Student test for each coefficient of the model (Table 2). It is worth noting that the constant was not inserted in the functions of the model. This is justified by having used the first differences of variables, whose values generally fluctuate around zero. With the correlations between the statistically insignificant variables having been neglected and considering the results of Akaike and Schwarz information criterion, the implemented VAR model considers the following linear relations in (1).

t-ratios	Δprc_t	$\Delta rent_t$	Δint_t	var_GDP_t	Δinv_h_{t-1}
Δprc_t	5.6542	-	-2.847	1.994	-2.659
$\Delta rent_t$	3.7841	-	-2.853	2.657	-
Δint_t	2.4513	-	-	-	-
var_GDP_t	-	-	-	20.258	-
Δinv_h_{t-1}	2.357	-	-	2.124	2.357

Table 2 – t-Student of the coefficients in the model

Diagnostic tests (Portmanteau test, non-normality test, Jarque-Bera test), Granger-causality tests and Chow tests for the stability of the parameters are characterized by *p-values* that show the goodness of fit of model obtained.

4 Results

From the linear system that defines the model developed, it is possible to deduce that:

1) Housing prices depend on themselves delayed by a year, they react with the same one-year delay to changes in short-term interest rates and the differences between actual and expected GDP. The variable is related to investments in homes with two year delayed reactions. There is no significant relationship with rents.

2) Rents depend on real-estate prices, the short-term interest rate and the differences between actual and expected GDP with a one year delayed reaction.

3) The short-term interest rate is tied to variations in property prices with a one year delay.

4) Housing investments and property prices are related to the differences between actual and expected GDP with a simultaneous relationship as well as depend on themselves with a one year delay.

4.1 Response functions to the impulse

From the graphs in Fig. 3, in which the response functions of house prices to a unitary shock of the endogenous variables are correlated, it is evident that there is a direct relationship with the variable *var_GDP*, while the relationship is reversed with the short-term interest rate and housing investments (one-year delay).

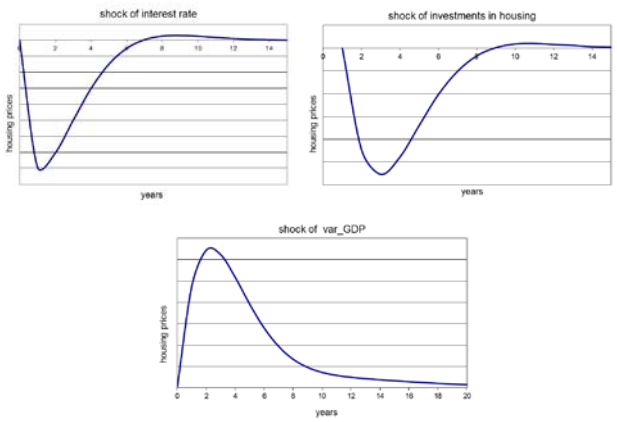

Fig. 3 - Response functions of house prices to impulses of the short-term interest rate, housing investments and variable var_GDP

Fig. 4 shows the response functions of rent to the impulse of other variables.

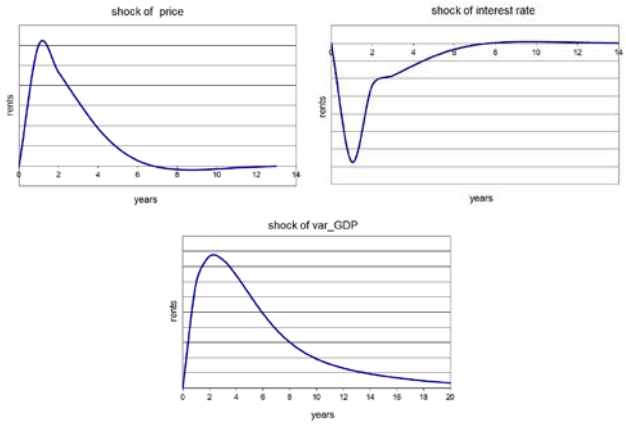

Fig. 4 - Response functions of rents to an impulse of housing prices, the short-term interest rate and variable var_GDP

With reference to other relationships identified by the model but not shown in the graphs, it is interesting to note that impulses to real-estate prices and the variable *var_GDP* produce instantaneous shocks to housing investments.

In order to compare the results in quantitative terms, each variable is given an impulse equal to the standard deviation of the transformed series and, output, the response is measured as a percentage, the standard deviation of the series represents in the model the dynamics of housing prices (Fig. 5) and rents (Fig. 6), respectively.

$$\begin{cases} \Delta prc_t = c_{prc,\,prc} \cdot \Delta prc_{t-1} + c_{prc,\,int} \cdot \Delta int_{t-1} + c_{prz,\,var\_GDP} \cdot var\_GDP_{t-1} + c_{prc,\,inv\_h} \cdot \Delta inv\_h_{t-2} + u_{t,prc} \\ \Delta rent_t = c_{rent,\,prc} \cdot \Delta prc_{t-1} + c_{rent,\,int} \cdot \Delta int_{t-1} + c_{rent,\,var\_GPD} \cdot var\_GDP_{t-1} + u_{t,\ rent} \\ \Delta int_t = c_{int,\,prz} \cdot \Delta prc_{t-1} + u_{t,\,int} \\ var\_GDP_t = c_{var\_GDP,\,var\_GDP} \cdot var\_GDP_{t-1} + u_{t,\,var\_GDP} \\ \Delta inv\_h_{t-1} = c_{inv\_h,\,prc} \cdot \Delta prc_{t-1} + c_{inv\_h,\,var\_GDP} \cdot var\_GDP_{t-1} + c_{inv\_h,\,inv\_h} \cdot \Delta inv\_h_{t-2} + u_{t-1,\,inv\_h} \end{cases} \quad (1)$$

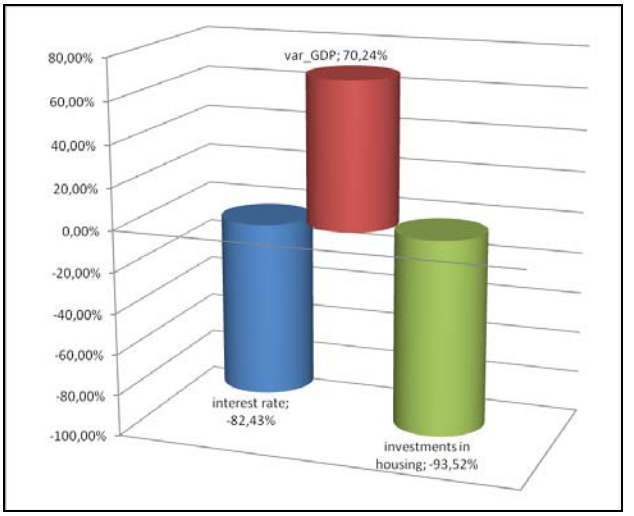

Fig. 5 - Quantitative response of housing prices, as a percentage of the standard deviation, effect of "normal" impulses of the other variables

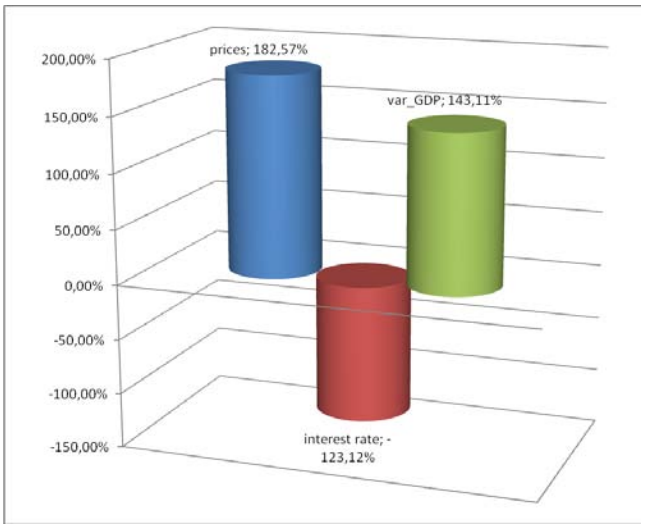

Fig. 6 – Response functions of rents to an impulse of housing prices, the short-term interest rate and variable var_GDP

It therefore seems that "normal" changes in the explanatory variables of rents have effects that are about two times greater than those affecting housing prices.

4.2 Forecast Error Variance Decomposition

The Forecast Error Variance Decomposition (FEVD) makes it possible to obtain information about the contribution that each of the variables considered has on the variability in housing prices. This process reveals, in particular, that the dynamics of the real-estate prices is explained for about 44% (the unexplained part being attributed to the characteristics of the housing market). The short-term interest rate is the variable that provides the greatest contribution in explaining the variance in housing prices (22%), followed by housing investments (18%), and, finally, the variable *var_GDP* (4%).

As regard the breakdown of the variance of rents, in this case the variable interest rate is the most significant (25%). This is followed by real-estate prices (11%) and the variable *var_GDP* (5%). Overall, the dynamics of the time series of rents (41%) is explained by the variables considered in the VAR (1) model.

As for the other relationships identified, the variance of the interest rate is explained by the real-estate prices (22%), whereas the variance in housing investments is accounted for 35% by property prices and 7% by the variable *var_GDP*.

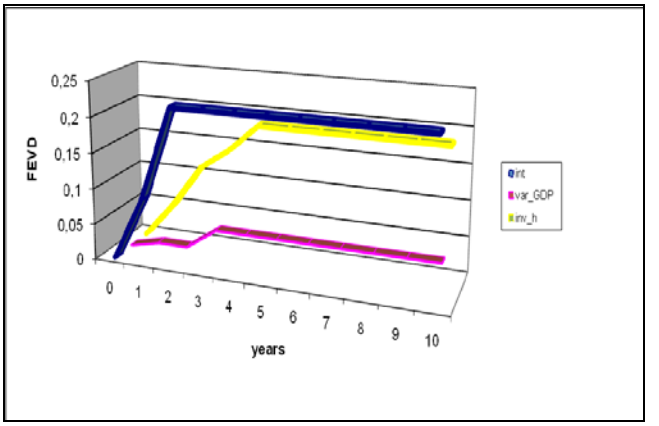

Fig. 7 – Response functions of rents to an impulse of housing prices, the short-term interest rate and variable var_GDP

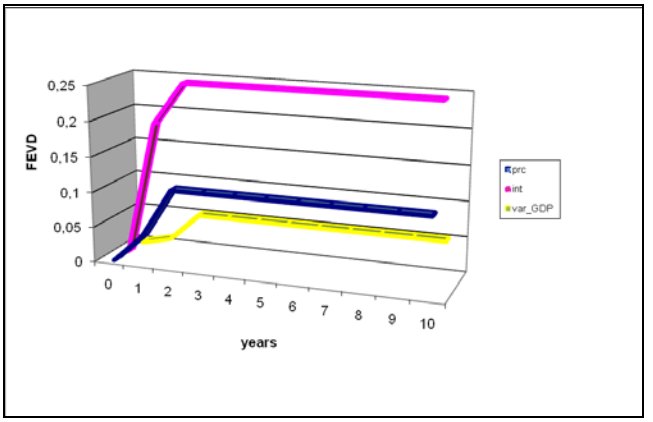

Fig. 8 – Response functions of rents to an impulse of housing prices, the short-term interest rate and variable var_GDP

5 Conclusions

An interpretation of the results indicates how funding decisions as well as the resulting change in demand for the purchase (which in turn produces a change in housing prices) are highly responsive to short-term real interest rates. No significant meaning can be attributed merely on this evidence due to the variable of inflation rate having been excluded from the analysis. While other studies have highlighted it as the most decisive factor in explaining the dynamics of residential property prices. Due to the fact that real-estate investments in Italy are perceived as an alternative to bond investments and/or government bonds, the increased uncertainty about future returns expected from the latter, in periods of persistent high inflation, directs savings towards real-estate. Less likely, is the hypothesis that Italian investors have an "intelligent" attitude, i.e. to purchase property in times of high inflation and high nominal interest rates, borrow money in times when there is a low real interest rate. As illustrated by Tsatsaronis and Khu [25], financing decisions are normally more responsive to the nominal yield curve rather than real tax rates. This correlation, from which we should expect an inverse relationship between inflation and real estate prices, however, plays a lesser role than the factor that indicates the purchase of real property as a refuge against the risk of inflation.

The model also describes a reaction logic to the housing demand in expectation of future income. Similarly, positive expectations lead to an increase of the offer (housing investments). It is also consistent with the economic logic of the asymmetry in the mutual relationship, highlighted by the model, between the latter variable and housing prices. On the one hand, a change in housing investments results in a change in the inverse change of the balance in the market (increasing supply will reduce prices and vice versa); while on the other, price increases stimulate new investments.

The coherence between the statistical significance of the functional dependencies described above, and the behavioural and institutional relationships which follow from economic theory confirms the reliability of this VAR model, defined to analyse the interdependence between housing prices and rents in Italy.

With specific reference to this relationship, also directed, between house prices and the respective rents, the model describes it as being non-bidirectional. Housing prices can influence rents but not vice versa. This, in particular, highlights that the cost of a housing service has a unique underlying fundamental real estate prices. The other functions of the model that complement the explanation of the variance of the rents are to be interpreted as "spurious" relationships due to always having price as the intermediate variable. The housing demand, even the one for investment, does not seem to consider rent as a *proxy* for the corresponding dividend. In fact, a change in rents is always generated by a similar change in housing prices but by itself, it is unable, for the same boundary conditions, to become an increase in the value of the underlying activity. When choosing a housing investment, the current amount of the rent has a minimal role. The reasons are to be found in the relevant transaction costs, the structural limits of the rental market, and probably in the fact that the investor considers when making the choice, the rate of return linked to the capital gains to be decisive rather than that generated by rent.

References:

[1] Agenzia del Territorio, Appunti di economia immobiliare, *Quaderni dell'Osservatorio*, No. 2, 2012.

[2] Ayuso J., Restoy F., House prices and rents: an equilibrium asset pricing approach, *Journal of Empirical Finance*, Vol. 13, 2006, pp. 371-388.

[3] Beltratti A., Morana C., International house prices and macroeconomic fluctuations, *Journal of Banking & Finance*, Vol. 34, 2010, pp. 533-545.
[4] Berg L., Prices on the second-hand market for Swedish family houses: correlation, causation and determinants, European Journal of Housing Policy, Vol. 2, 2002, pp. 1-24.
[5] Box G.E.P., Jenkins G.M., *Time series analysis: forecasting and control*, Holden-Day, 1970.
[6] Capozza D.R., Hendershott P.H., Mack C., Mayer C.J., *Determinants of real house price dynamics*, NBER, Vol. 9262, 2002.
[7] Cochrane J., What do the VARs Mean? Measuring the Output Effects of Monetary Policy, *Journal of Monetary Economics*, Vol. 41, 1998, pp. 277-300.
[8] Conner P., Liang Y.J., Income and cap rate effects on property appreciation, *Journal of Portfolio Management*, Vol. 31 (Spec. Iss.), 2005, pp. 70-79.
[9] Elbourne A., The UK housing market and the monetary policy transmission mechanism: a SVAR approach, *Journal of Housing Economics*, Vol. 17, 2008, pp. 65–87.
[10] European Central Bank, monthly bulletin august 2010.
[11] Gallin J., The long-run relationship between house prices and income: evidence from local housing markets, *Real Estate Economics*, Vol. 34, 2006, pp. 417-438.
[12] Gjerstad S., Smith V.L., *Gross domestic product and its components in recessions*, Orange, 2010.
[13] Glaeser E.L., Gyourko J., Saks R.E., Why have housing prices gone up?, *American Economic Review*, Vol. 95, 2005, pp.329-333.
[14] Goodhart C., Hofmann B., House prices, money, credit and the macroeconomy, *European Central Bank*, working paper series No. 888, 2008.
[15] Iacoviello M., *House Prices and Business Cycles in Europe: a VAR Analysis*, Boston College Department of Economics, working paper No. 540, 2002.
[16] Johansen S., Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, Vol. 59, 1991, pp. 1551-1580.
[17] King R., Plosser C., Stock J., Watson M., Stochastic Trends and Economic Fluctuations, *American Economic Review*, Vol. 81, 1991, pp. 819-840.
[18] Lütkepohl H., Judge G.G., Hill R.C., Griffith W.E., Lee T.C., *Introduction to the Theory and Practice of Econometrics*, Wiley & Sons, 1988.
[19] Lütkepohl H., Econometric Analysis with Vector Autoregressive Models, *European University Institute – Department of Economics*, working paper, 2007.
[20] Manganelli B., Morano P., Tajani F., Economic relationship between selling and rental prices in the Italian housing market, *Recent Advances in Business Administration, Marketing and Economics*, Reinhard Neck, 2013, pp. 25-30.
[21] Mikhed V., Zemčík P., Do house prices reflect fundamentals? Aggregate and panel data evidence, *Journal of Housing Economics*, Vol. 18, 2009, pp. 140-149.
[22] Peracchi F., *Econometria*, McGraw-Hill, 1995.
[23] Poterba J., Tax Subsidies to Owner-Occupied Housing: an Asset Market Approach, *Quarterly Journal of Economics*, 1984, pp. 729-752.
[24] Sivitanides P., Southard J., Torto R., Wheaton W., The Determinants of Appraisal-Based Capitalization Rates, *Real Estate Finance*, Vol. 18, 2001, pp. 27-37.
[25] Tsatsaronis K., Zhu H., What Drives Housing Price Dynamics: Cross-Country Evidence, *BIS Quarterly Review*, March 2004, pp. 65-78.
[26] Verbeek M., *Econometria*, Zanichelli, 2006.
[27] Wheaton W., Real estate cycles: some fundamentals, *Real Estate Economics*, Vol. 27, 1999, pp. 209-230.
[28] www.bancaditalia.it.
[29] www.istat.it.
[30] www.prometeia.it.
[31] www.scenari-immobiliari.it.