Special Article

Cross Country Residential Investment Rates and the Implications for the Irish Housing Market

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Introduction[1]

Even by international standards, the experience of the Irish residential property market over the period 1995 to the present stands out. As the Irish economy rapidly converged to the living standards of other European countries from the mid-1990s onwards, activity in the property market increased dramatically. At that time the stock of Irish dwellings completed per 1,000 inhabitants was one of the lowest across Europe, therefore the combination of improving economic circumstance, a young population and accommodative international financing conditions resulted, almost inevitably, in a housing boom.

This situation was complicated significantly by changes in international wholesale markets in the early 2000s which ultimately enhanced the ability of credit institutions in one Member State of the Euro Area to borrow from institutions in another. The significant returns apparent in the Irish property sector up to this point resulted in a dramatic inflow of bank funding into the domestic market culminating in a substantial increase in the amount of property-related lending. Therefore, while most of the developments in the property sector up to 2002/2003 had been driven by improvements in fundamental variables such as income, interest rates and demographics, activity from then on was more a function of a substantial credit-fuelled bubble. Housing construction which had averaged 30,000 units per annum in the 1990s increased to almost 60,000 units in 2002 before reaching a peak of over 80,000 units per annum between 2004 and 2007.

By 2007, it was evident that house prices in the Irish market were significantly overvalued, driven in part by property speculation which became more frequent in the 2000s. Thus, with Irish financial institutions exposed to property-related lending, the international financial crisis of 2007/2008 had particularly calamitous implications for the domestic market. Over the period 2007-2012, Irish house

[1] This paper was presented at a joint EU Commission/ESRI Seminar: 'Housing Ireland's recovery: Policy perspectives', Radisson Blu hotel, Golden Lane, Dublin, 6 November, 2015.

prices fell, in nominal terms, by 50 per cent while housing supply all but ceased with the number of units built per annum falling to 26,000 units in 2009 and then to just over 8,000 units in 2013.

Given the, albeit nascent, recovery in house prices observed since early 2013, it is timely and pertinent to consider the potential supply response of the Irish residential construction sector. As of yet, this increase in house prices has not been accompanied by an associated increase in housing supply. This is despite the fact that studies such as Duffy et al. (2014) suggest that, on the basis of likely trends in household formation, approximately 25,000 new housing units are required per annum in Ireland over the medium term.

In this paper we assess the future prospects for Irish residential investment. However, in so doing we are confronted by a number of challenges. First is the relatively few studies in the international literature concerned with this issue. Vermeulen and Rowendal (2007) and DiPasquale (1999), amongst others, highlight the lack of empirical studies, particularly outside of the US, on the supply side of the construction sector. Therefore, in examining the likely supply-response of the Irish market we adopt an approach well established on the demand side of the housing market; we estimate a long-run fundamental rate of housing supply and we then examine the degree to which the actual rate converges to this fundamental rate. The fundamental rate is the rate empirically determined on the basis of key economic variables typically judged to influence the rate of housing supply.

Another difficulty in addressing the Irish market is the variability in supply observed over the past 20 years. Therefore, it becomes difficult to ascertain a long-run 'steady-state rate' of housing supply. One way to address this issue is to examine the likely supply response of the Irish market in a cross-country, European context. This enables any long-run rate to be determined on the basis of a relatively wide number of housing markets, many of which were not exposed to the volatility seen in the Irish case.

The rest of this article is structured as follows; in the next section we discuss recent trends in European housing investment. We then discuss the empirical approach adopted in the article followed by a counterfactual analysis whereby we determine the long-run fundamental investment rate based on our model. This rate is then compared with the actual rate of investment which enables us to determine the current rate of investment which should prevail in the Irish market. We then discuss the results from our models and finally conclude with some implications and policy recommendations.

Trends in European Investment

Figure A.1 shows residential investment rates for all of the countries in our sample. Most countries with the exception of three appear to have a relatively stable rate of investment from 2003 to 2014. It is clear that Spain, Greece and Ireland diverge substantially from the other countries with very high rates of residential investment from 2003 until 2007 being followed by a substantial decline in 2008. This large increase in housing supply is indicative of the housing bubble and subsequent bust that emerged in each of these countries.

The relatively high rate of investment in these countries is, in many respects, a function of the convergence towards the European average in living standards experienced by these countries from the 1990s onwards. Ireland, Spain and Greece had been amongst the poorest of EU Member States, and all three experienced a relatively late transition from agriculture, compared with the rest of Europe (Dellepiane et al., 2013). The convergence in each country's living standard from the mid-1990s was coupled with historically low interest rates resulting in these countries experiencing a rapid improvement in housing affordability. Changes in European international finance post-2000 meant that the high returns from the property sectors attracted large inflows of capital into these countries, the bulk of which went into construction-related activities. Eichengreen (2006) notes that the availability of new factors of production (whether in the form of human capital or financial capital) may result in an expansion of economic activity which is not easily translated into an upgrading of productivity. This is more likely to result in 'extensive' rather than 'intensive' growth in less developed economies. Consequently it was more profitable to invest in construction activities over other investments such as manufacturing or high-tech software development, or other traded services activities.

Empirical Approach

Long-run model

Given the highly volatile nature of the Irish housing market, we elect to estimate the likely residential supply response in a cross-country European context. This enables the estimates of our empirical approach to be as much influenced by markets, which have experienced relatively stable conditions, as those, such as Ireland's, which are of a less stable nature. In the empirical approach, we employ a two-stage methodology similar to McQuinn and O'Reilly (2007), Addison-Smyth et al. (2008) and Gattini and Ganoulis (2012). In the first stage we estimate the long-run determinants of the residential investment rate using a fixed effects OLS model. We then proceed to model the short-run dynamics using an error-correction model. The long-run model is estimated on an annual basis over the period 2003 to 2014 covering 12 Euro Area countries.[2]

To motivate our model and variable choice we consider both economic theory as well as some of the previous literature in this area. In particular we follow closely the methodology and variable choice set out in Gattini and Ganoulis (2012) who propose that residential investment depends on a set of parsimonious long-term fundamental variables that affect demand. As supply should equal demand in the long run, the investment rate depends on supply factors as well as demand factors. In particular, we specify the investment rate (rin) as a function of the following demand shifters: real house prices (rhp), GDP per capita (gdppc), the ratio of people in the 20 to 39 age cohort to total population (pop) and the real interest rate (rrat). We expect that house prices have a positive relationship with the investment rate. Figure A.2 (located in the Appendix) shows a simple linear regression of investment rates on house prices across all countries in our sample. It is clear that there is a positive upward sloping relationship between the two and this is consistent with the idea that as house prices rise, developers have more incentive to supply houses to the market and therefore the investment rate will increase.

GDP per capita should also have a positive relationship with the investment rate as greater overall wealth in the economy increases the demand for housing and therefore supply. We also expect that as the levels of population at the age where people are most likely to buy a home increases (20-39), the investment rate would also increase. Finally, the real interest rate or cost of financing should have a negative impact as higher rates increase the cost of borrowing for developers and lead to a reduction in the investment rate. This variable likely played a role in the huge increase in the investment rates observed in Ireland, Spain and Greece during the early 2000s. Figure A.3 shows that the real interest rates in these countries were actually negative in the late 1990s and early 2000s which would have facilitated construction-related borrowing.

More formally the long-run model of residential investment rates is expressed as follows:

$$\ln rin_{it} = \beta_0 \ln rhp_{it} + \beta_1 \ln gdppc_{it} + \beta_2 \ln pop_{it} + \beta_3 rrat_{it} + \sum_{\mathrm{i}}^{12} a_i D_i + \epsilon_{\mathrm{it}}$$

2 Data obtained from the AMECO database.

The model is a fixed effects panel model with all variables log transformed apart from rrat and $\mathrm{D_i}$ being the dummy for each country. Including dummy variables allows us to capture any unobserved cross-country heterogeneity that is constant over time. We apply a Hausman test[3] to motivate the use of fixed effects over a random effects model and the results are located in Table A.1.

Results

Our results from the long-run fixed effects model are presented in Table 1. The long-run relationship between the variables seems to coincide with standard economic theory. In particular, the investment rate is positively related to real house prices, income per capita and the ratio of the population in the young age cohort as we would expect. As all variables bar the interest rate have been log transformed, the coefficients represent long-run elasticities. All variables appear to be significant and are greater than one, indicating long-run elasticity between the independent and dependent variables. The results suggest, for example, that a one percentage point increase in house prices increases the long-run investment rate by 1.64 per cent. It appears that in the long run, the proportion of population in the 20-39 age cohort exhibits the largest effect on residential investment with a one percentage point increase in this population cohort increasing the residential investment rate in the long run by 2.86 per cent. This suggests demographics have an important role in determining the dynamics of residential investment in the Euro Area and Ireland, and is particularly relevant given expected demographic trends in Europe in the coming years.[4] As well as this GDP per capita is an important determinant for the long-run investment rate with the coefficient being greater than one.

The real interest rate variable is signed as hypothesised, negative, however, the variable is not significant; interest rates over the period in question were quite stable for the majority of countries and would not have differed significantly on a cross-country basis. Nonetheless, we retain the variable in our model for simulation purposes. In order to capture the potential differences across countries we include dummy variables for each of the countries in the sample. In particular, including these dummies ensures that our model satisfies the Gauss Markov assumptions and is the best linear unbiased estimator. Since our model includes a dummy variable for all countries, we drop the constant term from our regression. As a result, the individual country dummies now represent separate

3 See Hausman, J.A., 1978. 'Specification Tests in Econometrics,' *Econometrica*, Econometric Society, Vol. 46(6), pp. 1251-71, November.

4 See McQuinn K. and K. Whelan, 2015. 'Europe's Long-Term Growth Prospects: With and Without Structural Reforms,' Working Papers 201508, School of Economics, University College Dublin

intercept terms or equivalently the expected value of the log of the residential investment rate when our independent variables jointly equal zero. It is clear that in the absence of our explanatory variables the long-run residential investment rate for all countries rate is lower, again highlighting the relevance of these variables.

Table 1 Long-run Model of Cross-country Residential Investment Rates

Variable	Parameter	Estimate	T-Stat
$ln\ rhp_{i,t}$	β_0	1.64	8.56
$ln\ gdppc_{i,t}$	β_1	1.17	2.44
$ln\ pop_{i,t}$	β_2	2.86	7.04
$rrat_{i,t}$	β_3	-1.24	-1.01
Additional Controls			
Belgium	α_1	-10.57	-7.74
Germany	α_2	-10.67	-7.90
Ireland	α_3	-11.48	-8.28
Greece	α_4	-10.34	-8.72
Spain	α_5	-10.37	-8.48
France	α_6	-10.43	-7.77
Italy	α_7	-10.52	-8.11
Luxembourg	α_8	-12.59	-7.57
The Netherlands	α_9	-10.92	-7.77
Austria	α_{10}	-11.15	-8.10
Portugal	α_{11}	-10.34	-9.05
Finland	α_{12}	-10.49	-7.55
N		144	
R2		0.81	
F-Test		0.00	

Note: Estimated over the period 2003 to 2014.

Counterfactual Analysis

Next we conduct our counterfactual analysis where we present the actual and *fundamental* investment rate based on our long-run model for each of the 12 countries. The fundamental rate of investment consists of the level of investment that can be explained reasonably due to supply and demand factors. Our long-run model thus captures the dynamics of the residential investment that can be attributed to these factors. We can then compare the fundamental rate i.e. the fitted values from the model with the actual ratios observed in the data. This allows us to assess whether the actual investment rate is in line with what the key fundamental variables in the market over the period would suggest it should be. This kind of analysis can be useful in detecting for the presence of disequilibria in markets and in particular, in housing, assessing whether prices have diverged significantly from fundamentals.

As noted previously, over the period 2003-2007 there was a substantial difference in the actual and fundamental Irish investment rate, suggesting the presence of a bubble in residential construction. This is not surprising as a number of studies[5] have examined the potential presence of disequilibrium in the Irish market over this period. However, what is notable from the residential investment results is that the bubble existed even when allowing for actual house price levels i.e. the fitted value used to generate the fundamental rate is based on actual house prices. Even with the highly elevated and ultimately unsustainable nature of Irish house prices, the domestic construction sector still supplied more housing than economic conditions suggested. Therefore, it is interesting to explore the implications for the residential investment rate of the acknowledged deviation between Irish actual and fundamental house prices during this period.

There would appear to be two different experiences amongst the countries for the period in question (i) countries such as the Netherlands, Spain and Finland where developments in the residential market appeared to unfold very much in accordance with what key economic variables in those markets would suggest (Figures A.4, A.5, A.6 in Appendix) and then (ii) the remaining countries; Ireland, Greece, Portugal Belgium, Germany, France, Italy, Luxembourg and Austria where there were periods of sizeable differences between the actual and fundamental rate.

In the cases of Ireland, Greece and Portugal there appeared to be an investment bubble in the period preceding the financial crisis of 2007; the actual investment rate was significantly higher than what key economic factors would suggest it should have been. This is particularly interesting in the Irish context where actual house prices (a key right hand side variable) were also commonly regarded[6] as being overvalued during this period. By contrast, for the larger European countries, Germany, Italy and France, residential investment appeared to be quite subdued during the same period as the fundamental rate is quite a bit larger than what actually transpired in those markets.

If we look closely at the results of the analysis on the Netherlands (Figure A.4), we can see a stark difference vis-à-vis Ireland's results. Although we observe a

[5] See Kelly and McQuinn (2014) for a summary of these.
[6] See Honohan (2010) for more on this.

decrease in investment rates post-2008 we find that there is very little deviation between fundamentals and the actual investment rate through the entire sample. This suggests that the residential investment rate is mainly driven by fundamental factors, which is in contrast to Ireland's position. The lack of divergence between actual and fundamental rates of investment up to the present could be a result of strict land use policies in the Netherlands which limits the supply of new housing. As well as this, Vermeulen and Rowendal (2007) found that in the short run, the supply of housing in the Netherlands is nearly entirely inelastic making it significantly more difficult for an oversupply of housing to occur.

Impact of Fundamental House Prices

In the previous section the fundamental investment rate was solved for on the basis of the *actual* house price. However, we now examine the implications of where the model is solved for on the basis of a 'fundamental' house price.

To arrive at a fundamental house price, we use the fitted values from a standard house price model, popular in the international literature. The approach, which can be observed in an Irish context in Addison-Smyth and McQuinn (2015) and Kelly and McQuinn (2014), involves inverting the demand function for housing and rearranging such that the dependent variable is now the price of housing as opposed to the quantity. Similar applications can be observed in Cameron et al. (2006), Muellbauer and Murphy (1997), Muellbauer and Murphy (1994), Meen (1996, 2000), Peek and Wilcox (1991). The model, which assumes that the demand for housing services is proportional to the housing stock, can be derived, in log linear fashion, as follows:

$$ln\left(\frac{h}{pop}\right) = a_1 ln\left(\frac{y}{pop}\right) - a_2\, ln\, rent + a_3 ln\, pop$$

where h is the housing stock, pop is the population level, y is disposable income and $rent$ is the real rental rate of housing in the economy. The coefficients a_1 and a_2 are the income and price elasticities of demand for housing. In equilibrium, the real rental rate of housing can be assumed to be equal to the real user cost. This can be outlined as follows:

$$p\left(r - \frac{p^e}{p}\right) \equiv p \times uc$$

where r is the mortgage interest rate, p is house prices, e denotes expectations and uc is the user cost of housing. While expressions for the user cost can be augmented to include taxation considerations and expenditure rates of maintenance and repair, very often the main determinants of the expression are the mortgage rate and expected house price inflation.[7] Thus, solving the two previous equations provides the following inverted demand equation for housing:

$$ln\,p = \frac{a_1}{a_2} ln\left(\frac{y}{pop}\right) - \frac{1}{a_2} ln\left(\frac{h}{pop}\right) - ln\,uc + \frac{a_3}{a_2} ln\,pop$$

House prices are positively related to real income per capita and population levels and negatively related to the per capita housing stock and the user cost of capital.

The actual and fitted values for the house price model are shown in Figure A.16.[8] In McQuinn (2014), the results are compared with those of three other house price models. In general, as can be seen from McQuinn (2014), the overall result concerning the degree of over/undervaluation is quite similar across the models in question. Therefore, we are not concerned that the estimated housing market disequilibria are unduly *model-specific*.

From the results of our *fundamental* house price model (Figure A.16), it is clear that actual house prices far exceeded fundamental levels in the early 2000s with peak divergence observed in 2006. Prices then had a precipitous decline in 2008 leading to an extended over correction where they remain below *fundamental* levels at present. This is consistent with the housing bubble Ireland faced in the 2000s where price levels diverged significantly from what can be considered sustainable levels.

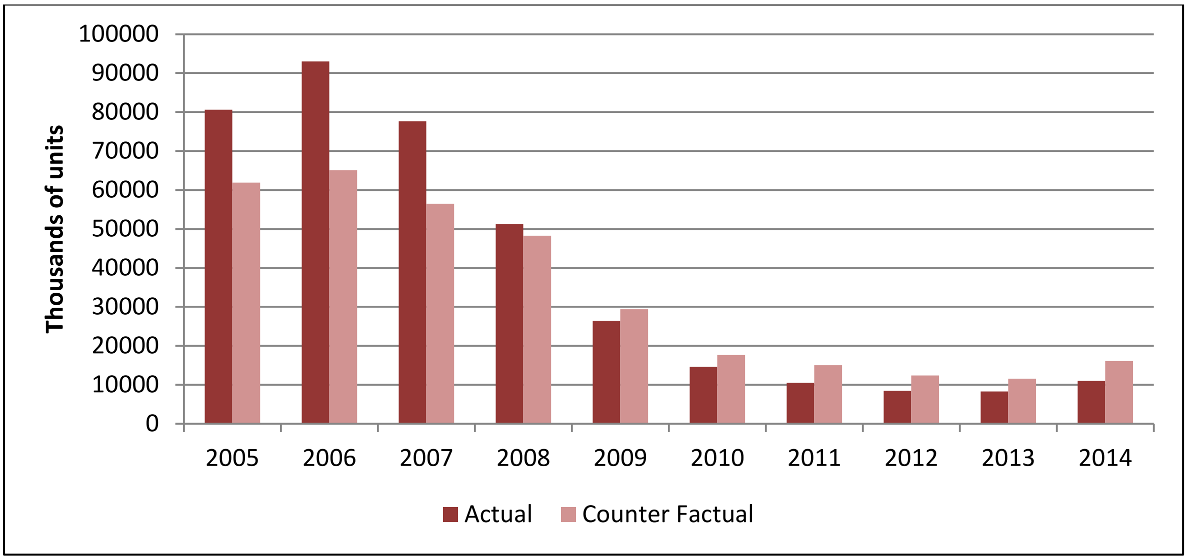
Using our *fundamental* house price model above we next substitute our predicted values from this into our long-run residential investment model. Doing this allows us to present a counterfactual scenario whereby we quantify the *fundamental* level of housing units and compare this to the actual current level observed. Looking at Figure 1 implies that the actual level of housing units in the periods 2005-2007 were far higher than the levels implied by *fundamentals*. This is again consistent with the observed housing boom and means that there was a large glut of housing in the market leading up to the crisis. Perhaps more interesting is what we observe after 2008. There was an over correction and housing supply was consistently below levels implied by our model. In 2014 for

7 In calculating the user cost expression, Kelly and McQuinn (2014) use a variety of different house price expectations mechanisms, however they find that their results do not change on the basis of the different assumptions.

8 Full regression results are available, upon request, from the authors.

example, the model suggests we should have somewhere in the region of 16,000 housing units being supplied where in reality there were only 11,000. Although somewhat smaller than estimates obtained from other studies of 25,000 per annum,[9] it is consistent with the overall notion that Ireland is simply not producing enough houses to meet current demand. These results have important implications for Ireland at the moment given the recent surge in rents (9 per cent over the last year)[10] observed in Dublin, which seems to be driven by the consistent under-supply.

FIGURE 1 Supply of Housing Units Actual vs. Fundamental



Source: Authors' own calculation.

Short-Run Residential Investment Model

Given the degree of disequilibrium observed across the different European countries, we also examine the extent to which actual residential investment rates converge back to their long-run rates. To do this we employ an error-correction framework. It is first necessary to check for the presence of unit roots in the data. We then check that all variables are integrated of the same order before proceeding to co-integration tests. We use tests that are specifically designed for panel data. In particular, to test for unit roots we use both the Im, Pesaran, Shin test and the Harris-Tzavalis test. To test for co-integration we use the Kao test. Our tests conclude that the variables are non-stationary at levels and are co-integrated with the results presented in Table A.2. Accordingly, we specify the following error-correction model:

9 Duffy et al., 2014. Estimates based on structural demand.
10 PRTB/ESRI Quarter 4 2015 Rent Index. Available from: www.esri.ie/pubs/RI2015Q4.pdf.

$$
\begin{aligned}
\Delta\ ln\ rinv_{it} \\
&= \lambda(\ln rinv_{it-1} - \beta_0 \ln rhp_{it-1} - \beta_1 \ln gdpcc_{it-1} \\
&- \beta_2 \ln pop_{it-1} - \beta_3 rrat_{it-1}) + \sum_{i=1}^{2} \theta_i \Delta \ln \mathrm{rinv_{it-i}} \\
&+ \sum_{i=0}^{2} \theta_{i+3} \Delta \ln rhp_{it-i} \\
&+ \sum_{i=0}^{2} \theta_{i+6} \Delta \ln gdppc_{it-i} + \sum_{i=0}^{2} \theta_{i+9} \Delta \ln pop_{it-i} \\
&+ \sum_{i=0}^{2} \theta_{i+12} \Delta \ln rrat_{it-1} + u\_t
\end{aligned}
$$

where the long-run rate is based on the results from the fixed effects model and the error-correction term can be interpreted as the residuals in time $t-1$. We estimate the short-run model with both OLS and fixed effects results.

The results for the error-correction model are located in Table 2. We present the error-correction model using both long-run models, i.e. the OLS and fixed effects model's lagged residuals are used to calculate the short-run error-correction model. In both cases, the sign of the coefficients on $ect_{i,t-1}$ is negative as we would expect given that theory suggests that this term adjusts the dependent variable back towards equilibrium. The degree of error-correction is very similar at 29 and 24 per cent in both models. Given that this term also shows the speed at which adjustment takes place, this suggests that any deviation between actual and fundamental rates takes approximately four years to close. The results of the F-test indicates that the OLS specification is warranted in this case, thereby suggesting that country-specific factors are important in explaining cross-country differences in the investment rate in the long run but not in the short run.

TABLE 2 Short-run Cross-country Residential Investment Rate models

Variable	Parameter	Estimate (OLS)	T-Stat	Estimate (Fixed effects)	T-Stat
$ect_{i,t-1}$	λ_0	-0.29	-3.88	-0.24	-2.94
$\Delta \ln rinv_{i,t-1}$	θ_1	0.42	3.46	0.31	2.28
$\Delta \ln rinv_{i,t-2}$	θ_2	0.25	2.01	0.15	1.05
$\Delta \ln rhp_{i,t}$	θ_3	0.88	2.16	0.89	1.97
$\Delta \ln rhp_{i,t-1}$	θ_4	0.28	0.72	0.39	0.95
$\Delta \ln rhp_{i,t-2}$	θ_5	0.19	0.52	0.39	0.96
$\Delta \ln gdppc_{i,t}$	θ_6	0.45	1.81	0.38	1.38
$\Delta \ln gdppc_{i,t-1}$	θ_7	0.24	0.86	0.36	1.17
$\Delta \ln gdppc_{i,t-2}$	θ_8	-0.26	-1.03	-0.24	-0.91
$\Delta \ln pop_{i,t}$	θ_9	3.80	1.47	3.22	1.11
$\Delta \ln pop_{i,t-1}$	θ_{10}	-3.24	-0.92	-2.47	-0.68
$\Delta \ln pop_{i,t-2}$	θ_{11}	-2.03	-0.83	-2.25	-0.87
$\Delta \ln rrat_{i,t}$	θ_{12}	0.56	0.77	0.78	1.02
$\Delta \ln rrat_{i,t-1}$	θ_{13}	-1.65	-2.08	-1.51	-1.82
$\Delta \ln rrat_{i,t-2}$	θ_{14}	-2.15	-2.58	-2.02	-2.33
N			108		108
R2			0.65		0.63
F-Test (Fixed Effects)					0.35

Note: Estimated over the period 2003 to 2014.

Conclusion

Over the period 1995 to 2007 it is estimated that the Irish economy, as measured by real GDP, more than doubled in size. The unemployment rate fell from 8.5 per cent in Quarter 1, 1998 to 4.2 per cent in the first quarter of 2005. Apart from a short interruption in 2001, the Irish housing market grew significantly during this period. This growth is reflected not only in house prices but also in other indicators which show a huge expansion of activity levels within the market. Post-2007 the housing market experience has been very different. House prices declined substantially by almost 50 per cent, and housing supply, which reached a peak of 93,000 units in 2006, fell back to approximately 10,000 levels by 2011.

It is therefore of great interest to understand the mechanics behind residential investment. This Special Article attempts to analyse the dynamics of residential investment throughout selected European countries from the period 2003 to 2014. Our empirical strategy consists of two stages whereby we measure both the long-run and short-run dynamics by means of a fixed effects and error-correction model. Our analysis finds that residential investment can be well described by a set of fundamental factors affecting demand in the long run. We find a significant positive impact caused by real GDP per capita, real house price, as well as the ratio of population aged 25-39 to total population. As well as this, co-integration analysis indicates that that there is error-correction of between 25 and 29 per cent per year, meaning that it takes approximately four years for residential investment to return to equilibrium following a shock to one of the endogenous variables. Our counterfactual analysis suggests that actual levels of investment in Ireland were far above levels necessary in the early 2000s and at present are below the level suggested by fundamentals. Finally, in terms of housing units, our model implies that we are below the level that is currently needed at present and this has important policy implications.

The housing supply problem in Ireland is very clear when one considers that as of 1 February 2016 there were only 3,600 rental homes available on the market across the country.[11] With rents having risen 43 per cent since the low in 2010, this shortage has certainly been a major factor in the observed increases. As well as this, there has also been a consistent shortage in housing for sale with data showing as of December 2015 only 25,000 homes on the market.[12] Morgenroth (2014) notes that the need for housing in Ireland is not spread evenly throughout the country. He estimates that 60 per cent of the required additional housing is needed in Dublin with much of the rest being needed in the Dublin commuter belt and other large cities. Given that average total annual housing completions since 2011 is just over 10,000,[13] this implies that the amount of house being built is not even enough to meet the demand for additional housing in Dublin, let alone the rest of the country.

There are however, a variety of potential policy measures that can be undertaken in order to alleviate this problem. Morley et al. (2015) survey various housing supply measures that have been undertaken over the years in a variety of countries. For example, they review the use of a land value tax in Denmark. The value of this tax increases with the price of land and therefore provides an incentive for landowners to release this land for development at a time when it is demanded. As well as a land tax, the authors also discuss solutions in relation to planning regulations such as minimum space requirements for housing as well as the timeframe of the planning process. While relatively successful in other countries, it is unclear how some of these policies would work if applied in Ireland. It is therefore worth conducting more research into the potential effectiveness of these policies in the Irish housing market.

11 Lyons, R., 2016. 'Daft Q4 2015 Rental report'.

12 Lyons, R., 2016. 'Daft Q4 2015 house price report'. Available at: www.daft.ie/report/q4-2015-houseprice-report-daft.pdf.

13 Based on data from the Department of the Environment, Community and Local Government, Housing Statistics.

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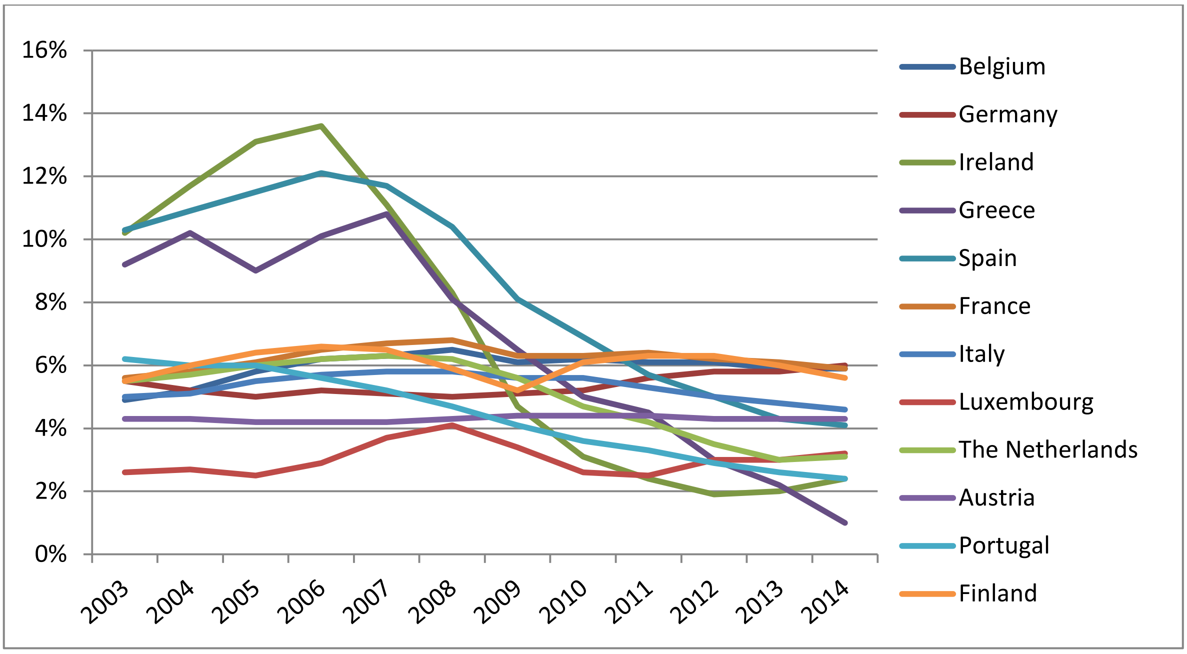
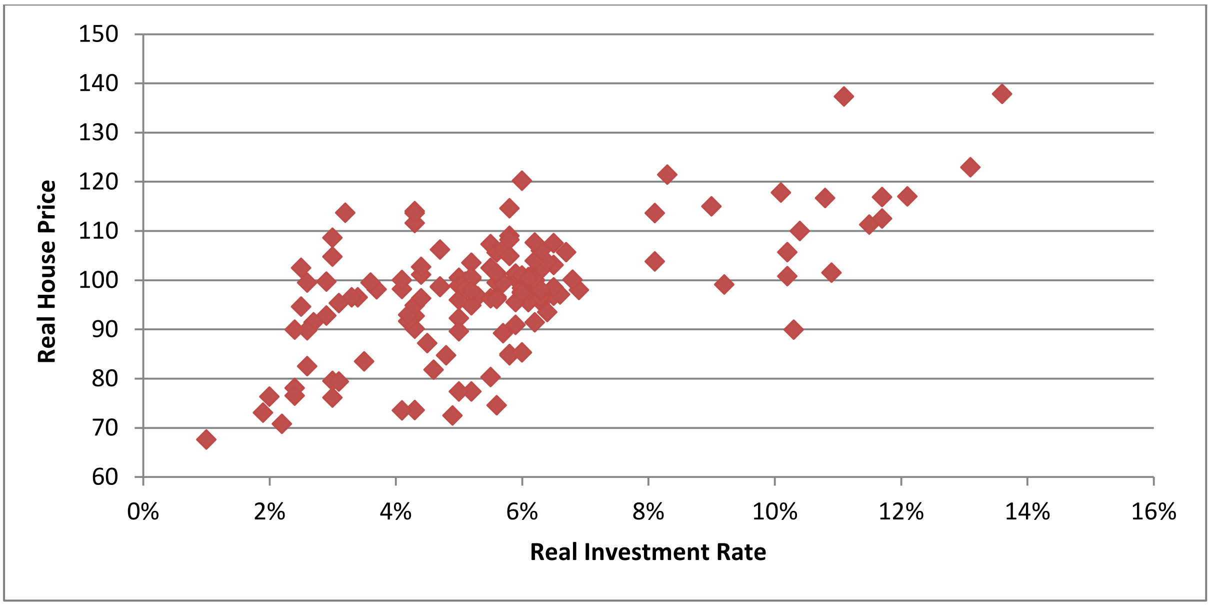
Appendix

FIGURE A.1 Residential Investment Rates



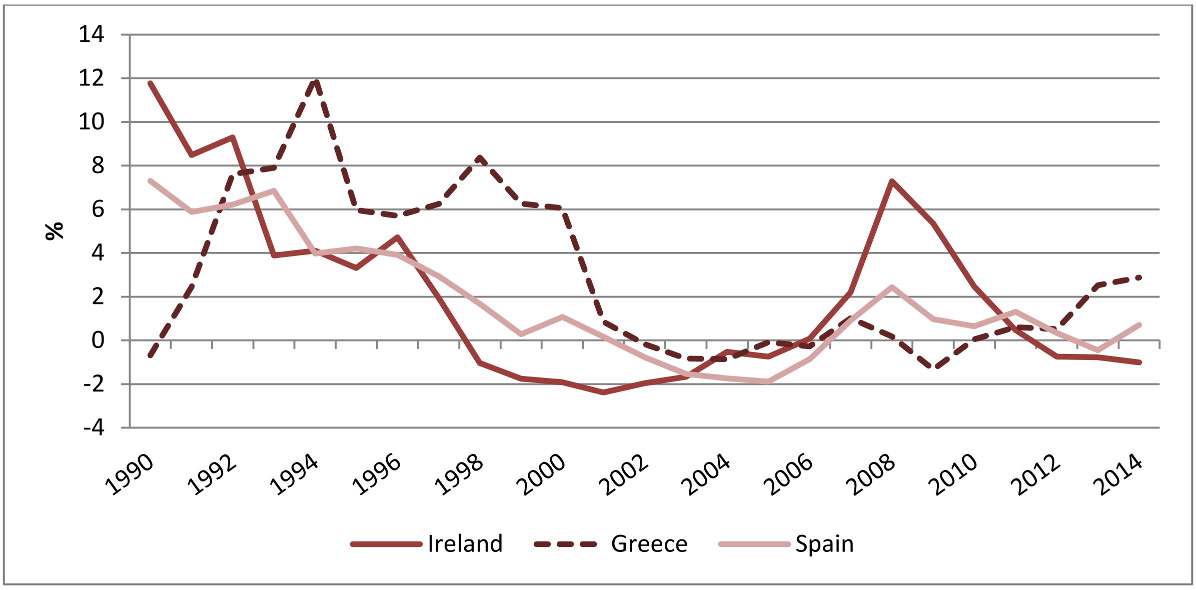
Source: Ameco.

FIGURE A.2 Correlation of House prices and Investment Rates



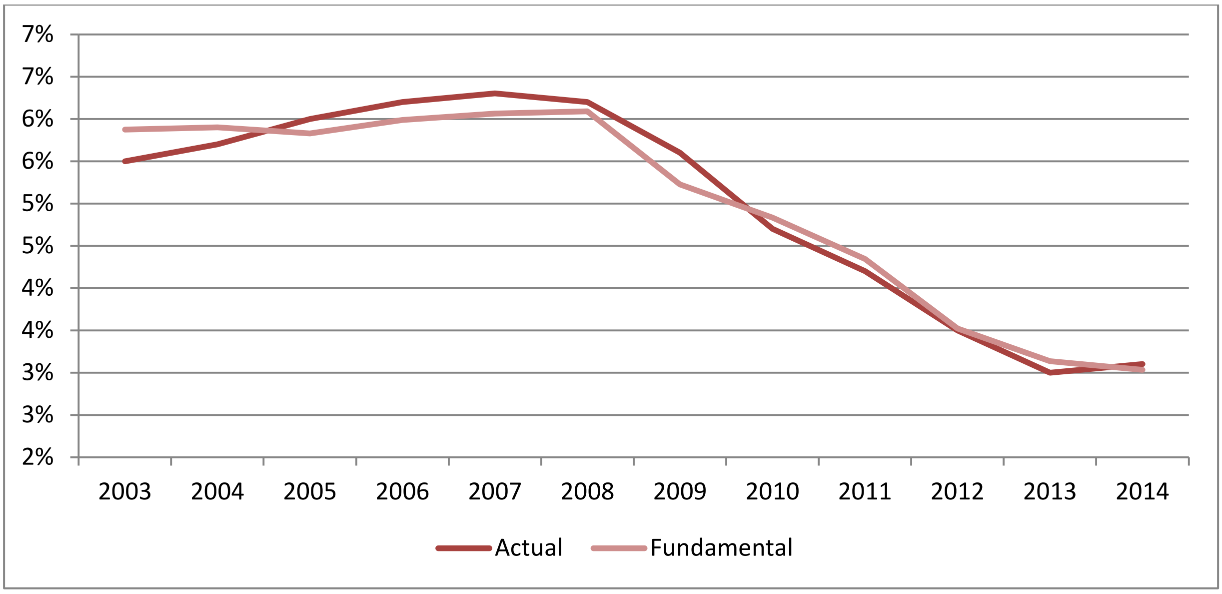
Source: Authors' own calculations.

FIGURE A.3 Real Interest Rates



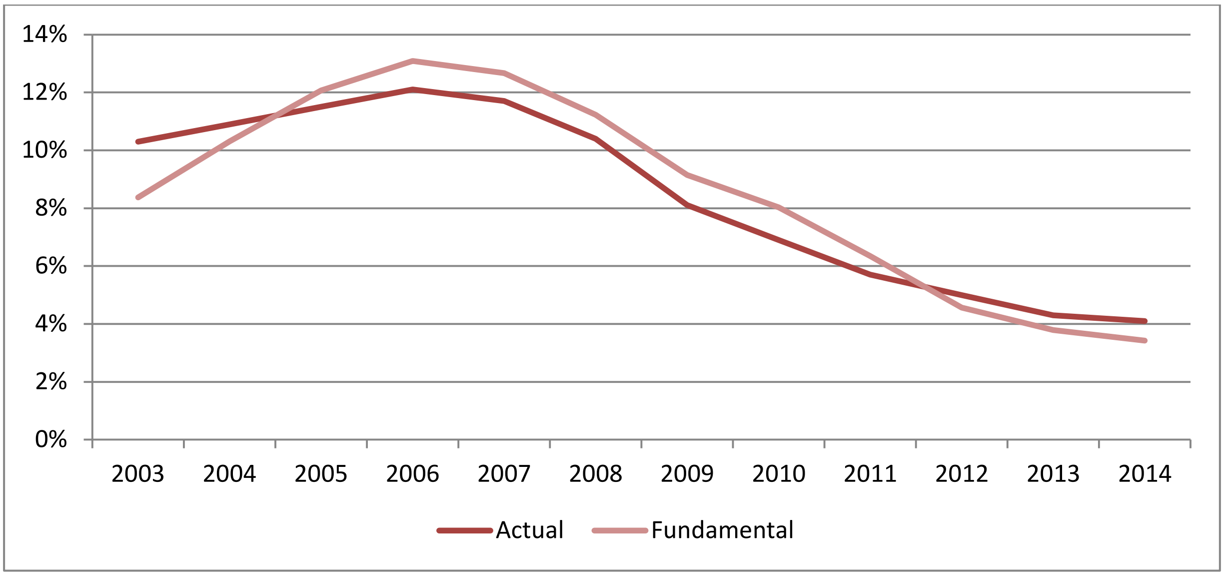
Source: Ameco.

FIGURE A.4 Actual vs Fundamental Investment Rate the Netherlands



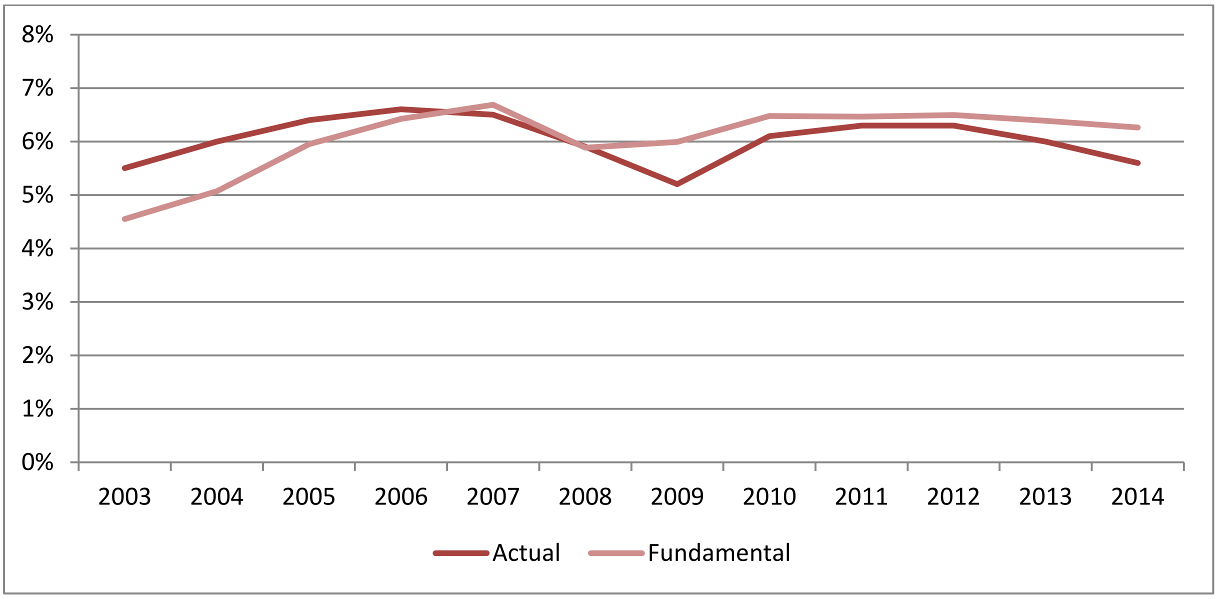
Source: Authors' own calculations.

FIGURE A.5 Actual vs Fundamental Investment Rate Spain



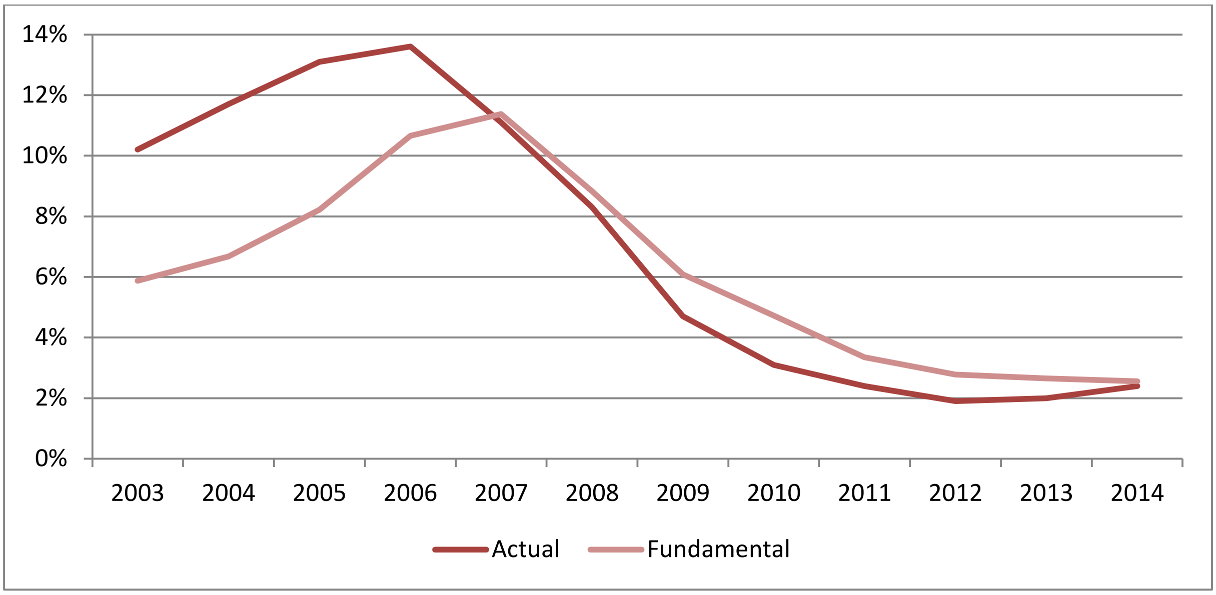
Source: Authors' own calculations.

FIGURE A.6 Actual vs Fundamental Investment Rate Finland



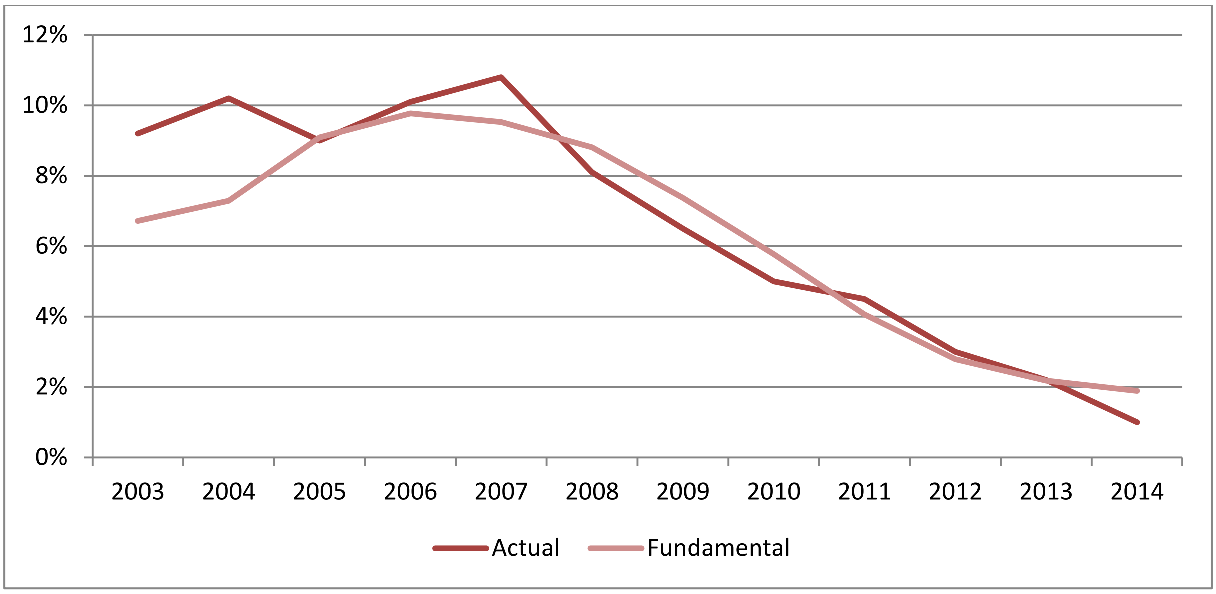
Source: Authors' own calculations.

Figure A.7 Actual vs. Fundamental Investment Rate Ireland



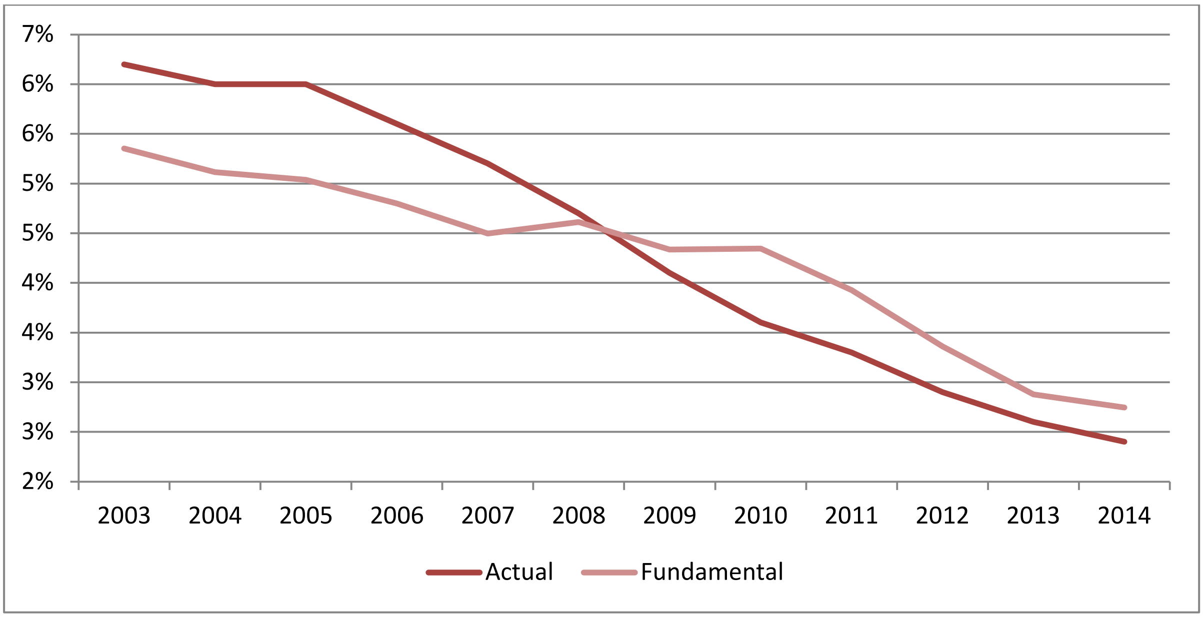
Source: Authors' own calculations.

Figure A.8 Actual vs Fundamental Investment Rate Greece



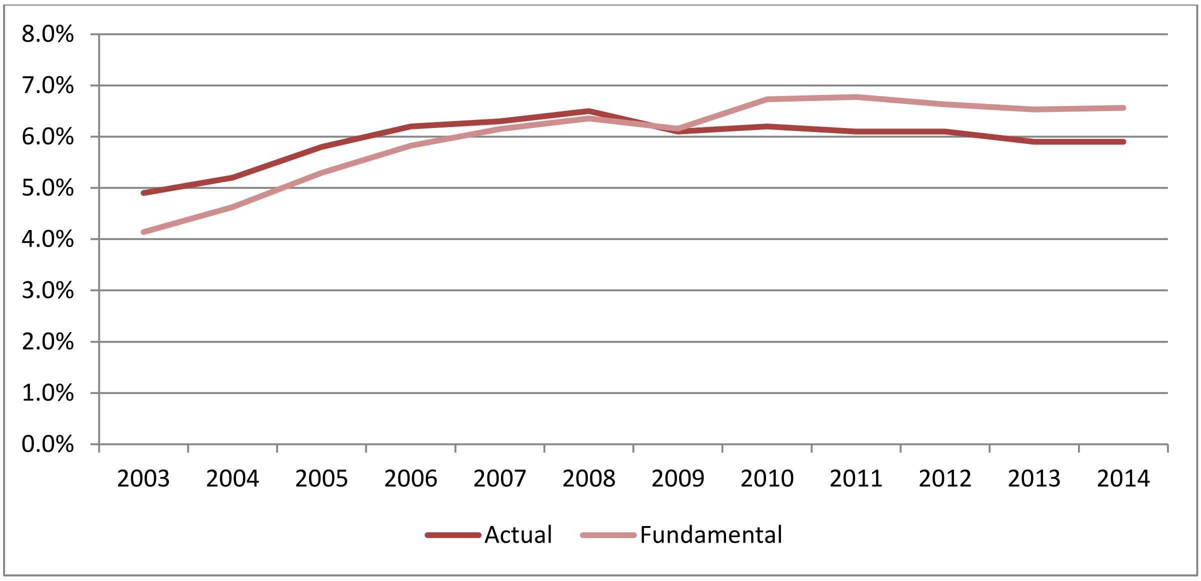
Source: Authors' own calculations.

FIGURE A.9 Actual vs Fundamental Investment Rate Portugal



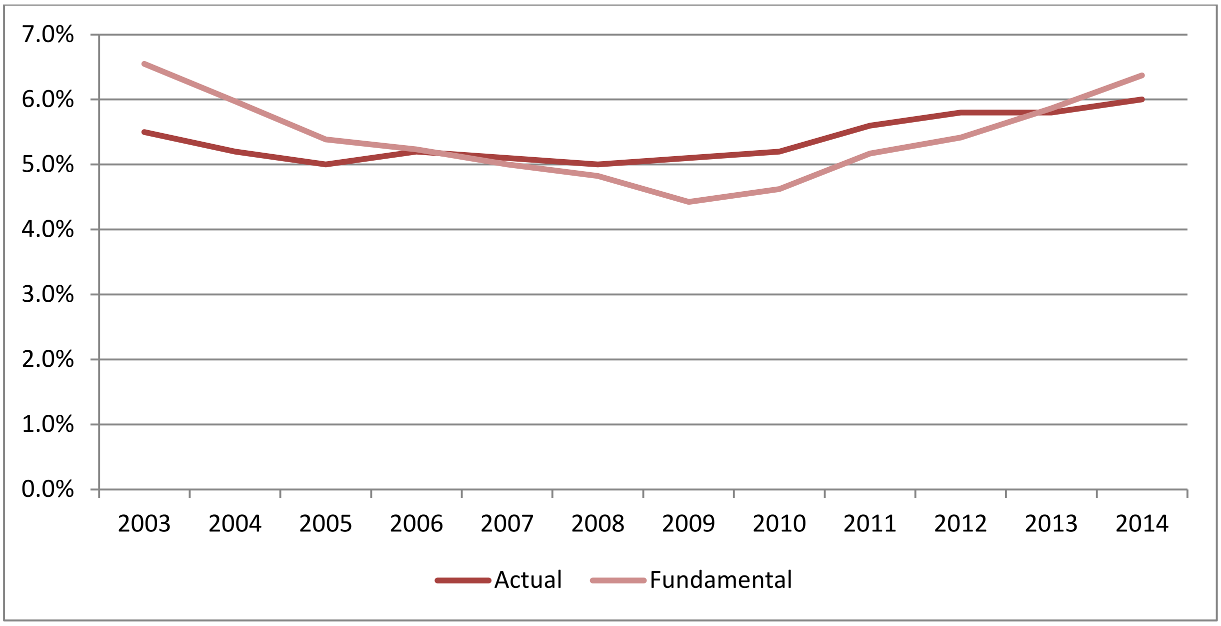
Source: Authors' own calculations.

FIGURE A.10 Actual vs Fundamental Investment Rate Belgium



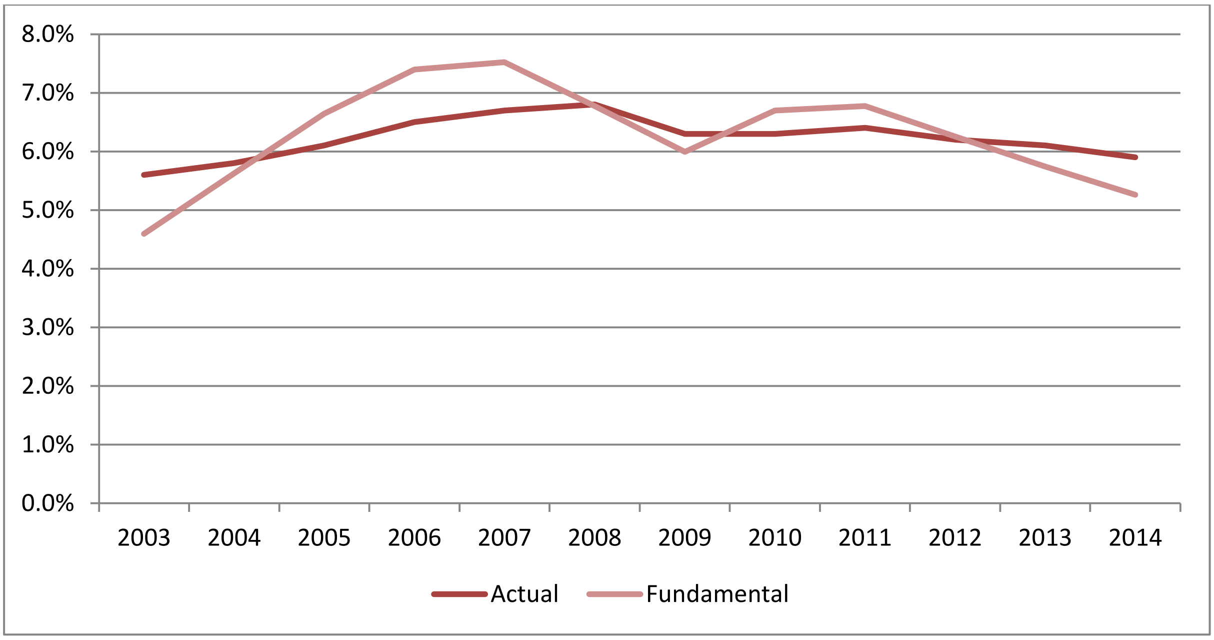
Source: Authors' own calculations.

Figure A.11 Actual vs Fundamental Investment Rate Germany



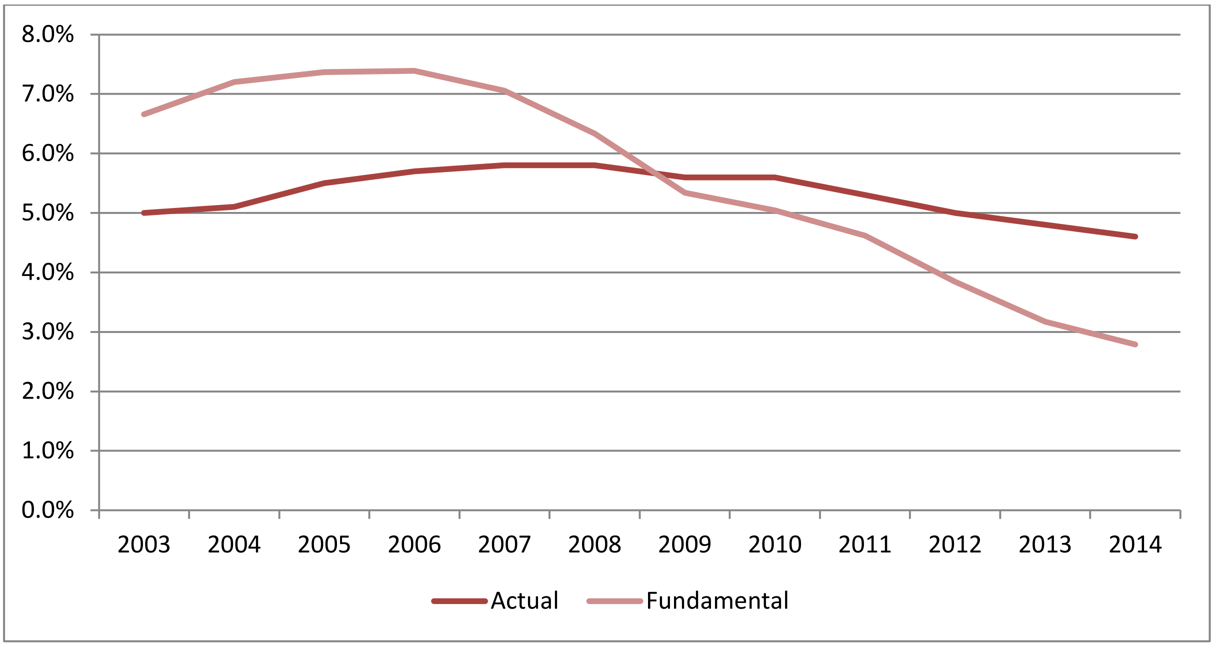
Source: Authors' own calculations.

Figure A.12 Actual vs Fundamental Investment Rate France



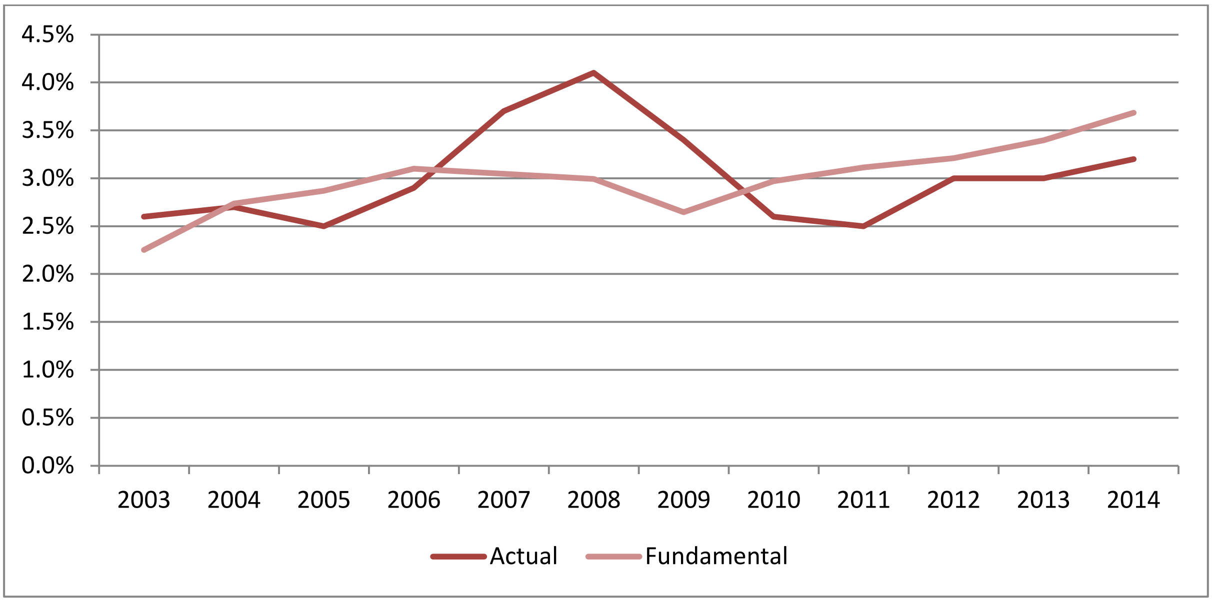
Source: Authors' own calculations.

FIGURE A.13 Actual vs Fundamental Investment Rate Italy



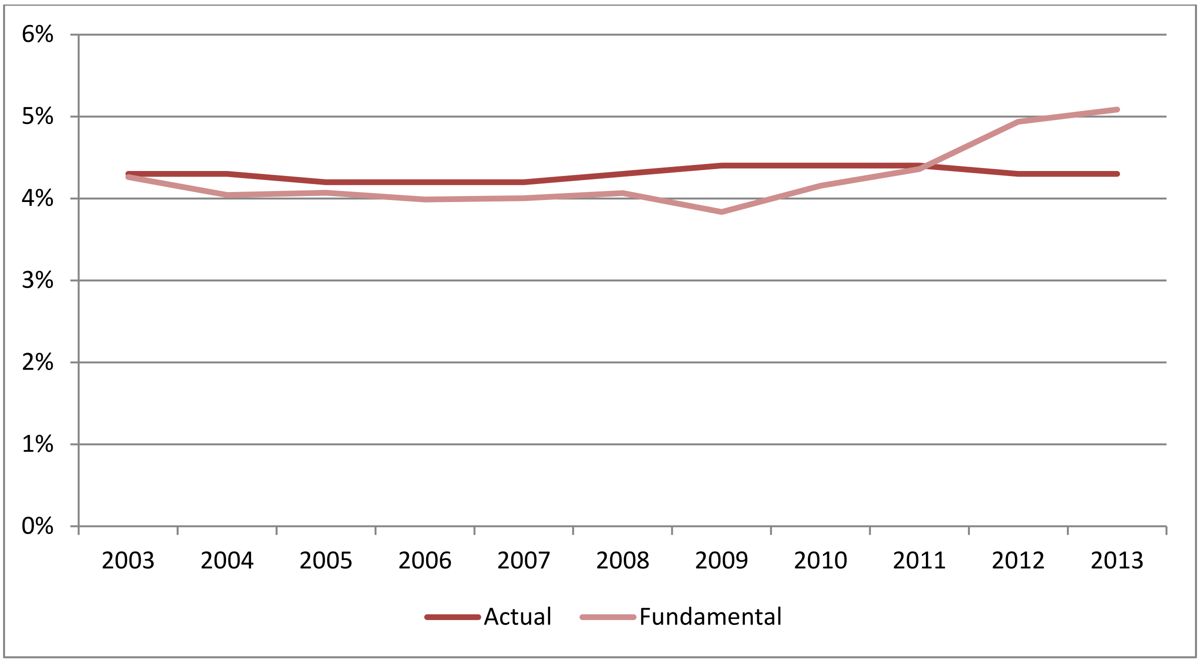
Source: Authors' own calculations.

FIGURE A.14 Actual vs Fundamental Investment Rate Luxembourg



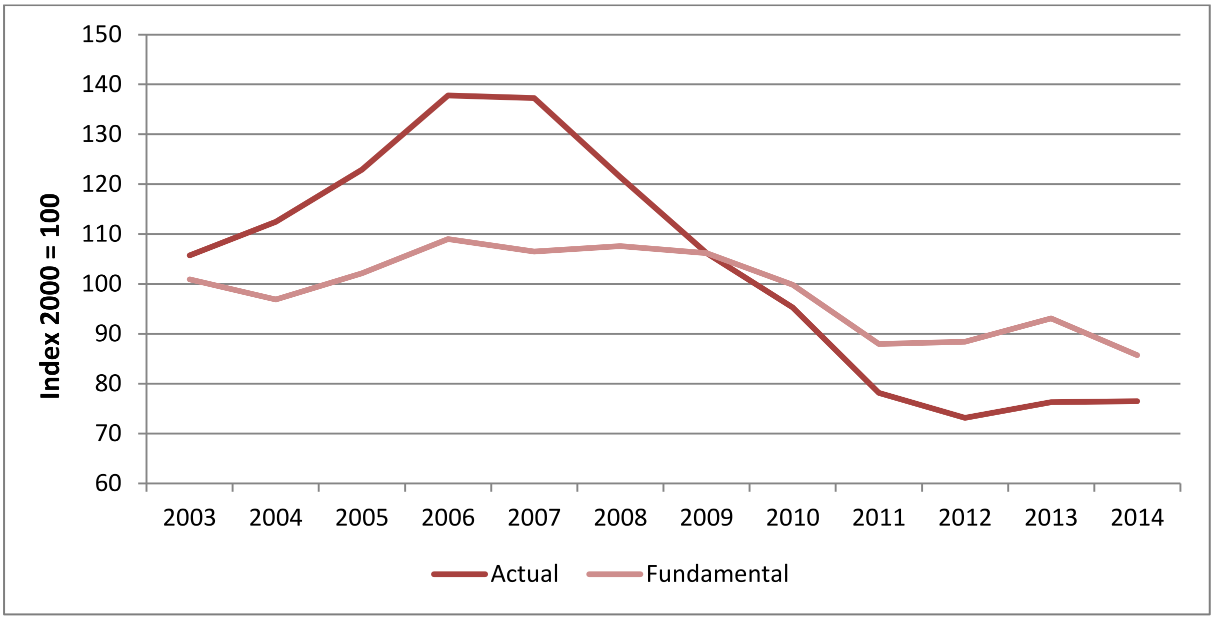
Source: Authors' own calculations.

FIGURE A.15 Actual vs Fundamental Investment Rate Austria



Source: Authors' own calculations.

FIGURE A.16 Actual vs. Fundamental House Prices Ireland



Source: Authors' own calculations.

TABLE A.1 Hausman Test Fixed effects vs. Random effects

Hausman Test	Statistic	P-value
Result	79.36	0.00

Note: Random effects model, H_1 : Fixed effects model.

TABLE A.2 Unit Root Test Results

Test Type	Harris-Tzavalis		Im, Pesaran, Shin	
Variable	Statistic	P-value	Statistic	P-value
$rinv$	0.963	0.148	-1.144	0.126
$rgdppc$	0.635	0.059	-0.511	0.305
rhp	0.946	0.996	-0.622	0.267
$ryoungpop$	1.009	0.596	1.192	0.883
$rrate$	0.654	0.095	-1.132	0.129

Note: H_0: Panel contains unit root. H_1 : Panel is stationary.

TABLE A.3 Panel Co-integration Test Results

Kao Test	Statistic	P-value
Result	-5.344	0.000

Note: H_0: No Cointegration . H_1 : Cointegration