-5.878	-20.682	-1.517	-3.451	.971**	6	0.463
Nhw	-2.668	-20.682	-0.795	-3.451	0.632*	6	0.463
Nfw	-9.964	-20.682	-2.176	-3.451	1.41*	6	0.463
Nhfw	-10.223	-20.682	-2.208	-3.451	1.41**	6	0.463
Hp	-0.907	-13.684	-0.355	-2.892	.505*	6	0.463
$\Delta tc$	-157.558**	-13.684	-43.374**	-2.892	.177	7	0.463
$\Delta ndc$	-149.139**	-13.684	-64.384**	-2.892	.0209	4	0.463
$\Delta di$	-154.250**	-13.684	-55.887**	-2.892	.121	6	0.463
$\Delta li$	-156.112**	-13.684	-37.514**	-2.892	.14	6	0.463
$\Delta hw$	-102.151**	-13.684	-10.308**	-2.892	.208	3	0.463
$\Delta nhw$	-97.167**	-13.684	-9.513**	-2.892	.165	7	0.463
$\Delta nfw$	-110.429**	-13.684	-11.037**	-2.892	.0775	3	0.463
$\Delta nhfw$	-114.045**	-13.684	-12.385**	-2.892	.0666	5	0.463

$\Delta hp$	-62.540**	-7.892	-6.660**	-1.950	.459	6	0.463
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Notes: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; KPSS always without time trend; KPSS lag selection is based on the automatic bandwidth selection procedure proposed by Newey and West (1994) as described by Hobijn et al. (1998, p.7).

Until now it has been assumed that there are only zero-frequency unit roots and ignored the effects of the seasonal unit root. Applying the HEGY seasonal unit root test (Hylleberg et al. 1990), I obtain the results as reported in Table B4. There are evidences of seasonal unit roots for consumption, but none for income and wealth. However, the test results of long run (zero frequency) unit root nulls are not affected.

Table B4: HEGY Quarterly seasonal unit root tests

Variab	Deterministic	t- $\pi_1$	t- $\pi_2$	t- $\pi_3$	t- $\pi_4$	$\pi_3$ & $\pi_4$
tc	trend+constant+season	-1.881	-2.245	-2.773	-1.406	4.838
ndc	trend+constant+season	-1.464	-1.097	-2.168	-0.889	2.759
di	trend+constant+season	-1.671	-4.62**	-5.83**	-2.594*	23.15**
li	trend+constant+season	-1.962	-5.13**	-6.72**	-4.47**	46.59**
hw	trend+constant+season	-2.387	-4.29**	-3.85**	-4.30**	16.49**
nhw	trend+constant+season	-1.580	-5.20**	-5.28**	-5.95**	49.35**
nfw	trend+constant+season	-2.197	-6.07**	-6.10**	-4.94**	46.82**
nhfw	trend+constant+season	-2.366	-4.62**	-7.36**	-4.86**	64.46**
hp	Constant+season	-1.238	-4.95**	-7.11**	-7.27**	123.6**
$\Delta tc$	Constant+season	-3.97**	-2.311	-3.041	0.791	5.010
$\Delta ndc$	Constant+season	-5.61**	-0.752	-1.853	0.907	2.107
$\Delta di$	Constant+season	-4.12**	-3.071*	-3.937*	2.882	23.15**
$\Delta li$	Constant+season	-3.057*	3.244*	-4.57**	2.103	14.00**
$\Delta hw$	Constant+season	-3.78**	-4.37**	-5.88**	-0.567	17.61**
$\Delta nhw$	Constant+season	-4.11**	-4.18**	-6.30**	-0.698	20.34**
$\Delta nfw$	Constant+season	-5.26**	-6.11**	-8.03**	0.464	32.45**
$\Delta nhfw$	Constant+season	-4.56**	-4.18**	-7.32**	1.032	28.18**
$\Delta hp$	Constant+season	-2.648 <sup>#</sup>	-4.43**	-8.42**	-0.136	35.50**

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; #, Significant at 10%.

However, a crucial limitation of “Dickey-Fuller”-style unit root tests is their bias towards non-stationary when the true process is a series with structural break(s). In this case, structural break would be confused with permanent stochastic disturbance (Perron, 1989). To address this potential bias, I apply the test developed by Zivot & Andrews (1992), which allows for a single structural break without the prior knowledge of breakpoint. The test results of Zivot-Andrews tests are reported in Table B5. Despite evidence of potential structural breaks, the Zivot-Andrews test results did not reject the null that the series are individually I(1).

I also applied the test developed by Clemente et al. (1998) to test I(1) null against a sudden change (AO1, additive outlier) or gradual change in the mean (IO1, innovational outlier). This also allows us to check whether the alternative is a series with a double-break additive outlier (AO2) or innovational outlier (IO2). The results are reported in Table B6. Once again, there is evidence of potential structural breaks, but not to the extent that it would change key conclusions.

Table B5: Zivot-Andrews test statistics against structural break

Variable	$t$ -Break in constant	$t$ -Break in trend	$t$ -Break in both	H0: I(1)
Tc	-3.499	-1.310	-3.523	Accepted
Ndc	-2.966	-1.895	-3.156	Accepted
Di	-4.084	-2.424	-4.632	Accepted
Li	-4.314	-2.091	-4.483	Accepted
Hw	-2.640	-2.237	-2.937	Accepted
Nhw	-2.288	-2.285	-2.807	Accepted
Nfw	-3.448	-2.523	-3.956	Accepted
Nhfw	-3.932	-3.032	-4.479	Accepted
Hp	-4.459	-2.784	-5.034	?
$\Delta tc$	-4.735	-4.023	-4.998	? <sup>2</sup>
$\Delta ndc$	-7.517**	-6.864**	-7.589**	Rejected
$\Delta di$	-5.984**	-5.105**	-5.951**	Rejected
$\Delta li$	-4.489	-3.498	-4.572	?
$\Delta hw$	-5.152*	-3.959	-5.356*	Rejected
$\Delta nhw$	-10.059**	-9.805**	-10.025**	Rejected
$\Delta nfw$	-11.572**	-11.152**	-11.606**	Rejected
$\Delta nhfw$	-12.654**	-12.347**	-12.648**	Rejected
$\Delta hp$	-3.524	-2.469	-3.721	?

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ . 5%. Lag selection via BIC. Critical  $t$ -values for I(1) null against one break in constant, break in trend, and break in both are -4.80, -4.42, and -5.08, respectively.

Table B6: Unit root tests against one-and double structural breaks

Variable	t-AO1	t-IO1	t-AO2	Break time	t-IO2	Break time
tc	-1.767	-2.250	-3.568	1986q1**, 1998q1**	-3.149	1985q2**, 1998q2**
ndc	-2.041	-3.022	-2.677	1987q1**, 1997q3**	-4.467	1986q2**, 1996q2**
di	-1.677	-1.619	-2.659	1989q1**, 2000q1**	-3.040	1989q2**, 1999q2**
li	-1.973	-1.668	-3.418	1989q1**, 2000q1**	-5.332	1989q2 **, 2000q2**
hw	-2.580	-1.836	-2.155	1987q2**, 1999q2**	-3.450	1986q3**, 1998q4**
nhw	-2.998	-2.202	-1.532		-1.689	
nfw	-3.366	-3.409	-3.460	1993q2**, 1996q2**	-3.938	1992q3**, 1995q3*
nhfw	-2.982	-3.193	-4.646	1985q2**, 1995q2**	-4.608	1985q3**, 1995q3**
hp	-2.678	-2.929	-3.098	1990q3, 2000q4**	-3.408	1990q4, 1997q3**

$\Delta tc$	-3.770*	-3.972	-4.327		-4.209
$\Delta ndc$	-6.750*	-6.643*	-6.287*		-6.555*
$\Delta di$	-2.754	-2.853	-2.579		-2.892
$\Delta li$	-2.541	-2.262	-3.297		-2.669
$\Delta hw$	-4.430**	-5.041*	-5.012		-6.087**
$\Delta nhw$	-7.261**	-10.852*	-8.326**		-12.399**
$\Delta nfw$	-7.541**	-11.75**	-8.142**		-12.688**
$\Delta nhfw$	-8.182**	-13.37**	-8.421**		-13.533**
$\Delta hp$	-2.131	-3.273	-2.671	1991q3*, 1992q3*	-4.476      1991q3**, 1992q4**

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$

In summary, with the accumulated evidence, one can be comfortably assured that the consumption, income, housing wealth/price, and financial wealth series considered in this paper are individually  $I(1)$ .



### 8.3. Appendix C: Cointegration test results

Table C1: Cointegration tests

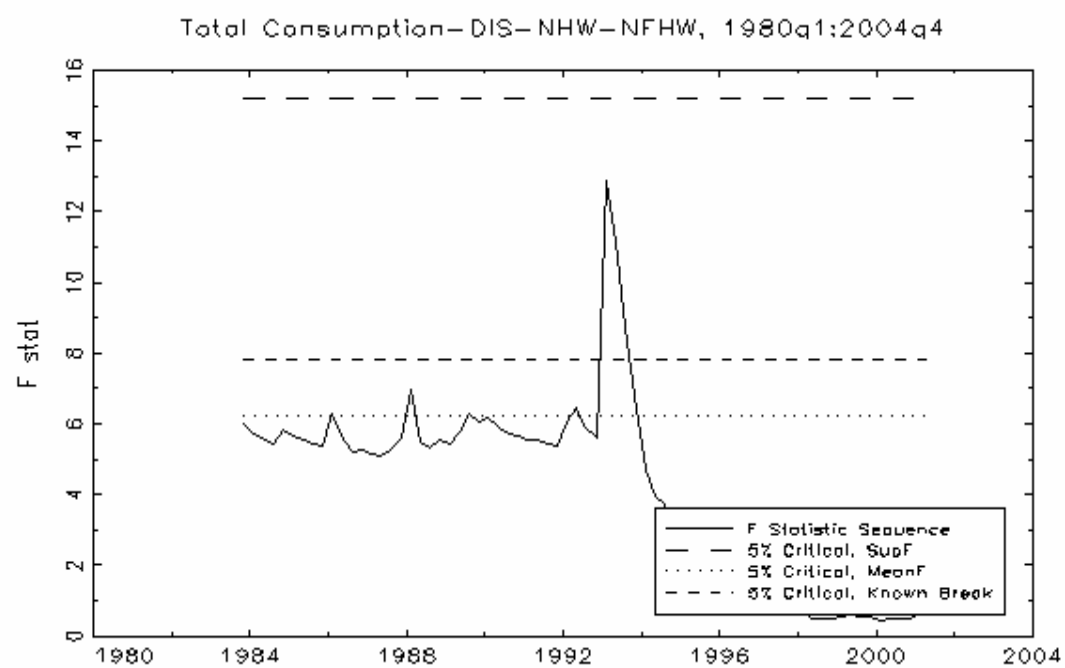
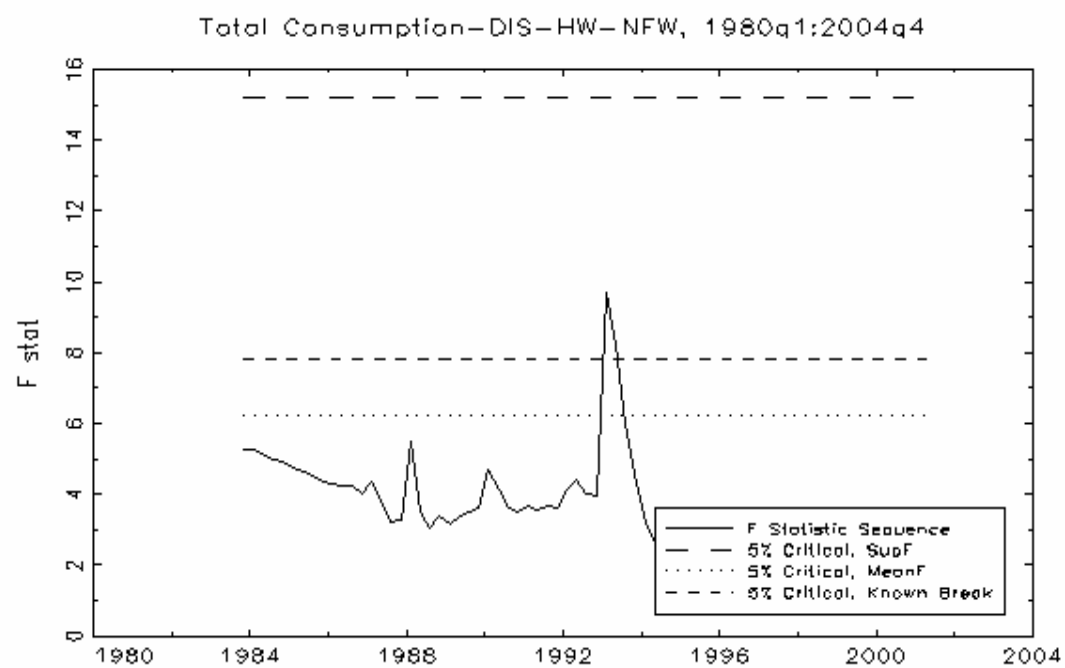
Test statistics	Critical 5% level	System A	System B
<u>Standard Engle-Granger</u>			
lag=4	-4.160	-2.168	-2.100
lag=5	-4.160	-2.456	-2.290
<u>Johansen FIML test</u>			
Maximum statistics, lag=5			
r=0	27.07	31.876*	31.226*
r=1	20.97	15.869	16.815
r=2	14.07	9.513	8.263
r=3	3.76	0.959	0.322
Trace statistics, lag=5			
r=0	47.21	58.177**	56.625**
r=1	29.68	26.301	25.400
r=2	15.41	10.472	8.585
r=3	3.76	0.959	0.322
<u>Gregory &amp; Hansen (1996a)</u>			
<i>Case 1: level shift (C)</i>			
ADF* test and Break point	-5.28	-3.165 (1993q3)	-3.714 (1992q1)
Zt* statistics and Break point	-5.28	-6.315**(1993q1)	-6.844**(1993q1)
Z <sub>a</sub> * statistics and Break point	-53.58	-54.531*(1993q1)	-61.35**(1993q1)
<i>Case 2: trend shift (C/T)</i>			
ADF* test and Break point	-5.57	-4.448 (1985q1)	-4.498 (1985q1)
Zt* test and Break point	-5.57	-6.791**(1984q1)	-7.138**(1984q1)
Z <sub>a</sub> * test and Break point	-59.76	-60.799*(1984q1)	-64.82**(1984q1)
<i>Case 3: regime shift (C/S)</i>			
ADF* test and Break point	-6.00	-5.222(1993q1)	-4.694 (1992q1)
Zt* test and Break point	-6.00	-7.382**(1989q1)	-8.158**(1989q1)
Z <sub>a</sub> * test and Break point	-68.94	-67.598 (1989q1)	-78.479**(1989q1)

Note: \* p<0.05; \*\* p<0.01.

Table C2: Applying Hansen (1992) test of parameter stability in regression with I(1) series for Systems A-B

Stability Test statistics	System A	System B
LC	0.485 (0.122)	0.582(0.07)
MeanF	3.624 (0.200)	4.179 (0.200)
SupF	9.693 (0.200)	12.891 (0.200)

Note 1: figures in parentheses represent p-value of rejecting stability null; p>=0.200 is restricted to p=0.200.



## 8.4. Appendix D: Main Estimation Results

Table D1: Johansen-type VECM estimation results for System B

$$EC_t = tc_t - 0.427di_t - 0.105nhw_t - 0.060nfhw_t$$

Variable	$\Delta tc_t$	$\Delta di_t$	$\Delta nhw_t$	$\Delta nfhw_t$
$EC_{t-1}$	-0.117	0.037	<b>0.998**</b>	-0.016
$\Delta tc_{t-1}$	0.016	-0.128	0.139	0.46
$\Delta tc_{t-2}$	-0.037	0.005	-0.076	0.243
$\Delta tc_{t-3}$	-0.086	0.005	0.159	0.089
$\Delta tc_{t-4}$	0.442**	0.11	-0.152	0.931*
$\Delta tc_{t-5}$	0.084	0.260**	0.188	0.459
$\Delta di_{t-1}$	-0.04	-0.567***	-0.382	-0.083
$\Delta di_{t-2}$	0.085	-0.147	-1.198*	-0.925
$\Delta di_{t-3}$	0.246*	0.037	-0.592	-1.162*
$\Delta di_{t-4}$	0.380**	0.384***	-1.190*	-0.503
$\Delta di_{t-5}$	-0.113	0.312**	-1.138*	-0.688
$\Delta nhw_{t-1}$	<b>0.064**</b>	0.004	-0.041	-0.115
$\Delta nhw_{t-2}$	-0.002	-0.036	-0.062	-0.087
$\Delta nhw_{t-3}$	-0.016	-0.013	-0.123	-0.024
$\Delta nhw_{t-4}$	0.022	0.033	0.081	-0.008
$\Delta nhw_{t-5}$	0.001	0.005	-0.051	0.027
$\Delta nfhw_{t-1}$	-0.014	-0.034	-0.157	-0.04
$\Delta nfhw_{t-2}$	0.026	0.012	0.000	-0.062
$\Delta nfhw_{t-3}$	<b>0.054*</b>	0.005	0.011	0.064
$\Delta nfhw_{t-4}$	0.038	0.025	0.183	-0.296**
$\Delta nfhw_{t-5}$	0.019	0.013	-0.072	0.117
Quarter 2	0.003	0.050*	0.134	-0.144
Quarter 3	-0.024	-0.014	-0.048	0.009
Quarter 4	0.006	0.079**	0.128	-0.217*
constant	-0.001	-0.025	0.002	0.112*
R <sup>2</sup>	0.9630	0.9656	0.3822	0.5496
Chi-square	1796.959	1938.512	42.68207	84.20686

Note: \* p<0.5; \*\* p<0.01; log likelihood=851.2268

Table D2\_1: Post-estimation diagnostics of VECM estimates of System B

Equation	$\Delta tc_t$	$\Delta di_t$	$\Delta nhw_t$	$\Delta nfw_t$	All
<u>Normality tests:</u>					
Jarque-Bera test Chi2 value	5.235	1.732	9.603**	11.047**	27.62**
(P value)	(0.073)	(0.42)	<b>(0.008)</b>	<b>(0.003)</b>	<b>(0.001)</b>
Skewness	.0235	-.147	.354	.536*	
(P value —Chi2)	(0.925)	(0.560)	(0.16075)	(0.034)	(0.146)
Kurtosis	1.845	2.4038	4.3963**	4.2925*	
(P value)	(0.022)	(0.238)	<b>(0.006)</b>	<b>(0.011)</b>	<b>(0.001)</b>
<u>Parameter constancy tests:</u>					
H0: Long run parameter stability <sup>1</sup> , (P value)	7.3492 (0.1185)	6.1721 (0.1867)	2.9552 (0.5654)	3.4789 (0.4811)	
H0: Short run coefficients constant for all t <sup>2</sup> (P value)	1.6021 (0.2566)	2.2809** <b>(0.0013)</b>	1.0719 (0.9965)	2.7434** <b>(0.0032)</b>	
Break time		1997:2		1997:2	
<u>ARCH tests:</u>					
1 <sup>st</sup> order, (P-value)	0.0980 (0.9228)	0.3960 (0.2516)	0.1186 (0.6849)	1.0795 (0.4066)	
4 <sup>st</sup> order, (P-value)	2.8435 (0.8562)	1.7626 (0.7450)	0.8259 (0.9083)	2.6093 (0.6529)	
<u>Wald-type weak exogeneity test</u> —H0: adjustment coefficient is zero, Only P-value	0.060	0.4987	<b>0.0001</b>	0.9420	
Note: * p<0.05; ** p<0.01; 1: LM test; 2: Ploberger-Kröer-Kontrus fluctuation test.					

Table D2\_2: Post-estimation diagnostics of VECM estimates of System B

Tests	Statistics	P-value
Testing of restriction constants	LR(3)=9.8560	<b>0.0198</b>
<u>LM type of autocorrelation:</u>		
H0: no autocorrelation at lag order 1 vs. H1: residuals follow VAR(1)	LM(16)=12.2978	0.7232
H0: no autocorrelation at lag order 4 vs. H1: residuals follow VAR(4)	LM(16)=20.3162	0.2063
H0: no autocorrelation at lag order 5 vs. H1: residuals follow VAR(5)	LM(16)=13.5356	0.6333
<u>LM type test of common cycles:</u>		
H0: at most 1 common cycle vs. H1: more than 1 common cycles	LM(60)=121.9**	<b>0.0000</b>
H0: at most 2 common cycle vs. H1: more than 2 common cycles	LM(38)=61.76**	<b>0.0087</b>
H0: at most 3 common cycle vs. H1: more than 3 common cycles	LM(18)=24.20	0.1484

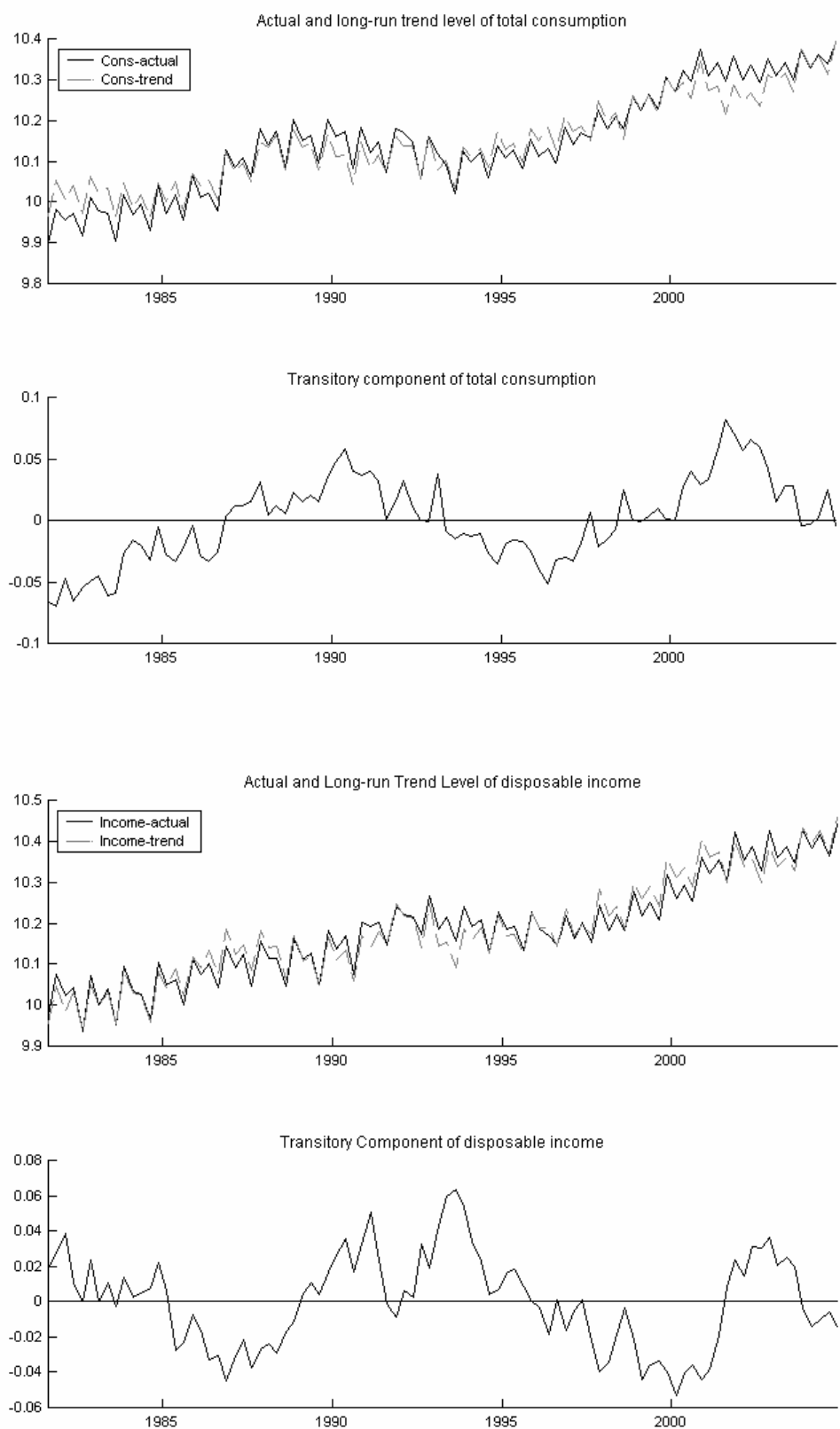
Note: \* p&lt;0.05; \*\* p&lt;0.01.

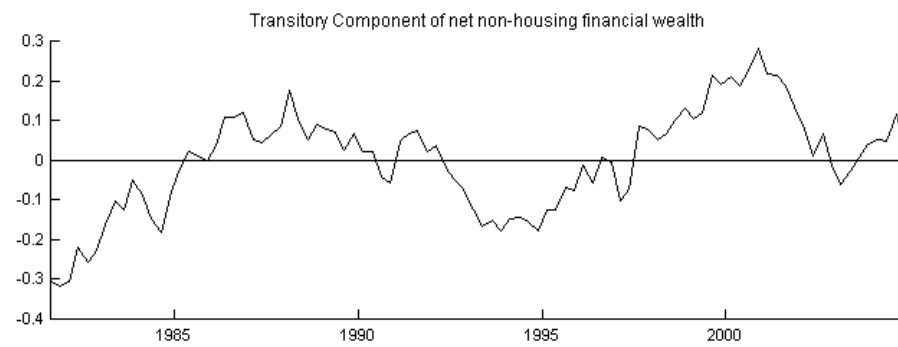
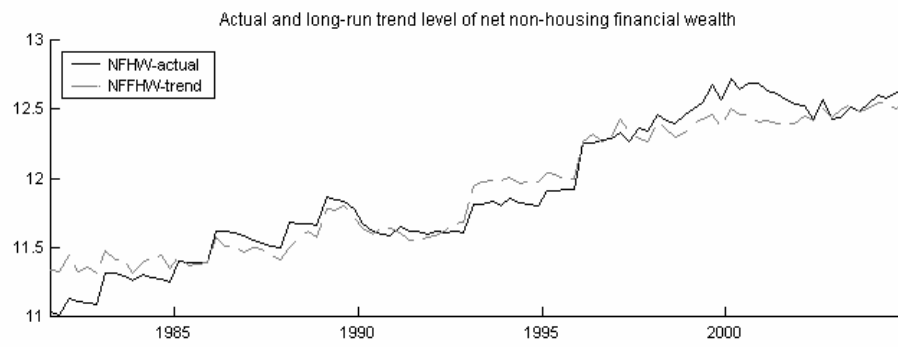
Table D3: Variance decomposition of h step-ahead forecast error of System A by persistence

Period	$\Delta tc_t - E \Delta tc_{t-h}$		$\Delta di_t - E \Delta di_{t-h}$		$\Delta hw_t - E \Delta hw_{t-h}$		$\Delta nfw_t - E \Delta nfw_{t-h}$	
	P	T	P	T	P	T	P	T
1	1	0	1	0	0.133	0.867	1	0
2	0.993	0.007	0.995	0.005	0.245	0.755	0.999	0.001
3	0.994	0.006	0.981	0.019	0.344	0.656	0.996	0.004
4	0.995	0.005	0.981	0.019	0.436	0.564	0.995	0.005
5	0.995	0.004	0.988	0.012	0.481	0.519	0.988	0.013
6	0.994	0.006	0.991	0.010	0.558	0.442	0.987	0.013
7	0.996	0.005	0.990	0.010	0.627	0.373	0.988	0.012
8	0.996	0.004	0.992	0.008	0.684	0.316	0.988	0.012
9	0.996	0.004	0.993	0.007	0.730	0.271	0.988	0.011
10	0.996	0.004	0.994	0.006	0.770	0.230	0.989	0.011
11	0.997	0.003	0.995	0.005	0.802	0.197	0.990	0.010
12	0.997	0.003	0.995	0.005	0.828	0.171	0.990	0.010
13	0.997	0.003	0.995	0.004	0.851	0.149	0.991	0.009
14	0.997	0.003	0.996	0.004	0.870	0.131	0.991	0.009
15	0.997	0.003	0.996	0.004	0.885	0.116	0.992	0.008
16	0.997	0.002	0.996	0.003	0.897	0.103	0.992	0.008
17	0.998	0.002	0.996	0.003	0.908	0.092	0.993	0.007
18	0.998	0.002	0.997	0.003	0.919	0.082	0.993	0.007
19	0.998	0.002	0.997	0.003	0.926	0.074	0.993	0.007
20	0.998	0.002	0.997	0.003	0.933	0.067	0.993	0.006
36	0.998	0.002	0.998	0.002	0.979	0.021	0.996	0.004

Note: 95% CI (confidence interval) have been generated following the bootstrap procedure described in Gonzalo & Ng (2001) but omitted here.

Figure D1: Actual, permanent and transitory component plotting





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