Residential versus Financial Wealth Effects on Consumption from a Shock in Interest Rates

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Abstract

This paper carries out a breaking down of the dynamic response of Spanish consumption to a shock in interest rates. This approach allows for a richer comparison of the importance of each type of wealth in the final dynamic response of consumption. In order to avoid estimation biases, the core variables in both, life cycle and financial accelerator models, have been used. The results for the Spanish economy indicate that the relative importance of each component varies with the term considered, but, in the long-run, the component associated with Housing Wealth is the most important, out of five, followed by the Financial Wealth.

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1 Introduction

This paper deals with the problem of estimating and comparing the relative importance of different types of wealth, housing and financial, on private consumption.

Using the method of (León and Flores, 2012), the dynamic effect of a permanent shock in interest rates on consumption is broken down into five components: (1) A direct effect of interest rate on consumption, named here "the cost of credit effect" (2) the housing wealth effect, (3) the price of housing effect, (4) the financial wealth effect and (5) the feedback effect from the Central Bank.

In comparing the two types of wealth, previous papers relied on specific shocks, one for each type of wealth. Although that comparison is very interesting, it can be considered incomplete in two respects. First, the comparison is made only over long-run effects, ignoring the short and medium term ones. Second, as many shocks come from monetary policy, it is important to evaluate the long, medium and short-run contribution to consumption, of each type of wealth, when a common, monetary, shock hits both variables. The different answer of each type of wealth will determine the contribution of each type of wealth on the behaviour of consumption.

In this paper it is studied the case of a common shock in interest rates, and how different variables in the information set contribute to the consumption response. Thus, a special attention is given to the feedbacks effects coming from the reaction of the Central Bank, very often forgotten. If there is a rise in interest rate this will affect wealth, but also it is likely that after some periods, it will make inflation to decrease. That might lead the Central Bank to relax its monetary policy, what will affect wealth for a second time.

It is interesting to know how consumption reacts, both in the short and long run. As well as, to estimate the relative contribution of each type of wealth to the movements experienced by consumption, both in the short and the long-run. That is why the decomposition method mentioned above is especially useful for the goal of this paper.

In order to break down the response of consumption into its components, the theoretical framework used in (Flores et al., 1998) and (Pereira and Flores, 1999) has been adapted.

This theoretical framework has a VAR representation, it allows for non stationary variables, cointegration and any kind of dynamic relationship among the variables. Moreover, it allows for identifying structural shocks without constraining neither the statistical properties of the variables or their relationships dynamics. The identifying assumptions are clearly stated and, with them, the possible weaknesses of the analysis. Finally, an important feature of the model is that the contribution of each component, to the consumption final response, can be algebraically computed.

In recent empirical papers, whatever the theoretical approach used, life cycle or financial accelerator, the VEC or VAR models building methodology has been used. (Lettau and Ludvigson, 2004), (Pichette and Tremblay, 2003) or (Chen, 2006) are examples of empirical papers based on life cycle models. (Aoki et al., 2002, 2004) and (Iacoviello, 2005) are examples of empirical papers based on the financial accelerator model.

The information sets used by papers under these two different theoretical frameworks are also different. In the first case, the life cycle group, authors use Consumption, Wealth (residential and financial) and Interest Rate as the core variables in the agent's information set. While in the second case, financial accelerator group, authors use Consumption, Price of Housing and Interest Rate. That is, the former excludes the Price of Houses while the later does it the same for the Wealth. As Wealth is equal to Hosing Stock times Price of Housing, when Wealth is used alone in the empirical analysis, the coefficients associated to it and its lags are constrained to be the same for both, the Housing Stock and the Price of Housing. On the other hand, to assume that Housing Stock is constant as some authors does, it is not realistic, at least for the Spanish case.

In estimating the importance of wealth there is another important difference between the two approaches. The former consider the existence of a specific shock affecting the Real Wealth, while the later considers a shock in the Interest Rate which affects all variables in the system.

Even with these important differences, both groups arrive to a common result: Residential Wealth is a major determinant of consumption behavior.

If both are wrong because the price of housing as well as the real wealth play an important and different role in explaining the behavior of Consumption, none of those approaches could give consistent estimates of the consumption response, whatever the shock is coming from. Note, that when real wealth is used in the empirical work, nominal wealth and price of housing are constrained, on a priori grounds, to have associated the same coefficients with opposed signs.

Also, a measure of financial wealth has been included with the purpose of being able to discuss the relative importance of each type of wealth in the consumption behaviour. Thus, the relevant variables in this paper will be: Consumption, Housing Wealth, Housing Price, Financial Wealth and Interest Rates, all coming from the Spanish economy. With this wider set of variables the risk of bias due to omitted variables (or miss-constrained specifications) is avoided. If an extra variable were to be irrelevant, the empirical analysis would detect it. Thus, any loss of efficiency due to an excess of variables should be avoided.

There are many reasons why housing and financial wealth should have different effects on consumption, see (Case et al., 2005) for an exhaustive review.

Our results indicate that both types of wealth have not only significant but very important and different effects on consumption. Their relative importance change with the term considered, getting their maximum in the long run (i.e.: after five years). None type of wealth has significant contemporaneous effects, but both present important lagged effects. The same happens with the Price of Housing, which moves as predicted in the financial accelerator model. Finally, a significant feedback effect, coming from the Central Bank is detected.

Given the results obtained in this research, the policy of low interest rates carried out by the European Central Bank (ECB) during the last two decades, could explain the spectacular and lasting growth of the Spanish Consumption, via residential as well as financial wealth effects.

The paper is organized as follows: Section (2) presents the theoretical framework used as well as the mathematical expressions for each component, Section (3) shows the empirical analysis, Section (4) discusses the estimated components and Section (5) summarizes the concluding remarks.

2 The Model

Assume an economy with two types of agents: (1) the private sector agents and (2) the Central Bank.

It is assumed that that private agents (PA) determine, for each period "t" the levels of vector $z_t = (c_t, \nabla w_t, \nabla pv_t, f_t)$ where lower case letters represent the natural log of the corresponding upper case variables: Consumption (C_t), Housing Wealth (W_t), Housing Price (PV_t) and Financial Wealth (F_t). And ∇ is the difference operator $1 - B$, with B the lag operator. The empirical analysis will show that all variables in z_t are integrated of order one, I(1).

The Central Bank (CB) determines, for each period, the level of interest rates, $r_t(Ln(1 + R_t))$, where R_t is the nominal interest rate.

Both agents, PA and CB, know, at the beginning of period "t", all past values of the mentioned variables. However, while the PA fixed z_t knowing r_t (CB let PA to know r_t at the beginning of the period) the CB fixes r_t without knowing z_t, which is not yet determined. This assumption is the first, out of two, crucial assumptions needed for exactly identifying all the structural parameters in the model. Although it is an important assumption it does not seem to be very restrictive, given the information that, nowadays, many central banks provide to economic agents.

Mathematical representation of PA's behavior

The information set, held by the PA, at "t" (Ω_{zt}) is made of past values of z_t as well as the present and past values of r_t, that is:

$$\Omega_{zt} = \{z_{t-j}, r_{t-j}, r_t\}, j = 1, 2, 3, ...$$

In each period "t", PA determine the level of c_t, ∇w_t, ∇pv_t, and f_t using the information in Ω_{zt}. This can be represented as:

$$\begin{aligned} z_t &= \nu_z(B) r_t + \epsilon_{zt} \\ \pi_z(B)\epsilon_{zt} &= \alpha_{zt} \end{aligned} \tag{1}$$

Where $\nu_z(B) = (\nu_c(B), \nu_{pv}(B), \nu_w(B), \nu_f(B))'$ is a (4x1) vector of stable transfer functions, each of them having the form:

$$\nu_j(B) = \nu_{j0} + \nu_{j1}B + \nu_{j2}B^2 + ...$$

They capture the unidirectional effect of r_t on each variable of z_t. Its coefficients would account for the final response of c_t if no reaction from the CB were to be consider.

The noise $\epsilon_{zt} = (\epsilon_{ct}, \epsilon_{pvt}, \epsilon_{wt}, \epsilon_{ft})'$ is a vector of random variables following an invertible VARMA process, with $\pi_z(B) = I - \pi_1 B - \pi_2 B^2 - ...$ being an infinite polynomial matrix whose determinant might have roots in the unit circle. Finally, $\alpha_{zt} = (\alpha_{ct}, \alpha_{pvt}, \alpha_{wt}, \alpha_{ft})'$ is a white noise vector of random variables, with contemporaneous covariance matrix Σ_z.

Mathematical representation of CB's behavior

The information set, in period "t", for the CB is made of past values of all variables:

$$\Omega_{rt} = \{r_{t-j}, z_{t-j}\}, j = 1, 2, 3, ...$$

For each period "t", the CB determines r_t using Ω_{rt}:

$$\begin{aligned} r_t &= \nu_r(B) z_t + \epsilon_{rt} \\ \pi_r(B)\epsilon_{rt} &= \alpha_{rt} \end{aligned} \tag{2}$$

Where $\nu_r(B) = (\nu_{rc}(B), \nu_{rpv}(B), \nu_{rw}(B), \nu_{rf}(B))$ is a (1x4) vector of stable transfer functions which represent the reaction function (feedback response) of the CB to previous values of z_t; ϵ_{rt} is a scalar noise following a general ARIMA model. Finally, α_{rt} is a scalar white noise process, with variance σ_r^2.

Note that, as consequence of the above first identifying assumption, $\nu_{rc}(0) = \nu_{rpv}(0) = \nu_{rw}(0) = \nu_{rf}(0) = 0$.

The second crucial assumption needed for identifying the parameters in representations (1) and (2) is the independence between α_{rt} and α_{zt}. That is, α_{rt} is a structural shock independent of the elements of α_{zt} that would not be structural shocks unless Σ_z be a diagonal matrix, assumption that it is NOT necessary to make.

The VAR form of the model

Equations (1) and (2) can be represented as:

$$\begin{bmatrix} \pi_z(B) & -\pi_z(B)\nu_z(B) \\ -\pi_r(B)\nu_r(B) & \pi_r(B) \end{bmatrix} \begin{bmatrix} z_t \\ r_t \end{bmatrix} = \begin{bmatrix} \alpha_{zt} \\ \alpha_{rt} \end{bmatrix} = \tag{3}$$

In a more compact notation:

$$\Pi_y(B) y_t = \alpha_{yt}$$

With contemporaneous error covariance matrix:

$$\Sigma = \begin{bmatrix} \Sigma_z & 0 \\ 0 & \sigma_r^2 \end{bmatrix} \tag{4}$$

$\Pi_y(B)$ is a (5x5) polynomial matrix where the ratio between the elements in positions (1,5) and (1,1) captures the dynamic, direct effects on consumption from r_t, that is, the coefficients in this ratio capture the direct effects on consumption due to variations in the cost of credit. Those effects denoted by $\Gamma_c(B)$ will play an important role in the breaking down process of the final response of c_t.

The multivariate stochastic model (3) is not normalized in terms of Alavi ((Jenkins and Alavi, 1981)) because:

$$\Pi_y(0) = V = \begin{bmatrix} I & -\nu_{z0} \\ 0 & 1 \end{bmatrix} \tag{5}$$

Where $\nu_{z0} = (\nu_{c0}, \nu_{w0}, \nu_{pv0}, \nu_{f0})'$ is the vector of contemporaneous effects of r_t on z_t.

Model (3) can be normalized by premultiplying by V^{-1}:

$$\Pi_y^*(B) y_t = \alpha_{yt}^* \tag{6}$$

Where

$$\Pi_y^*(B) = V^{-1}\Pi_y(B)$$
$$\alpha_{yt}^* = V^{-1}\alpha_{yt}$$

The contemporaneous error covariance matrix of (6) is:

$$\Sigma^* = V^{-1}\Sigma(V^{-1})^T = \begin{bmatrix} \Sigma_z + \nu_{z0}\nu_{z0}'\sigma_r^2 & \nu_{z0}\sigma_r^2 \\ \nu_{z0}'\sigma_r^2 & \sigma_r^2 \end{bmatrix} \tag{7}$$

The model proposed in (6) and (7) can be estimated either using the VARMA model building methodology or by the standard VAR building methodology, assuming the existence of a finite VAR approximation for the true VARMA generating process. From the estimated VAR, built directly from data on y_t, and in particular, from its estimated contemporaneous error covariance matrix, it is possible to obtain an estimation of V. Once V has been estimated, the estimation of the remaining parameters of (3) is straightforward.

Impulse response functions

Using model (3):

$$z_t = \Psi_r(B)\alpha_{rt} + \Psi_z(B)\alpha_{zt} \tag{8}$$

Where:

$$\Psi_r(B) = [I - \nu_z(B)\nu_r(B)]^{-1}\nu_z(B)\pi_r(B)^{-1} = \Phi_{r0} + \Phi_{r1}B + \Phi_{r2}B^2 + ... \tag{9}$$

$$\Psi_z(B) = [I - \nu_z(B)\nu_r(B)]^{-1}\pi_z(B)^{-1} = I + \Phi_{z1}B + \Phi_{z2}B^2 + ... \tag{10}$$

Matrix $\Psi_r(B)$ is the (4x1) polynomial matrix:

$$\Psi_r(B) = \begin{pmatrix} \Psi_{rc}(B) \\ \Psi_{rw}(B) \\ \Psi_{rpv}(B) \\ \Psi_{rf}(B) \end{pmatrix} \tag{11}$$

Each component of this matrix is a polynomial whose coefficients capture the dynamic response of the corresponding variable in z_t to an impulse in α_{rt}. In particular, the element in position (1,1) is the polynomial whose coefficient measure the dynamic response of c_t to an impulse in α_{rt}, that is, the sum of the direct effect and all indirect effects coming from other variables being affected by the shock in r_t, including the feedback response coming from the CB.

Break down of consumption response

A detailed proof for the mathematical expressions of the components in the breaking dawn of the consumption response is presented in Appendix (Appendix 1).

Their main steps are: From (9) and using:

$$[I - \nu_z(B)\nu_r(B)]^{-1} = I + \frac{\nu_z(B)\nu_r(B)}{1 - \nu_r(B)\nu_z(B)} \tag{12}$$

It leads to:

$$\Psi_{rc}(B) = \left[\nu_c(B) + \frac{\nu_c(B)\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)}\right]\pi_r(B)^{-1} + \\ + \left[\frac{\nu_c(B)\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} + \frac{\nu_c(B)\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)}\right]\pi_r(B)^{-1} \tag{13}$$

With:

a)

$$\Upsilon_{cw}(B) = \frac{\nu_c(B)\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} \tag{14}$$

This component captures the effects on c_t coming from the reaction of the CB to movements in residential wealth (likely null).

b)

$$\Upsilon_{cpv}(B) = \frac{\nu_c(B)\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} \tag{15}$$

This component captures the effects on c_t coming from the reaction of the CB to movements in the price of houses.

c)

$$\Upsilon_{cf}(B) = \frac{\nu_c(B)\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \tag{16}$$

Finally, this component captures the effects on c_t coming from the reaction of the CB to movements in the financial wealth (likely null).

Those three components are part of the set of indirect components of the final response of c_t.

Then, (13) in compact notation can be written as:

$$\Psi_{rc}(B) = \nu_c(B) + \Upsilon_{cw}(B) + \Upsilon_{cpv}(B) + \Upsilon_{cf}(B) \tag{17}$$

On the other side, from (3), the direct effect on consumption is:

$$\Gamma_c(B) = \left[\nu_c(B) + \frac{\pi_{12}(B)}{\pi_{11}(B)}\nu_w(B) + \frac{\pi_{13}(B)}{\pi_{11}(B)}\nu_{pv}(B) + \frac{\pi_{14}(B)}{\pi_{11}(B)}\nu_f(B)\right] \tag{18}$$

Where:

d)

$$\Theta_w(B) = -\frac{\pi_{12}(B)}{\pi_{11}(B)}\nu_w(B) \tag{19}$$

It is the unidirectional, indirect effect of interest rates on consumption, due to variations in the housing wealth.

e)

$$\Theta_{pv}(B) = -\frac{\pi_{13}(B)}{\pi_{11}(B)}\nu_{pv}(B) \tag{20}$$

It is the unidirectional, indirect effect of interest rates on consumption, due to variations in housing prices.

f)

$$\Theta_f(B) = -\frac{\pi_{14}(B)}{\pi_{11}(B)}\nu_f(B) \tag{21}$$

It is the unidirectional, indirect effect of interest rates on consumption, due to variations in the financial wealth.

Then, the unidirectional component of the consumption response is:

$$\nu_c(B) = \Gamma_c(B) + \Theta_w(B) + \Theta_p(B) + \Theta_f(B) \tag{22}$$

Where $\Gamma_c(B)$ is, as mentioned above, the direct component of the response of c_t.

Now, by combining (22) and (17) gives the desired breaking down of the consumption response:

$$\Psi_{rc}(B) = [\Gamma_c(B) + \Theta_w(B) + \Theta_p(B) + \Theta_f(B) + \Upsilon_{cw}(B) + \Upsilon_{cpv}(B) + \Upsilon_{cf}(B)]\pi_r(B)^{-1} \tag{23}$$

3 Empirical Analysis

In this section an estimated version of model (3) will be obtained.

Data set

All variables used in this paper come from the Spanish economy. They are yearly time series corresponding to the period 1974-2003:

C: "Domestic Consumption". This series is built up by the INE, according to the SEC-95 methodology which standardises the annual accounts of EU countries .The data are obtained from the Economics ministry, on the web (http://www.meh.es/es-ES/Estadistica%20e%20Informes/Paginas/estadisticasV2.aspx). The series is measured in real terms (1995 euros)[1].

W: "Stock of Real Net Housing Wealth"(millions of 1995 euros). These data are estimates made by the IVIE and BBVA ((Mas et al., 2007)). (http://www.ivie.es/banco/stock.php and http://www.fbbva.es/TLFU/tlfu/esp /areas/econosoc/bbdd/capital.jsp) .

PV : "Implicit Deflator of Housing Wealth", measured as the ratio between nominal and real stock . Both series are obtained from IVIE and BBVA.

R: "MIBOR 1-Month", obtained from the Bank of Spain (http://www.bde.es/webbde/es/estadis /estadis.html).

F : "Financial Wealth", obtained as the Spanish Stock Market real capitalization.

Statistical properties of data

A detailed univariate and integration analysis for each variable is presented in Appendix (Appendix 2). The augmented Dickey-Fuller (ADF), as well as a Box-Jenkins univariate analysis of the time series, indicate that c_t, r_t and f_t are I(1)

[1] The data with SEC-95 methodology are available up to 1980. Previous data are provided with the growth rate of the National Private Consumption variable.

variables, while w_t and pv_t are clearly I(2).

The (Box and Tiao, 1975) intervention analysis indicates the absence of important outliers in all variables, except in the case of f_t where an important step effect in 1986 was detected and properly treated. The intervened variable has been used for model building.

Using the methods of Johansen as well as Engle and Granger, two cointegration relationships were detected among the vector z_t of I(1) variables.

$$ecm1_t = \nabla w_t - 0.13\nabla pv_t + 0.05r_t \tag{24}$$

$$ecm2_t = f_t + 13.42r_t \tag{25}$$

The first cointegration equation is a stable relationship among the rate of growth of housing wealth, the level of interest rate and the rate of growth of housing prices. Given the signs of the coefficients, it can be interpreted as a housing long run supply. An increase in ∇pv_t leads to an increase in ∇w_t, while an increase in r_t leads to a decrease in ∇w_t. Later, the corresponding VEC will show that any disequilibrium in this relationship will be first corrected by changes in $\nabla^2 pv_t$.

The second cointegration equation shows a stable relationship between the levels of the financial wealth and the interest rate. It could be seen as a demand equation for f_t, where r_t keeps a negative long run relationship with f_t. The VEC model will reveal ∇f_t as the adjusting variable.

The VEC model

Table 1 shows the GLS (Lütkepohl and Krätzig, 2004) joint estimation of a VEC(2) model and its contemporaneous error covariance matrix.

Table 1: VEC model estimation

	equations[a]				
Dependent variable	∇c_t	$\nabla^2 w_t$	$\nabla^2 pv_t$	∇f_t	∇r_t
μ	0.013 (0.003)			11.85 (1.93)	
$ecm1_{t-1}$		-0.023 (0.012)			
$ecm2_{t-1}$				-0.81 (0.13)	
∇c_{t-1}	0.53 (0.10)				
$\nabla^2 w_{t-1}$	2.22 (1.10)	0.50 (0.11)			
$\nabla^2 pv_{t-1}$	0.18 (0.06)		-0.36 (0.17)		0.36 (0.09)
∇f_{t-1}	0.025 (0.008)				
∇r_{t-1}	-0.13 (0.08)	-0.035 (0.009)		2.21 (1.33)	
∇c_{t-2}				4.58 (1.63)	
$\nabla^2 w_{t-2}$					
$\nabla^2 pv_{t-2}$					
∇f_{t-2}			0.058 (0.023)		
∇r_{t-2}		-0.039 (0.009)			

[a]The table shows the estimated coefficients of the VEC model where each column represents an equation of the same. The standard deviations are presented in brackets. The terms $ecm1$ and $ecm2$ represent cointegration relationships.

$$\Sigma_u = \begin{pmatrix} 9.78\text{E-}05 & 4.64\text{E-}06 & 5.20\text{E-}05 & -3.99\text{E-}04 & -3.56\text{E-}05 \\ 4.64\text{E-}06 & 1.73\text{E-}06 & -1.30\text{E-}06 & 9.46\text{E-}05 & -1.38\text{E-}05 \\ 5.20\text{E-}05 & -1.30\text{E-}06 & 6.80\text{E-}04 & -3.63\text{E-}04 & -1.85\text{E-}05 \\ -3.99\text{E-}04 & 9.46\text{E-}05 & -3.63\text{E-}04 & 3.80\text{E-}02 & -3.00\text{E-}03 \\ -3.56\text{E-}05 & -1.38\text{E-}05 & -1.85\text{E-}05 & -3.00\text{E-}03 & 4.41\text{E-}04 \end{pmatrix} \tag{26}$$

Functions of matrices of cross-correlations and partial correlations indicate that the error vector follows a multivariate white noise process.

The model in Table 1, expressed as a non-stationary VAR(3) in z_t, is the estimated version of the normalized theoretical model (6). From Σ_u it is possible to estimate V as:

$$V = \begin{pmatrix} 1 & 0 & 0 & 0 & 0.081 \\ 0 & 1 & 0 & 0 & 0.031 \\ 0 & 0 & 1 & 0 & 0.042 \\ 0 & 0 & 0 & 1 & 6.788 \\ 0 & 0 & 0 & 0 & 1.000 \end{pmatrix} \tag{27}$$

Matrix V is used for obtaining the estimated version of the orthogonalized theoretical model (3). Thus, when the VAR(3) is pre-multiplied by V, it is obtained:

$$\begin{pmatrix} (1-1.53B)\nabla & -2.22B\nabla & -0.21B\nabla & -0.03B\nabla & (0.08+0.13B)\nabla \\ 0 & (1-0.52B)\nabla & -0.01B\nabla & 0 & (0.03+0.04B-0.04B^2)\nabla \\ 0 & 0 & (1+0.035B)\nabla & -0.05B^2\nabla & 0.04\nabla \\ -2.73B^2\nabla & 0 & -2.44B\nabla & 1-0.19B & 6.79+1.83B+2.21B^2 \\ 0.00 & 0.00 & -0.36B\nabla & 0 & 1-B \end{pmatrix} \cdot \begin{pmatrix} c_t \\ \nabla w_t \\ \nabla pv_t \\ f_t \\ r_t \end{pmatrix} =$$

$$\begin{pmatrix} 0.01 \\ 0 \\ 0 \\ 11.85 \\ 0 \end{pmatrix} + \begin{pmatrix} \epsilon_{c_t} \\ \epsilon_{w_t} \\ \epsilon_{pv_t} \\ \epsilon_{f_t} \\ \epsilon_{r_t} \end{pmatrix} \tag{28}$$

Directly from (28) it is possible to identify and estimate the polynomials $\pi_{ij}(B)$ and $\Gamma_i(B)$. For estimating $\nu_i(B)$ it is necessary to solve the system:

$$
\begin{aligned}
-\pi_{11}(B)\nu_c(B) - \pi_{12}(B)\nu_w(B) - \pi_{13}(B)\nu_{pv}(B) - \pi_{14}(B)\nu_f(B) &= \Gamma_c(B) \\
-\pi_{21}(B)\nu_c(B) - \pi_{22}(B)\nu_w(B) - \pi_{23}(B)\nu_{pv}(B) - \pi_{24}(B)\nu_f(B) &= \Gamma_w(B) \\
-\pi_{31}(B)\nu_c(B) - \pi_{32}(B)\nu_w(B) - \pi_{33}(B)\nu_{pv}(B) - \pi_{34}(B)\nu_f(B) &= \Gamma_{pv}(B) \\
-\pi_{41}(B)\nu_c(B) - \pi_{42}(B)\nu_w(B) - \pi_{43}(B)\nu_{pv}(B) - \pi_{44}(B)\nu_f(B) &= \Gamma_f(B)
\end{aligned} \tag{29}
$$

The program Mathcad gives the following solutions:

$$
\nu_c(B) = \frac{-0.08 - 0.35B + 0.05B^2 - 0.15B^3 + 0.02B^4 - 0.01B^5 + 0.02B^6 - 0.01B^7}{1 - 0.90B + 0.05B^2 - 0.08B^3 + 0.31B^4 - 0.19B^5 + 0.06B^6 - 0.01B^7} \tag{30}
$$

$$
\nu_w(B) = \frac{-0.03 - 0.02B - 0.02B^2 + 0.02B^3 + 0.005B^4 - 0.001B^5 - 0.007B^6 + 0.002B^7 - 0.001B^8}{1 - 0.90B + 0.05B^2 - 0.08B^3 + 0.31B^4 - 0.19B^5 + 0.06B^6 - 0.01B^7} \tag{31}
$$

$$
\nu_{pv}(B) = \frac{-0.04 + 0.05B - 0.35B^2 + 0.26B^3 - 0.12B^4 + 0.08B^5 - 0.01B^6 - 0.01B^7 + 0.01B^8}{1 - 0.90B + 0.05B^2 - 0.08B^3 + 0.31B^4 - 0.19B^5 + 0.06B^6 - 0.01B^7} \tag{32}
$$

$$
\nu_f(B) = \frac{-6.79 + 2.84B - 0.32B^2 + 0.62B^3 + 0.42B^4 - 0.29B^5 + 0.19B^6 + 0.09B^7}{1 - 0.90B + 0.05B^2 - 0.08B^3 + 0.31B^4 - 0.19B^5 + 0.06B^6 - 0.01B^7} \tag{33}
$$

These transfer functions give the unidirectional response of c_t, ∇w_t, ∇pv_t and f_t to an impulse in r_t, respectively. That is, these responses do not include the feedback response (Central Bank reaction) of r_t to changes in the level of z_t. The total response of z_t is made of both, the unidirectional and the feedback responses.

According to (23), the polynomials $\pi_{ij}(B)$, $\Gamma_c(B)$ and $\nu_i(B)$ will be necessary for breaking down the total response.

4 Effects of interest rate on consumption

According to the financial accelerator theory, a rise (fall) in the interest rates will make housing demand to fall (rise) and housing prices to fall (rise); the value of housing wealth, as collateral for loans, will diminish (rise) leading private consumption to fall (rise).

According to the life cycle-permanent income theory, a rise (fall) in the interest rates will make housing wealth to fall (rise); as the level of private consumption is positively determined by the level of wealth, agents will react by reducing (augmenting) their private consumption.

Those are long run results, but what happen in the medium and short term? When the financial wealth is included in the problem, which type of wealth has the biggest effects on consumption?

These two questions have not theoretical answers, but they have motivated many empirical studies. (Barata and Pacheco, 2003), (Pichette and Tremblay, 2003), (Catte et al., 2004), (Carrol, 2004), (Ludwing and Slok, 2004), (Case et al., 2005), (Rapach and Strauss, 2006), (Matsubayashi, 2006), (Carrol et al., 2006) and (Dvornak and Kohler, 2007) are some recent examples. All, except (Matsubayashi, 2006) conclude that, in the long run, the effects of the housing wealth are, at least, as bigger as those of the financial wealth. None of mentioned authors says anything about the shape of the short or medium term effects. This issue, together with that of the relative importance of each type of wealth, are studied in this section.

Table 2 and Graph 1 show the total dynamic response of c_t to a permanent unitary shock in r_t. Confidence 95% bands have been computed following (Efron and Tibshirani, 1993).

A permanent rise in the level of r_t leads to a permanent fall in the level of c_t. The magnitude of the response varies over time. One year after the initial shock the level has fallen 0.5 percentage points (pp), five years later the fall is about 2.0 pp. At this point, it almost stabilizes; therefore 2.0 pp can be considered its long run effect.

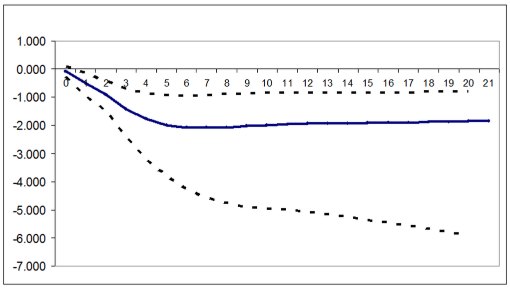

Figure 1: Response of c_t of a shock in r_t

Table 2: IRF of ∇r_t (percentage points)

years	c_t	f_t	r_t	∇c_t	∇w_t	∇pv_t	∇f_t	∇r_t	$ecm1_t$	$ecm2_t$
0	-0.08	-6.79	1.00	-0.08	-0.03	-0.04	-6.79	1.00	0.02	6.63
1	-0.50	-9.93	0.98	-0.42	-0.08	-0.03	-3.14	-0.02	-0.03	3.29
2	-0.91	-12.84	0.99	-0.41	-0.15	-0.36	-2.91	0.01	-0.05	0.45
3	-1.41	-14.34	0.87	-0.50	-0.18	-0.40	-1.51	-0.12	-0.08	-2.68
4	-1.77	-13.57	0.86	-0.36	-0.19	-0.53	0.77	-0.01	-0.08	-2.06
5	-1.98	-13.29	0.81	-0.21	-0.18	-0.55	0.29	-0.05	-0.07	-2.41
6	-2.08	-12.42	0.80	-0.10	-0.18	-0.51	0.86	-0.01	-0.07	-1.67
7	-2.09	-11.67	0.82	-0.01	-0.17	-0.51	0.75	0.02	-0.07	-0.69
8	-2.05	-11.34	0.82	0.03	-0.17	-0.47	0.33	0.00	-0.07	-0.38
9	-2.02	-11.07	0.83	0.04	-0.17	-0.44	0.28	0.02	-0.07	0.11
10	-1.99	-11.05	0.84	0.04	-0.16	-0.44	0.02	0.01	-0.06	0.23
20	-1.88	-11.29	0.84	0.01	-0.15	-0.44	0.01	0.00	-0.05	0.02

Table 3: Confidence 95% Bands - IRF of ∇r_t

	c_t		∇w_t		∇pv_t		f_t		r_t	
years	lower	higher	lower	higher	lower	higher	lower	higher	lower	higher
0	0.19	0.17	0.02	0.02	0.53	0.42	2.79	2.75	0.23	0.18
1	0.43	0.34	0.05	0.03	0.37	0.31	3.00	2.93	0.37	0.25
2	0.57	0.49	0.09	0.06	0.48	0.46	4.19	3.66	0.30	0.19
3	0.96	0.71	0.12	0.07	0.81	0.45	4.35	4.24	0.38	0.28
4	1.38	0.93	0.15	0.08	0.83	0.56	3.65	4.56	0.34	0.27
5	1.78	1.09	0.18	0.08	1.02	0.63	4.44	4.63	0.32	0.30
6	2.15	1.18	0.20	0.08	0.90	0.55	5.06	4.66	0.35	0.31
7	2.44	1.20	0.24	0.07	0.82	0.57	5.38	5.09	0.30	0.29
8	2.69	1.20	0.26	0.07	0.73	0.52	5.30	4.89	0.30	0.29
9	2.88	1.17	0.28	0.07	0.57	0.49	5.33	3.93	0.29	0.27
10	3.00	1.13	0.29	0.07	0.55	0.47	5.17	3.66	0.27	0.26
20	4.05	1.06	0.47	0.06	0.63	0.48	4.32	3.68	0.30	0.26

Using (23) the total response can be split into five different components, as shown in Table 4.

Table 4: Consumption Break Down (percentage points)

years	$\Psi_{rc}(B)$	$\Gamma_c(B)$	$\Theta_w(B)$	$\Theta_p(B)$	$\Theta_f(B)$	Υ_{cp}
0	-0.08	-0.08	0.00	0.00	0.00	0.00
1	-0.50	-0.25	-0.07	-0.01	-0.17	0.00
2	-0.91	-0.34	-0.22	-0.01	-0.35	0.01
3	-1.41	-0.39	-0.45	-0.08	-0.51	0.02
4	-1.77	-0.42	-0.64	-0.13	-0.66	0.08
5	-1.98	-0.43	-0.78	-0.18	-0.73	0.14
6	-2.08	-0.44	-0.87	-0.22	-0.78	0.23
7	-2.09	-0.44	-0.93	-0.23	-0.8	0.31
8	-2.05	-0.44	-0.95	-0.24	-0.79	0.37
9	-2.02	-0.44	-0.96	-0.25	-0.78	0.41
10	-1.99	-0.45	-0.96	-0.24	-0.76	0.42
20	-1.88	-0.45	-0.83	-0.22	-0.72	0.34

The direct effect ($\Gamma_c(B)$) or cost of credit effect, is the most important at the beginning, that is, contemporaneously and during the first year after the shock. Then, after two years, both, the financial ($\Theta_f(B)$) and housing wealth ($\Theta_w(B)$) start having effects. Their magnitudes are similar, and similar to the direct effect. Prices ($\Theta_p(B)$) are stickier and they start moving later; significant effects from prices are detected only three years after the shock.

Housing prices move more slowly than asset prices and explain why the effects of residential wealth are less important at the beginning.

As housing prices start falling (and with them, the general price level) the central Bank starts reacting. The lower pressure on inflation leads Central Bank to reduce interest rates, and this has a positive effect on consumption. This occurs two or three years after the shock.

The relative importance of the direct effect decreases as time passes by. The opposite happens with wealth, price and Central Bank effects.

In the long run, say 10 years after the shock, the direct effect accounts for a 18.7% of the total response, the housing wealth accounts for the 39.8%, the financial wealth contributes with a 31.5% and the price of houses with a 10%.

Most papers consider as the housing wealth effect what in this paper has been called $\Theta_w(B)+\Theta_p(B)$. That is, the sum of what it has been called the housing wealth effect and the housing price effect. Adding these two components, the long run contribution of the housing wealth to consumption total response would be a 49.8%, while that of the financial wealth would be a 31.5%. Clearly, in the long run, the housing wealth surpasses the financial wealth, and in this sense the results of this paper do not differ from those found by the majority of authors as mentioned above. However, this finding must be blended with the short and medium run responses.

Since 1990 up to 2003, the 12 month interbank interest rate in Spain (MIBOR) has evolved from a 14.96% to a 2.34%. The MIBOR is the reference rate used for mortgages and many other loans in Spain. Its behavior is followed by all economic agents and it conditions their investment and consumption decisions. Also it is cointegrated with all shorter term rates at the interbank money market and its behavior comes much explained by the monetary policy of the ECB. The spectacular fall experienced by the MIBOR during such a long period, explains the spectacular and long lasting Spanish private consumption growth, the enormous building activity as well as the amazing performance of the Spanish stock market.

5 Concluding remarks

When comparing the effects on consumption of housing wealth versus financial wealth, it is important to distinguish whether there are two specific shocks (one for each type of wealth) or there is an external shock affecting both variables. Most papers dealing with measuring the relative importance of the effects of housing wealth versus those of the financial wealth on consumption, consider the existence of two different, independent shocks.

This paper estimates and compares the effects of housing and financial wealth on consumption when both variables are hit by only one shock in interest rates.

The method of (León and Flores, 2012) is used for breaking down the dynamic response of consumption, to a permanent unitary shock in interest rates, into five components: (1) The cost of credit component, (2) The housing wealth component, (3) The housing price component, (4) the financial wealth component and (5) The Central Bank component.

The application of the decomposition method to the Spanish economy reveals important issues. The relative importance of each component changes over time and depends on the term chosen. In the short run (up to two years after the initial shock) the dominance corresponds to the cost of credit component. From two to three years after the shock, both types of wealth start having effects on consumption, lightly bigger in the case of financial wealth. After that, as prices start reacting to new market conditions, the housing price component starts having importance on the consumption response. The housing wealth component, whose contribution had kept in line with that of both, the cost of credit and financial wealth component, begins to dominate. This situation continues up to reaching the new equilibrium, five or six years after the shock.

Three years after the shock the central Bank starts reacting to the lower inflation, reducing interest rates. That reverses somewhat the negative effects on consumption from the initial shock.

Housing prices and real housing wealth have important and quite different effects on consumption. If any of these variables were to be omitted from the empirical analysis, biases in the estimated responses would likely appear.

Empirical results suggest that the great increase experienced by the Spanish Consumption, especially since 1995, could be mainly explained by residential and financial wealth effects; effects provoked by the low rates policy carried out by the ECB since 1990, the year when Germany started its reunification process.

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Appendix

Appendix 1 Algebraic Appendix - Breakdown of effects: PROOF

From Matrices Inversion lemma:

$$(A - gh')^{-1} = \left(I + A^{-1} \frac{gh'}{1 - h'A^{-1}g} \right) A^{-1}$$

Making $A = I$, $g = \nu_z(B)$ and $h' = \nu_r(B)$:

$$[I - \nu_z(B)\nu_r(B)]^{-1} = I + \frac{\nu_z(B)\nu_r(B)}{1 - \nu_r(B)\nu_z(B)} \tag{1}$$

Where:

$$\nu_z(B)\nu_r(B) = \begin{pmatrix} \nu_c(B) \\ \nu_w(B) \\ \nu_{pv}(B) \\ \nu_f(B) \end{pmatrix} \cdot (\nu_{rc}(B), \nu_{rw}(B), \nu_{rpv}(B), \nu_{rf}(B)) =$$

$$\begin{pmatrix} \nu_c(B)\nu_{rc}(B) & \nu_c(B)\nu_{rw}(B) & \nu_c(B)\nu_{rpv}(B) & \nu_c(B)\nu_{rf}(B) \\ \nu_w(B)\nu_{rc}(B) & \nu_w(B)\nu_{rw}(B) & \nu_w(B)\nu_{rpv}(B) & \nu_w(B)\nu_{rf}(B) \\ \nu_{pv}(B)\nu_{rc}(B) & \nu_{pv}(B)\nu_{rw}(B) & \nu_{pv}(B)\nu_{rpv}(B) & \nu_{pv}(B)\nu_{rf}(B) \\ \nu_f(B)\nu_{rc}(B) & \nu_f(B)\nu_{rw}(B) & \nu_f(B)\nu_{rpv}(B) & \nu_f(B)\nu_{rf}(B) \end{pmatrix}$$

and

$$\nu_r(B)\nu_z(B) = (\nu_{rc}(B), \nu_{rw}(B), \nu_{rpv}(B), \nu_{rf}(B)) \cdot \begin{pmatrix} \nu_c(B) \\ \nu_w(B) \\ \nu_{pv}(B) \\ \nu_f(B) \end{pmatrix} =$$

$$\nu_{rc}(B)\nu_c(B) + \nu_{rw}(B)\nu_w(B) + \nu_{rpv}(B)\nu_{pv}(B) + \nu_{rf}(B)\nu_f(B)$$

Thus:

$$1-\nu_r(B)\nu_z(B) = 1-[\nu_{rc}(B)\nu_c(B)+\nu_{rw}(B)\nu_w(B)+\nu_{rpv}(B)\nu_{pv}(B)+\nu_{rf}(B)\nu_f(B)]$$

and

$$\frac{\nu_z(B)\nu_r(B)}{1-\nu_r(B)\nu_z(B)} = \begin{pmatrix} \frac{\nu_c(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_w(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_{pv}(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_f(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \end{pmatrix}$$

Then:

$$I+\frac{\nu_z(B)\nu_r(B)}{1-\nu_r(B)\nu_z(B)} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} + \begin{pmatrix} \frac{\nu_c(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_w(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_{pv}(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_f(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \end{pmatrix} =$$

$$\begin{pmatrix} 1+\frac{\nu_c(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_w(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & 1+\frac{\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_{pv}(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & 1+\frac{\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_f(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & 1+\frac{\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \end{pmatrix}$$

Since:

$$1+\frac{\nu_i(B)\nu_{ri}(B)}{1-\nu_r(B)\nu_z(B)} = \frac{[1-\nu_r(B)\nu_z(B)]+\nu_i(B)\nu_{ri}(B)}{1-\nu_r(B)\nu_z(B)}$$

A detailed form of (1) becomes:

$$\begin{pmatrix} \frac{[1-\nu_r(B)\nu_z(B)]+\nu_c(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_w(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{[1-\nu_r(B)\nu_z(B)]+\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_{pv}(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{[1-\nu_r(B)\nu_z(B)]+\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_f(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{[1-\nu_r(B)\nu_z(B)]+\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \end{pmatrix} \tag{2}$$

The first row of the expression:

$$\Psi_r(B) = [I - \nu_z(B)\nu_r(B)]^{-1}\nu_z(B)\pi_r(B)^{-1} =$$

$$\begin{pmatrix} \frac{[1-\nu_r(B)\nu_z(B)]+\nu_c(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_c(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_w(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{[1-\nu_r(B)\nu_z(B)]+\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_w(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_{pv}(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{[1-\nu_r(B)\nu_z(B)]+\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_{pv}(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \\ \frac{\nu_f(B)\nu_{rc}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{\nu_f(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} & \frac{[1-\nu_r(B)\nu_z(B)]+\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \end{pmatrix} \cdot \begin{pmatrix} \nu_c(B) \\ \nu_w(B) \\ \nu_{pv}(B) \\ \nu_f(B) \end{pmatrix} \cdot \pi_r(B)^{-1} \tag{3}$$

is:

$$\Psi_{rc}(B) = \left[\frac{[1-\nu_r(B)\nu_z(B)] + \nu_c(B)\nu_{rc}(B)\nu_c(B)}{1-\nu_r(B)\nu_z(B)} + \frac{\nu_c(B)\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} \right] \pi_r(B)^{-1} +$$

$$+ \left[\frac{\nu_c(B)\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} + \frac{\nu_c(B)\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \right] \pi_r(B)^{-1}$$

If $\nu_{rc}(B) = 0$:

$$\begin{aligned} \Psi_{rc}(B) &= \left[\nu_c(B) + \frac{\nu_c(B)\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)} \right] \pi_r(B)^{-1} + \\ &+ \left[\frac{\nu_c(B)\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)} + \frac{\nu_c(B)\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)} \right] \pi_r(B)^{-1} \end{aligned} \tag{4}$$

Equation (4) shows that $\Psi_{rc}(B)$ can be broken down into two components: (1) An unidirectional response from interest rate to consumption, represented by $\nu_c(B)$, and (2) the sum of three feedback effects:

1. the feedback effect due to the residential wealth:

$$\frac{\nu_c(B)\nu_w(B)\nu_{rw}(B)}{1-\nu_r(B)\nu_z(B)}$$

2. the feedback effect due to the housing price:

$$\frac{\nu_c(B)\nu_{pv}(B)\nu_{rpv}(B)}{1-\nu_r(B)\nu_z(B)}$$

3. the feedback effect due to the financial wealth:

$$\frac{\nu_c(B)\nu_f(B)\nu_{rf}(B)}{1-\nu_r(B)\nu_z(B)}$$

If we represent the residential wealth feedback effect by $\Upsilon_{cw}(B)$, the housing price feedback effect by $\Upsilon_{cpv}(B)$ and the financial wealth feedback effect by $\Upsilon_{cf}(B)$, then the reaction of consumption to the interest rate can be written as (5)

$$\Psi_{rc}(B) = \nu_c(B) + \Upsilon_{cw}(B) + \Upsilon_{cpv}(B) + \Upsilon_{cf}(B) \tag{5}$$

Moreover, it was pointed out in section (2) that the direct effect of the interest rate on consumption can be obtained from the structural model and takes the form:

$$\Gamma_c(B) = \left[\nu_c(B) + \frac{\pi_{12}(B)}{\pi_{11}(B)}\nu_w(B) + \frac{\pi_{13}(B)}{\pi_{11}(B)}\nu_{pv}(B) + \frac{\pi_{14}(B)}{\pi_{11}(B)}\nu_f(B)\right] \tag{6}$$

Then,

$$\nu_c(B) = \Gamma_c(B) + \Theta_w(B) + \Theta_p(B) + \Theta_f(B) \tag{7}$$

Where

$$\Theta_w(B) = -\frac{\pi_{12}(B)}{\pi_{11}(B)}\nu_w(B)$$

is the unidirectional indirect effect of interest rates on consumption, throughout residential wealth, because $\Theta_w(B)$ is the combination of two effects: (1) the effect of interest rate on residential wealth, represented by $\nu_w(B)$ and (2) the effect of residential wealth on consumption, represented by $\frac{\pi_{12}(B)}{\pi_{11}(B)}$.

And

$$\Theta_{pv}(B) = -\frac{\pi_{13}(B)}{\pi_{11}(B)}\nu_{pv}(B)$$

is the unidirectional indirect effect of interest rate on consumption through housing prices, because $\Theta_{pv}(B)$ is the combination of two effects: (1) the effect of interest rate on housing price represented by $\nu_{pv}(B)$ and (2) the effect of housing prices on consumption, represented by $\frac{\pi_{13}(B)}{\pi_{11}(B)}$.

And

$$\Theta_f(B) = -\frac{\pi_{14}(B)}{\pi_{11}(B)}\nu_f(B)$$

is the unidirectional indirect effect of interest rates on consumption, throughout financial wealth, because $\Theta_f(B)$ is the combination of two effects: (1) the effect of interest rate on financial wealth, represented by $\nu_f(B)$ and (2) the effect of financial wealth on consumption, represented by $\frac{\pi_{14}(B)}{\pi_{11}(B)}$.

Finally, (8) is obtained by substituting (7) in (5):

$$\Psi_{rc}(B) = [\Gamma_c(B) + \Theta_w(B) + \Theta_p(B) + \Theta_f(B) + \Upsilon_{cw}(B) + \Upsilon_{cpv}(B) + \Upsilon_{cf}(B)]\pi_r(B)^{-1} \tag{8}$$

Appendix 2 Empirical Appendix

In graphs (1), (2), (3), (4) and (5) the series c_t, w_t, pv_t f_t[2] and r_t are presented. The series are clearly nonstationary. Table (1) shows the augmented Dickey-Fuller test (ADF) for the first differences of these variables.

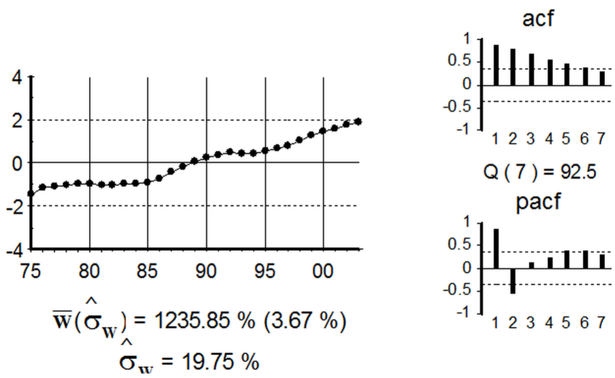

Figure 1: c_t

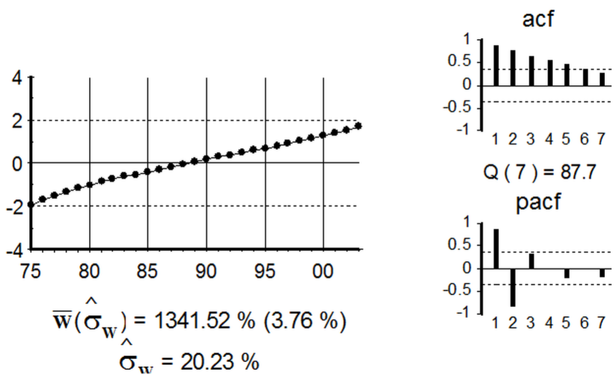

Figure 2: w_t

The findings suggest that the ∇c_t. ∇f_t and ∇r_t series are stationary, I(0), since the value of the statistic, -3.08, -2.61 and -4.32, is less than the critical value at 95% confidence. The ∇pv_t series is clearly nonstationary since the value of the statistic, for any number of lags is lower than the critical value. The ∇w_t series is

[2] f_t is the intervened variable, discounting the step effect in 1986.

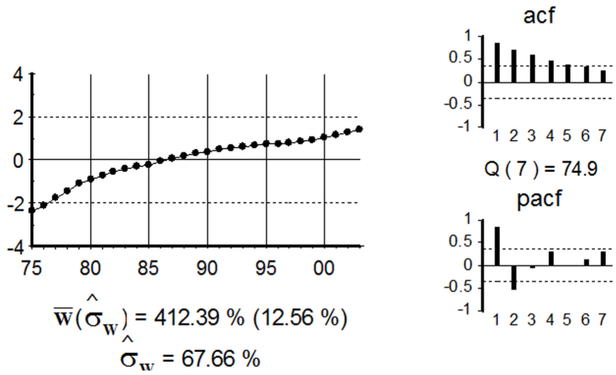

Figure 3: pv_t

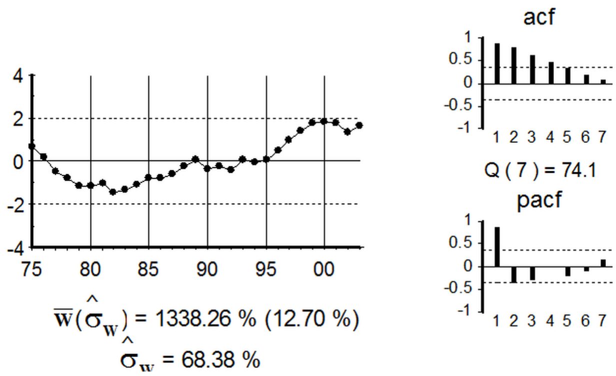

Figure 4: f_t

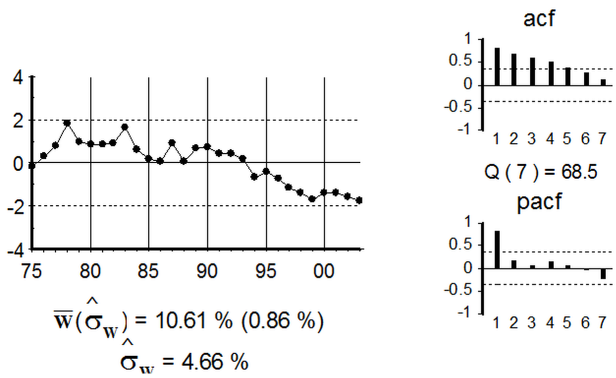

Figure 5: r_t

nonstationary since its statistic for p=3 is -2.27, less than the critical value of the tables. However, since with other values of p the result is ambiguous, the graphs of ∇pv_t and ∇w_t are presented in (6) and (7). In both graphs it can be seen that the variables ∇pv_t and ∇w_t are nonstationary since they show a negative trend.

Table 1: ADF Test for the ∇ series

ADF[a]	p=1	p=2	p=3	p=4
∇c_t	-3.08	-2.72	-2.58	-4.39
∇w_t	-4.54	-4.59	-2.27	-3.09
∇pv_t	-1.50	-1.98	-1.61	-2.01
∇f_t	-2.61	-2.31	-1.99	-1.86
∇r_t	-4.32	-3.68	-3.47	-2.02

[a]Note: $H_0 : \rho = 1$ in the model $\nabla^2 z_t = \mu + \rho \nabla z_{t-1} + \sum_{j=1}^{p} \gamma_j \nabla^2 z_{t-j} + u_t$. The critical value at 95% is -2.96 (MacKinnon). For

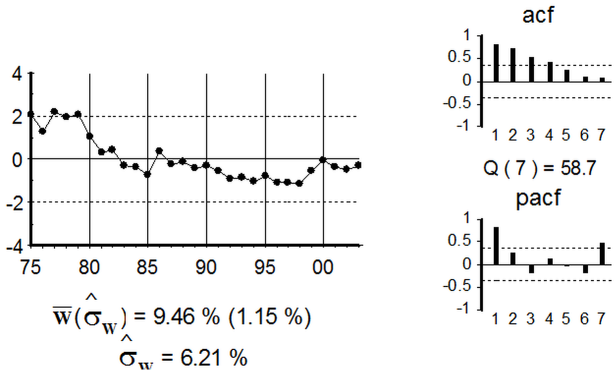

Figure 6: ∇pv_t

In Table (2) the estimates of the univariate ARMA models for the stationary series are presented.

It is important to stress the lack of moving average (MA) operators in the univariate models for $\nabla^2 w_t$ and $\nabla^2 pv_t$. The appearance of MA terms close to invertability would indicate a possible over differentiation problems.

The ADF test and the univariate models indicate that the series c_t, f_t and r_t are integrated of order 1, I(1). The ADF test, the graphic analysis and the

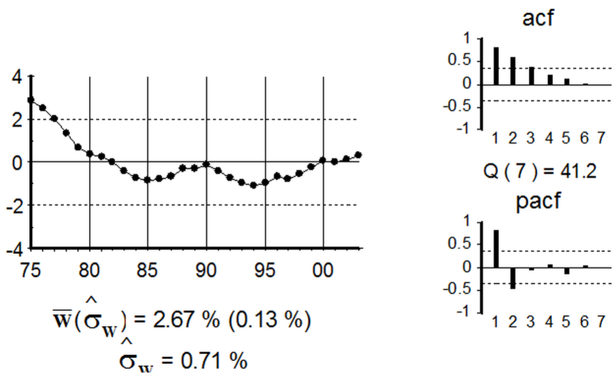

Figure 7: ∇w_t

Table 2: Univariate Model

variable[a]	ϕ	μ	σ_a %	Q(4)
∇c_t	0.61 (0.12)	0.024 (0.007)	1.59	3.23
$\nabla^2 w_t$	0.56 (0.15)	-	0.21	2.11
$\nabla^2 pv_t$	-	-	3.87	3.85
∇f_t	0.35 (0.17)	-	20.47	2.81
∇r_t	-	-	2.3	2.46

[a]Note: The specification of the univariate model for the stationary series (z_t) is $(1-\phi)[z_t-\mu] = a_t$. The SD are presented in brackets. σ_a , is the typical residual deviation and Q(4) is the Ljung-Box statistic for 4 lags.

estimation of the univariate models show sufficient evidence in favour of the series w_t and pv_t being I(2).

Cointegration

Using the methodology of (Engle and Granger, 1987), possible cointegration relationships are analysed. In Table (3) the ADF test for the residual of the regression of each nonstationary variable with the remaining ones is presented. If residuals are stationary, the regression shows a cointegration relationship.

Table 3: Engle-Granger Approach for cointegration

Dependent var	p=0	p=1	p=2	p=3	p=4
c_t	-2.19	-2.63	-2.92	-2.63	-3.24
∇w_t	-3.99	-2.76	-4.35	-3.75	-3.18
∇pv_t	-4.02	-2.75	-4.48	-3.19	-2.74
f_t	-4.20	-2.87	-2.84	-2.82	-2.74
r_t	-5.15	-3.24	-2.95	-2.57	-2.53

The critical value(95 %) is -4.11 ((Phillips and Ouliaris, 1990))

From Table (3) the conclusion can be drawn that there exists two cointegration relationships, one between ∇w_t and the other variables and one between f_t and other variables[3]. To analyse which variables should be included in the cointegration relationship, in table (4) and table (5) the ADF test for the residuals of the regression of ∇w_t and f_t are presented with the other variables excluded one by one.

Table 4: Engle-Granger Approach for cointegration with ∇w_t

Excluded variable	p=0	p=1	p=2	p=3	p=4
c_t	-4.20	-3.34	-5.86	-4.33	-3.90
∇pv_t	-2.75	-1.48	-1.81	-2.30	-2.27
f_t	-4.68	-2.71	-4.63	-4.04	-2.71
r_t	-3.30	-2.71	-3.80	-2.74	-3.16

The critical value (95 %) is -3.77 ((Phillips and Ouliaris, 1990))

[3]It could also be concluded that there is a relationship of ∇pv_t with the other variables but later analysis showed that it was the same relationship as with ∇w_t but normalised in another way The same is true for r_t and f_t.

From table (4) it can be concluded that neither c_t or f_t should not be in the relationship. The OLS estimation of this relationship is presented in equation (1).

$$\nabla w_t = \underset{(0.002)}{0.020} \underset{(0.01)}{+0.13} \nabla pv_t \underset{(0.02)}{-0.05} r_t + \xi_{1t} \tag{1}$$

The cointegration 3).

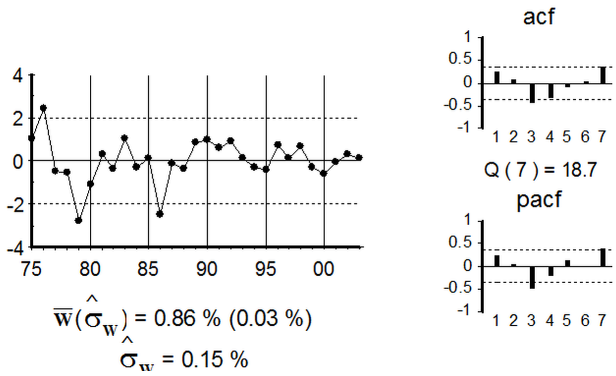

Figure 8: $ecm1_t$

Table 5: Engle-Granger Approach for cointegration with f_t

Excluded variable	p=0	p=1	p=2	p=3	p=4
c_t	-4.21	-3.09	-2.90	-2.61	-2.82
∇w_t	-4.33	-2.54	-2.50	-2.42	-3.07
∇pv_t	-4.86	-2.83	-3.08	-2.75	-3.21
r_t	-2.94	-2.61	-3.52	-3.29	-3.18

The critical value (95 %) is -3.77 (Phillips and Ouliaris (1990))

From table (5) it can be concluded that neither c_t or ∇w_t or ∇p_t should not be in the relationship. The OLS estimation of this relationship is presented in equation (2).

$$f_t = \underset{(0.13)}{14.83} \underset{(1.16)}{-13.42} r_t + \xi_{2t} \tag{2}$$

The cointegration relationship estimated in (2) is presented in graph (9).

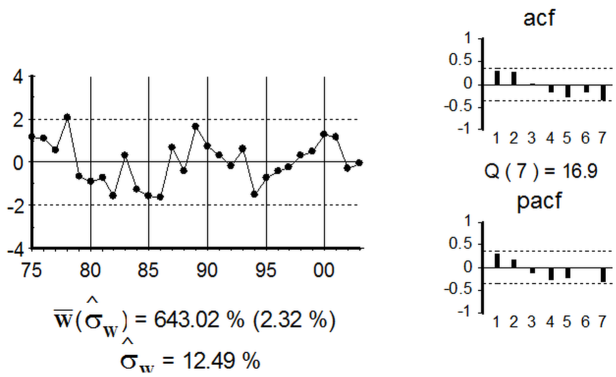

Figure 9: $ecm2_t$

Appendix 3 Data Appendix

years	Consumption	Housing Wealth	Price of Housing	Interest rate	Financial Wealth
1974	171872	433700.592	10.03	1.1180	1053658
1975	174966	454592.301	12.51	1.1016	1026251
1976	184764	475290.499	14.90	1.1273	734944
1977	187535	495230.181	18.77	1.1532	461429
1978	189223	513513.032	23.29	1.2112	374814
1979	191683	530000.770	29.06	1.1618	296911
1980	192833	545863.452	34.07	1.1566	292526
1981	190890	561548.428	38.16	1.1558	315106
1982	190962	576650.122	43.00	1.1590	237272
1983	191710	590610.669	46.34	1.1997	257232
1984	191304	603446.302	49.82	1.1430	309937
1985	195670	616195.888	52.31	1.1199	373279
1986	202251	629329.059	58.84	1.1165	738993
1987	214272	643321.138	63.65	1.1615	839901
1988	224637	659350.573	69.50	1.1145	1066351
1989	236673	675816.644	74.51	1.1476	1302992
1990	244836	693520.933	80.35	1.1496	979887
1991	251768	710122.446	85.50	1.1326	1054915
1992	257141	725551.793	88.77	1.1327	917022
1993	251899	739973.789	92.48	1.1215	1311185
1994	254285	754068.368	95.40	1.0791	1201298
1995	258645	769339.266	100.00	1.0915	1291329
1996	264242	786514.269	102.83	1.0759	1712576
1997	272621	803392.526	105.78	1.0546	2378544
1998	284482	822125.490	108.42	1.0433	3220865
1999	297733	843019.430	115.19	1.0284	4089443
2000	309908	866287.900	125.96	1.0421	4279286
2001	318641	889574.340	135.15	1.0431	4095936
2002	327695	914620.793	144.39	1.0329	3071220
2003	337039	941302.324	155.70	1.0234	3756143

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