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Modeling the Housing Market in OECD Countries

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ABSTRACT

Recent episodes of housing bubbles, which occurred in several economies after the burst of the United States housing market, suggest studying the evolution of housing prices from a global perspective. We utilize a theoretical model for the purposes of this contribution, which identifies the main drivers of housing price appreciation—for example, income, residential investment, financial elements, fiscal policy, and demographics. In the second stage of our analysis, we test our theoretical hypothesis by means of a sample of 18 Organisation for Economic Co-operation and Development (OECD) countries from 1970 to 2011. We employ the vector error correction econometric technique in terms of our empirical analysis. This allows us to model the long-run equilibrium relationship and the short-run dynamics, which also helps to account for endogeneity and reverse-causality problems.

1. INTRODUCTION

Financial deregulation was initiated by the vast majority of the developed and developing countries beginning in the early 1970s. This new era was characterized by a spectacular expansion of the financial system, which created new opportunities for the banking sector. Financial institutions compensated for the decreasing returns from their traditional business, i.e., financing of firms' productive activities, by exploring new alternatives, for instance, providing loans to households and also loans for risky investments, like for example subprime mortgages. Under this umbrella called "financialization," there is room for asset bubbles, as for example, the one in the housing market that preceded the August 2007 financial crisis, in a considerable number of Organisation for Economic Co-operation and Development (OECD) economies.

By focusing our attention on the collapse of the US housing market in August 2007, some differences emerge between this episode and previous bubbles in the housing market: (1) the size and the length of the upward trend of housing price appreciation; (2) global synchronization across several economies; (3) the separation between the dynamics of housing prices and the evolution of the housing cycle; (4) the decline in housing prices, which can bring the adjustment in the market, could be higher than in previous cases due to the stickiness of nominal housing prices and the existence of low inflation levels (see OECD 2005). All these features suggest the importance of conducting an analysis of the dynamics of the housing market by means of time series analysis in those countries where the housing cycle was synchronized.

We begin by proposing a theoretical explanation of housing prices that introduces the role of such basic fundamentals of this market as disposable income, real residential investment, mortgage rates, and demographics. Our model also accounts for the behavior of monetary authorities by including credit standards. Moreover, in our model specification, we analyze the public sector's use of taxation. We then proceed to test the validity of our theoretical model by applying cointegration analysis (Johansen 1995), on a sample of 18 OECD economies for the period 1970–11. Our econometric results demonstrate the existence of a long-run relationship among the variables and capture adjustments in the short run by means of a vector error correction model (VECM)—also accounts for endogeneity and reverse causality problems.

The remainder of this paper is organized as follows: Section 2 presents a review of those contributions relevant to our theoretical model. Section 3 discusses the econometric

techniques employed. Section 4 reviews the data and Section 5 presents the estimations undertaken for this study. Section 6 compares our results with other contributions to the literature. Finally, Section 7 summarizes and concludes.

2. LITERATURE REVIEW OF VARIABLES OF INTEREST

An external shock in demographics, income or changes in the behavior of fiscal or monetary authorities modifies households' preference for housing. This change provokes a disequilibrium, which is absorbed by prices, since the supply of housing is fixed in the short run. The existence of a new level of housing prices creates an incentive to property developers to alter the supply of housing over a longer period. As a result, there is a change in the flow of new residential assets, which modifies the supply of housing. At the same time, a strong effect in terms of unemployment and income emerges, which is related to construction activities. In this context, households determine the volume of housing assets that they desire to acquire and apply for bank credit to enable them to purchase these assets. Changes in housing prices modify the share of households who are able to enter the market, which finally affects the demand for housing and "feeds" this cycle. The system collapses when the banking sector perceives a high level of households' indebtedness that induces a tightening of credit standards and increases in interest rates since borrowers' risks are higher. As a result, there is a decline in housing demand and market adjustment emerges until a new position of equilibrium is reached.

In this context, the main determinant of housing prices is real disposable income, Y_D. More precisely, the demand for housing is driven by the affordability of housing, which is defined as the income-to-price ratio (OECD, 2005).[1] Any increase in households' income that makes it more affordable to purchase a home fuels demand for housing and induces an increase in housing prices appreciation since the supply of housing is fixed in the short run. This positive effect, which emanates from income, has also been identified by earlier research, for example, Bover (1993), Poterba (1984) and Klyuev (2008) among others.

The supply side of the housing market is also important in the determination of housing prices, i.e., the role of real residential investment, I_R, has to be considered.[2] The role that this element plays in the determination of housing prices varies depending on the time

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[1] The price-to-income ratio can be utilized as an indicator of housing prices overvaluation. Specifically, a strong deviation between this ratio and its long-run average could suggest the development of a bubble in this market (OECD 2005).
[2] Real residential investment captures the flow of real estate assets, which are produced during a given time period (Nobili and Zollino 2012).

horizon under consideration. In the short run, the housing market displays peculiar dynamics, i.e., quantities and prices move in the same direction (Igan and Loungani 2012). More specifically, an increase in real estate investment exerts a positive effect on house price appreciation. This is due to the fact that increasing households' desire to purchase housing assets increases the demand for housing. This hike in demand drives housing prices up since the supply of housing is fixed over this time horizon. This positive relationship is maintained until the point is reached where property developers increase the production of housing and homeowners start to sell their assets in order to capture the extraordinary capital gains that are produced by the high housing prices. As a result, there is an increase in the supply of housing, which curbs house price appreciation.

The relevance of the positive effect of the volume of bank credit, C_B, on housing prices cannot be ignored.[3] The volume of bank credit is a reflection of the credit standards, which the central bank establishes by means of prudential policy. Commercial banks have to identify credit-worthy demand according to the conditions defined by the central bank and must be willing to provide mortgages, which derive from the solvent demand for credit at the rate of interest established by the monetary authorities.[4] Credit standards and the cost of external finance are determined by considering the value of households' collateral, which is influenced by housing prices.[5] In terms of our approach, a relaxation in credit standards permits the entrance of more potential buyers into the housing market who can obtain those financial resources that are needed to purchase housing. As a result, an expansionary shift in demand for housing takes places, which fuels housing prices. More specifically, the role of credit market as related to the housing market has to be discussed in the context of the "financial accelerator" (Bernanke and Gertler 1989; Bernanke, Gertler, and Gilchrist 1996, 1999).

The "financial accelerator," or "credit multiplier," is supported by three main arguments: (1) internal finance is always more affordable than external finance, independent of the value of the collateral that backs the loan, which is due to the lenders' agency cost; (2) agents' risk premium is negatively related to their net wealth, i.e., internal funds (liquid

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[3] In our approach, the volume of bank credit is approximated by the domestic credit to the private sector as a percentage of GDP.

[4] See Lavoie (1984).

[5] There is also an important indirect effect on economic activity through the so called "wealth" effect, which emanates from unexpected increases in housing prices. In particular, there is a vast economic literature that considers households' wealth as the main determinant of consumption. In this sense, a decline in housing prices induces a decrease to the value of households' wealth, which mainly corresponds to real estate assets. As a result, households reduce their demand for final goods, i.e., a decline in consumption takes place, and finally a negative effect on the level of economic activity emerges (see, also, Nneji, Brooks, and Ward 2013).

assets) and collateral (illiquid assets);[6] (3) a decline in agents' net wealth induces a hike in the risk premium that provokes a rise in the volume of external funds that borrowers require and finally slows down borrowers' spending and production (Kiyotaki and Moore 1997; Bernanke, Gertler, and Gilchrist 1996).[7] Specifically, Bernanke, Gertler, and Gilchrist (1996) focus on the empirical evidence in which small variations, for example oil price fluctuations or changes in monetary policy, strongly influences aggregate economic activity. Bernanke, Gertler, and Gilchrist (1996) define the "financial accelerator" as the amplification of real or monetary shocks in the economy due to variations in credit conditions. This notion suggests that variations in credit-market conditions enhance and extend the impact that emanates from monetary or real shocks.[8] In this context, any kind of negative shock, which curbs economic expansion, hardens financial conditions and complicates the entrance of agents into the credit market, while agents' credit needs increase.[9] As a result, there is a slowdown in spending, which accelerates the downturn of the economy.[10] Bernanke, Gertler, and Gilchrist (1996) also coined the term "flight to quality," which refers to a situation in which agents have to deal with higher agency cost and, as a result, the volume of credit that they can receive is lower.

Furthermore, the negative impact of the cost of banking finance—i.e., mortgage rates, R_M—on housing prices has to be mentioned. The acquisition of a home is the main debt-financed investment decision that households undertake. The economic literature suggests that an increase in the mortgage rate reduces the affordability of housing assets.[11] This fact compels some potential buyers to abandon the market. As a result, this decline in demand for housing curbs housing prices. The mortgage rate accounts for one of the

[6] Bernanke, Gertler, and Gilchrist (1999) point to the existence of a positive risk premium as a natural phenomenon in a banking system characterized by the presence of "agency" problems.
[7] Bernanke and Gertler (1989) develop a model applied to the channels utilized by firms in order to finance their investment decisions. They conclude that the impact of the financial accelerator is more powerful in those cases where the economy is in recession. Kiyotaki and Moore (1997) display a dynamic model in which procyclical and endogenous changes in the price of the assets determine net wealth, the volume of banking credit that firms can withdraw and their spending. Kiyotaki and Moore's (1997) model considers the existence of credit limits and the evolution of asset prices as the main explanatory elements to explain the amplification effect of changes in credit on the economy.
[8] Eckstein and Sinai (1986) point to the hypothesis that agents tend to be overindebted and in a weak position to face cyclical peaks.
[9] A decline in agents' net wealth provokes an increase in the cost of external resources, which means a fall in borrowers' demand for credit. However, at the same time, there is an increase in the funds that are required to repay the fixed obligations since the volume of internal funds is reduced.
[10] Bernanke, Gertler, and Gilchrist (1996) explain the "financial accelerator" in a context of "principal-agent" conflicts, i.e., the "financial accelerator" could be identified with endogenous variations of the agency cost of lending. The "principal-agent" framework describes a situation in which lenders cannot obtain the information that they would know about borrowers without facing a cost.
[11] Iossifov, Čihák, and Shanghavi (2008) study the interest rate elasticity of residential housing prices. They point out that the acquisition of real estate assets is undertaken by means of external finance since the price of this asset is a multiple of home buyers' disposable income.

channels through which monetary authorities can affect the dynamics of the housing market.[12]

Moreover, policy makers have an important and effective "tool" to influence the evolution of housing prices and avoid the development of bubbles in this market, i.e., fiscal policy.[13] The most powerful channel that fiscal authorities could use in order to alter the dynamics of the market is taxation on property.[14] The justification for this statement is the fact that a high level of taxation could modify households' preferences for housing by making the decision to rent more attractive than purchasing a home.[15] Our approach assumes a negative effect of fiscal policy on housing prices since an increase in property taxation increases the cost of home ownership. This increase curbs the demand for housing and lowers housing prices as a result since there are some households who are not interested in purchasing real estate assets under the new conditions. Accordingly, renting the services of the property becomes more profitable than buying it.[16] Our proposal follows Hilbers et al. (2008) and includes the tax revenues-to-housing prices ratio, T, to account for the role of taxation in the housing market.

Finally, we account for the influence of demographic factors, which are an important driver of the demand for housing. On the one hand, there is a positive correlation between the growth of population, D_{PO}, and housing prices. A positive shock of population, i.e., rising population due to the natural trend of growth of population or inflows of immigrants, fuels demand for housing since the share of potential buyers that need to consume the services provided by real estate assets is higher.[17] This increase in demand is absorbed by higher prices in the short run since supply is fixed and property developers cannot satisfy immediately this rising demand. This positive relationship is especially strong in those areas that are densely populated due to the fact that the constraints regarding the availability of

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[12] See de Leeuw and Gramlich (1969) for an explanation of those channels that monetary authorities can utilize to influence the housing market. See, also, Shiller (2007) for a discussion of the role played by low interest rates in the development of asset bubbles since the 1990s.

[13] Fiscal policy could impact the housing market by means of several instruments, e.g., reducing mortgage interest payments, subsidies, taxation over property, capital gains levies, and public expenditure.

[14] Muellbauer (2003) highlights the role of taxation with respect to regulations in the use of land.

[15] See Hilbers et al. (2008) for details of taxation related to the housing market in the vast majority of the countries that we analyze in the empirical part of this contribution.

[16] Capozza, Green, and Hendershott (1998) emphasize the negative effects of taxation on housing prices and provide empirical evidence of this fact by using a sample of 63 metropolitan areas in the US during the period 1970–90. Haffner and Oxley (2011) discuss the influence of taxation on house price volatility in Denmark, Germany, the Netherlands, the UK, and the US. However, Fuest, Huber, and Nielsen (2004) suggest that taxation on capital gains could raise the volatility of housing prices.

[17] Holly and Jones (1997) study the impact of demographics in the UK during the period 1939–94. Bover (1993) focuses on the Spanish housing market.

land to produce new houses, i.e., the supply of housing becomes more inelastic, reinforces this mechanism.[18]

On the other hand, our testable hypothesis includes the negative effect that emanates from the presence of unemployment, D_{UN}. Rising unemployment curbs demand for housing since households that lose their employment suffer a reduction of their income, which makes purchasing housing less affordable.[19] Previous contributions, Cameron and Muellbauer (2001), also consider housing ownership as a determinant of unemployment, since housing ownership reduces the willingness of unemployed workers to move to others areas. Moreover, unemployment also exerts other indirect effects in the housing market. For example, unemployment is an indicator of the level of economic activity, which is utilized by agents in order to highlight their expectations. In the presence of unemployment, some households decide to postpone their investment decisions until the economic situation changes. At the same time, commercial banks will be more reluctant to issue new mortgages in this kind of context since their perception of risk is increasing. All these factors induce a decline in demand for housing, which reduces housing prices appreciation. We also note that rising unemployment exerts an additional effect on housing prices, since some home owners have to sell their assets due to the fact that they cannot repay their mortgages and try to get rid of their obligations before defaulting. Additionally, an increase in foreclosures also slows down housing prices appreciation.

The previous discussion can be encapsulated in equation (1), which summarizes the testable hypothesis that we utilize for the purposes of the empirical part of this contribution:

$$P_H = P_H(Y_D, I_R, C_B, R_M, T, D_{UN}, D_{PO}) \qquad (1)$$
$$+ \quad - \quad + \quad - \quad - \quad - \quad +$$

where P_H stands for real housing prices, Y_D for real disposable income, I_R for real residential investment, C_B for the volume of banking credit, R_M for the mortgage rate, T for the ratio of taxation to property/house price, D_{UN} for the rate of unemployment, and D_{PO} for the evolution of population. The sign below a variable indicates the partial derivative of P_H with respect to that variable.

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[18] See Miles (2012) for an analysis of the UK housing market.
[19] See, also, Ni, Huang, and Wen (2011), which focuses on the role of unemployment in the US housing market and Zhu (2010) for further empirical evidence in the case of the UK.

3. ECONOMETRIC SPECIFICATION

This section begins with the stationarity of the data under consideration, which is checked by means of the augmented Dickey-Fuller tests (Dickey and Fuller 1979, 1981), the Phillips-Perron test (Phillips and Perron 1988) and the GLS-based Dickey-Fuller test (Nelson and Plosser 1982). The null hypothesis of these three tests is the existence of a unit root. We also apply the Kwiatkowski-Phillips-Schmidt-Shin test (Kwiatkowski et al. 1992) with a null hypothesis of the absence of unit roots, i.e., the stationarity of the time series. Unit root/stationarity tests are utilized to check whether the data are integrated of first-order. The justification of this way of proceeding is due to the fact that in some cases, for example, if the variable displays structural breaks, the unit root/stationarity tests could identify unit roots instead of stationarity with structural changes. In our particular case, all these tests suggest the presence of unit roots, which is the pre-condition in the application of the cointegration analysis.[20]

Subsequently, we proceed to estimate the proposed relationship by using the vector error correction model (VECM; see, for example, Johansen 1995). In the VECM case, there is no need to make assumptions about the direction of the causality and the existence of temporal causality relationships amongst the variables involved, since all variables are jointly determined at the same time. The fact that this technique is based on VAR modeling allows the relaxation of the assumptions regarding the exogeneity or endogeneity of the explanatory variables.[21] This approach permits us to overcome problems of endogeneity of the regressors and reverse causality, which cannot be dealt with easily by means of other techniques, such as, for example, instrumental variables.[22] In this framework, first we conduct a preliminary test to calculate the length of the lag that our VECM computes.[23] Second, we apply the Johansen test for cointegration (Johansen 1988, 1991), which studies the existence of relationships among the variables in question and indicates the number of cointegrating relationships that can be estimated.[24] As a result, we proceed to estimate the VECM that produces the dynamics in the short run and provides the cointegrating parameters in its normalized form, which constitutes a long-run equilibrium relationship.[25]

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[20] The results of these unit root/stationarity tests are shown in the Appendix.

[21] A VAR (n) is characterized by utilizing as explanatory elements of each equation *n* lags of each variable, which is included in the model.

[22] Gonzalo (1994) states the superiority of this technique even in those cases where the dynamics of the variables are unknown or there is no normality in the residuals.

[23] This test is conducted by means of the STATA command *varsoc*.

[24] The STATA command *vecrank* is used to run this test.

[25] The estimation of the VECM is performed by the command *vec*.

For the particular purpose of this contribution, we estimate the VECM, which is specified in equation (2):

$$\Delta P_H = \beta_0 + \sum_{i=1}^{n} \varphi_{11} \Delta P_{H_{t-i}} + \sum_{i=1}^{n} \varphi_{12} \Delta X_{t-i} + \alpha_0 E_{t-1} + \varepsilon_t \qquad (2)$$

where P_H accounts for real house prices; X is a vector that computes the following variables: real disposable income, Y_D; real residential investment, I_R; the volume of banking credit, C_B; mortgage rate, R_M; the ratio of taxation to property/house price, T; the rate of unemployment, D_{UN}; and the population, D_{PO}. E is the error-correction term, ε is a random error term, and β_0, α_0, φ_{11} and φ_{12} are the estimated parameters. All the variables are computed in logarithms except the mortgage rate.

The validity of the short-run estimations is checked by the standard diagnostic/statistics that are reported in previous contributions that apply the same econometric technique. More precisely, we present the R-squared (R-sq), the Breusch-Godfrey Serial Correlation LM statistic (Breusch 1979; Godfrey 1978), the Akaike Information Criterion (AIC), the Schwartz Bayesian Information Criterion (SBIC), and the Hannan-Quinn Information Criterion (HQIC).[26]

4. UTILIZED DATA

The validity of our testable hypothesis is checked by utilizing a sample of 18 OECD economies during the period 1970–11. Particularly, the economies under consideration are the following: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Ireland, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States. This sample permits us to conduct a comparative study among the most important developed countries, which are different enough in terms of their banking sectors, taxation systems, incomes, and demographic factors, although their housing cycles are synchronized through time. The lack of homogeneous information before 1970 regarding housing prices compels us to start our analysis in 1970.[27]

The *AMECO* databank of the European Commission´s Directorate General for Economic and Financial Affairs is the principal source of the annual data provided. More precisely, the variables employed are the following: (1) Gross Fixed Capital Formation by

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[26] See Pulido and Pérez (2001) for further details on these tests.
[27] Real Housing Price Indexes are available at the website of the Bank of International Settlements (BIS): http://www.bis.org/.

type of Goods at Current Prices (Dwelling);[28] (2) Gross National Disposable Income per Head of Population; (3) Real Long-term Interest Rate;[29] (4) Unemployment Rate; (5) Total Population;[30] and (6) Gross Domestic Product Price Deflator.[31]

Furthermore, other data providers have been consulted: the OECD, which offers annual data regarding Taxation over immovable property (percent of GDP); and the World Bank, which publishes Domestic Credit to Private Sector (percent of GDP).[32]

STATA 11 and EViews 5.0 are the econometric packages utilized in order to estimate the econometric relationships and derive the relevant statistics/diagnostics.

5. EMPIRICAL RESULTS

5.1. Preliminary Analysis and Long-run Relationships

The length of the lag that the VECM includes is selected by applying the Akaike Information Criterion (AIC), the Hannan-Quinn Information Criterion (HQIC) and the Schwartz Bayesian Information Criterion (SBIC). We consider a maximum of four lags as reasonable to account for the dynamics of this market, especially so since annual data is utilized. Such a lag length should be sufficient for the majority of the duration of each phase of the cycle.[33] Another important consideration is that such lag length also allows the model to have enough degrees of freedom.[34] The selected length in all cases varies between 2 and 4 lags, as shown in Table 1.

Table 1 Lag selection

Selection-order criteria

	lag	AIC	HQIC	SBIC
Australia	2	-12.7037	-12.1517	-11.1523
Belgium	4	-15.0459	-14.0022	-12.0860
Canada	2	-19.0799	-18.5273	-17.5125
Denmark	2	-3.4588	-3.1365	-2.5445
Finland	4	-8.7783	-8.2509	-6.8768
France	2	-14.3994	-14.0774	-13.4944

[28] The OECD databank, *Gross fixed capital formation, housing*, is utilized in the case of Norway and Switzerland.

[29] The presence of missing information in the AMECO long-term interest rate time series is replaced by using the OECD databank for Switzerland, New Zealand, Australia, Norway, and Canada.

[30] The OECD databank, *Population Statistics*, provides the missing information in the event of Germany from 1970 to 1991.

[31] These time series can be downloaded at:
http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm.

[32] These databases can be consulted at:
http://data.worldbank.org/; http://stats.oecd.org/index.aspx

[33] OECD (2005) points out that the contraction stage of the housing market spans five years, while the expansionary one could last for up to six years.

[34] Our lag length is along the lines of other contributions, which also use annual data; see, for example, Holly and Jones (1997).

Germany	3	-17.8332	-17.0351	-15.5693
Ireland	2	-9.3157	-8.9543	-8.4199
Italy	4	-14.3582	-13.3144	-11.3976
Japan	4	-16.4367	-15.3930	-13.4761
Netherlands	2	-10.0907	-9.5380	-8.5071
New Zealand	4	-15.7876	-14.7466	-12.7349
Norway	4	-17.7750	-16.1634	-13.2035
Spain	3	-11.7462	-10.5183	-8.2631
Sweden	2	-14.0897	-13.3233	-11.4284
Switzerland	4	-18.2001	-17.1564	-15.2395
UK	2	-20.8103	-19.9661	-18.4157
US	4	-18.2444	-17.2006	-15.2838

Table 2 reports the results of the Johansen's trace test for cointegration (Johansen 1988, 1991) and confirms the existence of one cointegrating equation in each case. The first column presents the maximum rank, i.e., the number of cointegrating equations that exist among the variables under consideration.[35] The second column shows the values of the log-likelihood function, which are utilized to study the possibility of restricting a VAR of a given order to another VAR of lower order. The third column reports the eigenvalues, which are calculated in order to conduct the test. The fourth and the fifth columns display the trace statistics and the critical values at the 5 percent significance level. In all the cases, we strongly reject the null hypothesis of no cointegration. However, we cannot reject the null hypothesis of, at most, there is one cointegrating equation. As a result, the output presented in Table 2 confirms the existence of one cointegrating equation. [36]

Table 2 Johansen test for cointegration

Johansen tests for cointegration					
	maximum rank	LL	eigenvalue	trace statistic	5% critical value
Australia	1	26.5159	0.5175	24.4202	29.68
Belgium	1	31.3226	0.5597	21.9956	29.68
Canada	1	40.3057	0.5871	16.9803	29.68
Denmark	1	61.5947	0.3750	12.1370	15.41
Finland	1	129.8274	0.6377	9.0885	15.41
France	1	292.8084	0.4188	13.9409	15.41
Germany	1	352.4996	0.4935	21.6469	29.68
Ireland	1	196.3465	0.3903	12.6203	15.41
Italy	1	280.2785	0.5333	26.0087	29.68
Japan	1	323.2638	0.5301	26.2700	29.68
Netherlands	1	209.5143	0.5117	28.6008	29.68
New Zealand	1	287.3301	0.6233	25.8829	29.68
Norway	1	326.00000	0.5417	45.0277	47.21
Spain	1	254.9385	0.5728	45.5246	47.21

[35] The rank of a matrix is the number of its characteristic roots, which are different from 0 (Brooks 2008).

[36] The Johansen's trace test for cointegration considers as its null hypothesis that the number of cointegrating vectors is less than or equal to *r*. Its alternative hypothesis is that there are more than *r* cointegrating vectors. See, also, Brooks (2008) and StataCorp. (2009) for further details.

Sweden	1	217.0000	0.7994	41.8044	47.21
Switzerland	1	362.5041	0.6576	27.4091	29.68
UK	1	431.9571	0.6144	45.5785	47.21
US	1	374.0071	0.5394	29.4883	29.68

The normalized parameters that are estimated for the cointegrating equations are shown in Table 3.[37] Specifically, the coefficients of the long-run relationships are normalized with respect to real housing prices. As a result, the parameter on real housing prices is unity.[38]

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[37] Normalizing a given vector means obtaining a proportional vector, relative to the initial one, whose magnitude is equal to one (see, also, Brooks 2008).

[38] The normalization that is applied can be described as follows. If there are r cointegrating relationships, at least r^2 restrictions are needed to identify the free parameters in η. Johansen (1995) suggests the following identification scheme: $\eta' = \left(I_r, \widetilde{\eta}'\right)$, where I_r is the r x r identity matrix and $\widetilde{\eta}$ is a $(k\text{-}r)$ x r matrix of identified parameters (StataCorp. 2009).

Table 3 Long-run relationships

Long-run relationship - Normalized cointegrating coefficients

	Constant	L_P_H	L_Y_D	L_I_R	L_C_B	R_M	L_T	L_D_{UN}	L_D_{PO}
Australia	-22.2042	1					-3.4938***	0.3362***	-4.3416***
Belgium	-7.4023	1	-0.7364***				-0.1125**		-4.7702***
Canada	3.5053	1	-7.9711***			-12.9195***			15.9202***
Denmark	-5.2854	1			-0.3535***			-0.2491***	
Finland	-8.1336	1					-0.2332***		-2.5805***
France	-20.5767	1						-0.5292***	-16.0024***
Germany	-9.3527	1	0.6921***	0.5585***	-1.1060***				
Ireland	-1.5389	1	-0.8667***					0.1396***	
Italy	1.7715	1	-1.4185***					0.9251***	
Japan	-23.3930	1	1.8618***		-1.4440***		-1.1231***		
Netherlands	2.3718	1					3.9858***	-2.3811***	-7.2301***
New Zealand	5.7959	1	-4.2650***				-1.6773***		4.0455***
Norway	1.8573	1	-0.5975***	-0.8599***			-0.3459***		2.2988***
Spain	-10.0231	1	-4.9821***	3.40395***			-0.0660***		-4.6614***
Sweden	12.8830	1	-2.6284***			-14.2841***	0.5732***		
Switzerland	102.0127	1	-18.2373***		-6.1358***				52.6011***
UK	-25.4913	1	0.6446**			-8.8406***	-1.5948***		-17.5986***
US	7.2600	1			-0.6380***	9.3697***	3.3553***		

Note: *, **, and *** indicate statistical significance and rejection of the null at the 10-percent, 5-percent, and 1-percent significance levels, respectively. Numbers in parentheses, in the case of the variables, show the lag(s) of the relevant variable.

The estimated relationships shown in Table 3 point to real disposable income, which is one of the main determinants of housing affordability, as the most important variable in the explanation of housing prices in the long run. Specifically, the cointegrating equations reveal a positive relationship between income and real housing prices in the long run in the following economies: Belgium, Canada, Germany, Ireland, Italy, Japan, New Zealand, Norway, Spain, Sweden, Switzerland, and the United Kingdom.[39]

Real residential investment also contributes to explaining housing price development in the long run in the particular cases of Germany, Norway, and Spain. Demographic elements are also highlighted since they play an important role in the evolution of demand for housing, and are a key element in the determination of real housing price appreciation. The relevance of demographics in the explanation of housing prices has been suggested by previous contributions, such as Miles (2012), which focused on the UK. In particular, the growth of population exerts a significant impact in the case of Australia, Belgium, Canada, Finland, France, the Netherlands, New Zealand, Norway, Spain, Switzerland, and the UK. Regarding the second demographic variable that our analysis considers, i.e., unemployment, these cointegrating relationships confirm that this variable contributes to the determination

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[39] Holly and Jones (1997) also suggest the existence of a cointegrating relationship between housing prices and disposable income in the case of the UK.

of the long-run equilibrium in the cases of Australia, Denmark, Finland, Ireland, Italy, and the Netherlands.[40]

An important conclusion of our long-run analysis is the fact that fiscal policy, specifically taxation, could be a more effective approach than monetary policy focused on interest rate manipulation.[41] In particular, there is a significant impact that emanates from mortgage rates just in Canada, Sweden, the UK, and the US. However, taxation over immovable property contributes to the determination of the long-run equilibrium relationship in the case of Australia, Belgium, Finland, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, the UK, and the US.

Regarding monetary authorities' actions in this market, our results reveal that they can exert a stronger influence by means of prudential policy, i.e., by tightening the credit standards. This element, which is proxied by the volume of banking credit, is significant in Denmark, Germany, Japan, Switzerland, and the US.

In general terms, our study confirms the results of Igan and Loungani (2012), who suggest that housing prices in the long run are mainly determined by local fundamentals, namely, growth of population and income.

5.2. Analysis of the Short-Run Dynamics

The models that are estimated for the purpose of this contribution in order to analyze the dynamics in the short run are shown in Table 4.

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[40] The role of unemployment in the evolution of housing prices in the long run has been pointed out by previous contributions, such as, for example, Barot and Yang (2002). They find a relevant effect of unemployment in the case of the UK; although in our particular case, this coefficient is not significant.
[41] Our findings are in the same vein as those of Igan and Loungani (2012), who consider that interest rates do not play a very important role in the determination of global housing prices.

Table 4 Short-run equations

Short-run Relationship

	Constant	ΔL_Y_D	ΔL_I_R	ΔL_C_B	ΔR_M	ΔL_T	ΔL_D_UN	ΔL_D_PO	ΔL_P_H	EL_P_H
Australia	-0.0105							2.2714** (1)	0.5357* (1)	-0.1511**
Belgium	0.0384***					-0.0725** (2)			0.8676*** (1)	-0.4070***
						-0.0647*(3)			0.4486** (3)	
Canada	0.0062								0.4435** (1)	-0.0529***
Denmark	0.0157						-0.1128*** (1)		0.7938***(1)	-0.1563***
Finland	0.1506***					-0.1816** (2)			0.9903*** (1)	-0.4921**
France	0.0151**						-0.1913** (2)		0.9458*** (1)	-0.0777***
									-0.3833*** (2)	
Germany	-0.0055			0.3140* (2)					0.5650*** (1)	-0.1604***
Ireland	0.0141								0.6396*** (1)	-0.2640***
Italy	-0.0002	1.1754** (2)							0.4526*** (2)	-0.5555***
		1.6457*** (3)							0.2347* (3)	
Japan	-0.0104	0.9515*** (1)		0.5065*** (1)					0.3205** (1)	-0.0836**
Netherlands	0.0074								0.6338*** (1)	-0.0479***
New Zealand	-0.0015					-0.3157* (2)		3.0488*** (2)	0.4710*** (1)	-0.3806***
Norway	0.0333					-0.4220*** (1)		1.2589* (2)	1.3163***(1)	-0.4458***
						-0.3689*** (2)			0.7205** (2)	
						-0.1985*** (3)			1.3915*** (3)	
Spain	0.0156		0.6472** (1)						0.4748** (1)	-0.0884**
Sweden	0.0014				-2.5317*** (1)				0.6668*** (1)	-0.2134***
Switzerland	-0.0032							1.7194*** (1)	0.5371*** (1)	-0.0527***
								0.5329** (2)	-0.3335*** (2)	
								1.0958*** (3)	-0.2360* (3)	
UK	-0.0028	1.6433** (1)			-1.3988** (1)				0.3547* (1)	-0.1566*
US	0.0147**					-0.8211* (2)			1.0233*** (1)	-0.0873**
									-0.5121* (2)	
									-0.6068** (3)	

Note: *, **, and *** indicate statistical significance and rejection of the null at the 10-percent, 5-percent, and 1-percent significance levels, respectively. Numbers in parentheses, in the case of the variables, show the lag(s) of the relevant variable.

The VECMs in Table 4 show how, in the short run, real housing prices in the previous periods are a significant explanatory element of the evolution of housing prices in the short run. This finding supports the ideas advanced by Shiller (2007), which highlight the powerful role of expectations in the formation of prices in this market and also emphasize the fact that during booms, households decide to buy this kind of asset due to speculative reasons. Expectations and speculation are especially relevant in the explanation of the dynamics of Belgium, France, Italy, Norway, Switzerland, and the US, where the short-run models insert several lags of real housing prices.

These estimations also reveal a positive effect of real disposable income on real housing prices in the case of Italy (1.1754 and 1.6457), Japan (0.9515), and UK (1.6433). However, the impact of this variable is applies to more countries in the long run.

Real residential investment is only significant in the case of Spain (0.6472). The effect of this variable in this particular market is maintained regardless of the time horizon

considered. As discussed in Section 2, in the short run, real residential investment contributes to housing price appreciation.

These results also confirm the argument that the relaxation of credit standards permits the entrance of new home buyers into the market and favors an increase in the demand for housing, which is absorbed by prices. This impact is evident in the cases of Germany (0.3140) and Japan (0.5065), where the cointegrating equations also highlight the significance of this variable in these economies at the equilibrium position.

Moreover, fluctuations in mortgage rates curb housing price appreciation in the case of Sweden (-2.5317), the US (-0.8211) and the UK (-1.3988). These findings are consistent in the long run, although in a longer time horizon, our econometric results also pointed to a negative effect in the Canadian case.

Regarding the intervention of fiscal authorities in this market, our econometric results provide empirical evidence of how they can slow down hikes in housing prices by means of taxing property in the case of Belgium (-0.0725 and -0.0647), Finland (-0.1816), New Zealand (-0.3157), and Norway (-0.4220, -0.3689 and -0.1985). This variable is also significant in the determination of housing prices in the equilibrium relationship.

Finally, we note that the role of demographic factors in the short-run study follows the same pattern that is found in the long-run analysis. The positive effect, which emanates from the growth of population, is more important than the negative one that appears in the event of unemployment. In particular, unemployment is only relevant in Denmark (-0.1128) and France (-0.1913), where this effect is also significant in the long run in both markets. However, the evolution of population is a driver of housing prices in Australia (2.2714), New Zealand (3.0488), Norway (1.2589), and Switzerland (1.7194, 0.5329 and 1.0958). The relevance of this demographic factor in those economies is also relevant in the case of the long-run analysis.

The last column in Table 4 reports the value of the error-correction term, which indicates the proportion of disequilibria between the short-run dynamics and the cointegrating relationship that is dropped out in each period. The estimations show how between a 5 percent and 10 percent of the disequilibria is eliminated in Canada, France, Japan, the Netherlands, Spain, Switzerland, and the US. More dynamic is the housing market in Australia, Denmark, Germany, and the UK, where the speed of adjustment is around 15–16 percent. The differences in disequilibria between the short-run and the long-run are reduced slightly faster in the case of Sweden (20 percent) and Ireland (26 percent). This percentage rises twice in the case of Belgium, New Zealand, and Norway (between 40–45

percent). The most dynamic markets in the sample under consideration are the Finnish and the Italian ones, where the error-correction terms are 50 percent and 56 percent, respectively.

Table 5 Short-run equations: diagnostics/statistics

Diagnostic/Statistics						
	R-sq	LM (1)	LM (2)	AIC	HQIC	SBIC
Australia	0.5400	11.0725 (0.8049)	8.6140 (0.9284)	-12.5347	-12.1207	-11.3711
Belgium	0.8115	14.4587 (0.5645)	13.2798 (0.6522)	-14.4834	-13.5778	-11.9146
Canada	0.3644	10.5187 (0.8381)	16.8928 (0.3925)	-19.2850	-18.8717	-18.1333
Denmark	0.4518	6.7345 (0.6647)	1.1247 (0.9990)	-2.2869	-2.0267	-15.6176
Finland	0.7589	12.2407 (0.2000)	12.8484 (0.1695)	-8.3435	-7.8702	-6.6371
France	0.7537	5.4317 (0.7951)	8.0472 (0.5294)	-13.8644	-13.4665	-12.7554
Germany	0.5112	12.9895 (0.6735)	17.3518 (0.3632)	-17.2251	-16.5658	-15.3720
Ireland	0.7701	11.4062 (0.2488)	16.2195 (0.0624)	-9.1972	-8.9370	-8.4721
Italy	0.8152	7.2696 (0.6090)	12.0498 (0.2105)	-10.9906	-10.4539	-9.4823
Japan	0.6395	17.6975 (0.3419)	20.5436 (0.1967)	-15.1930	-14.7798	-14.0413
Netherlands	0.6696	10.1914 (0.8564)	12.0381 (0.7413)	-9.6060	-9.1920	-8.4424
New Zealand	0.7781	15.0927 (0.5178)	12.5596 (0.7046)	-16.5667	-15.6634	-13.9180
Norway	0.7625	18.4167 (0.8242)	29.0636 (0.2612)	-16.6910	-15.3249	-12.8161
Spain	0.7007	24.8467 (0.4709)	24.5402 (0.4883)	-11.1660	-10.1847	-8.4079
Sweden	0.7892	18.1561 (0.3148)	18.1749 (0.3137)	-13.7921	-13.4159	-12.4856
Switzerland	0.9092	6.3034 (0.9844)	31.1308 (0.0129)	-17.6312	-16.7256	-15.0624
UK	0.4853	29.5902 (0.2400)	28.9812 (0.2647)	-20.1516	-19.5547	-18.4880
US	0.8142	15.6865 (0.4750)	12.5552 (0.7049)	-17.8862	-16.9806	-15.3174

The first column of Table 5 shows the value of the R-squared. In the case of Canada and Denmark, the model displays the less powerful adjustment (36 and 45 percent). This statistic explains half of the variation in housing prices in the UK, Germany, and Australia (49 percent, 51 percent, and 54 percent, respectively). In the case of Japan, this percentage is higher (64 percent) and slightly higher in the Netherlands (67 percent) and Spain (70 percent). The statistic also explains around the 80 percent of the short-run fluctuations of real housing appreciation in France (0.75), Finland (0.76), Ireland (0.77), New Zealand (0.78), Norway (0.76), Sweden (0.79), Belgium (0.81), Italy (0.82), and the US (0.81). The higher adjustment is reached in the case of the Swiss market (91 percent). The second and the third columns of Table 5 display the results of the Breusch-Godfrey Serial Correlation LM (Breusch 1979; Godfrey 1978) statistic, which tests for the lack of autocorrelation of first- and second-order. In all the cases, the null hypothesis of absence of autocorrelation is accepted. Moreover, the last three columns of this table display the value of the Akaike Information Criterion (AIC), the Schwartz Bayesian Information Criterion (SBIC), and the Hannan-Quinn Information Criterion (HQIC). All these statistics permit us to select the specification that fits well with the structure of the data. These criteria are utilized in those cases where there are several alternatives for the same model. Specifically, the econometric

literature (Pulido and Pérez 2001) recommends choosing that model, which presents the lower value of this statistic. All these diagnostics/statistics validate our theoretical and econometric analyses.

6. COMPARISON WITH OTHER CROSS-COUNTRY STUDIES

We also check the validity of our findings by comparing them with the results of previous contributions.

Regarding the role of income in the evolution of housing prices, Miles and Pillonca (2008) find a positive relationship between real housing price appreciation and real income growth in the case of Norway, Ireland, the Netherlands, and Italy. These findings are supported by our cointegrating equations in all cases except for the Netherlands. Moreover, Miles and Pillonca (2008) emphasize the positive effect that emanates from an increase in population in Spain and the US. André (2010) also highlights the same effect in the case of Ireland, Spain, New Zealand, Canada, and the US. Our long-run results suggest the same impact in these countries except for in the US and Ireland, where the evolution of population has no influence in the long-run equilibrium relationship.

Furthermore, the role of the supply side of the housing market has also been discussed by André (2010), who analyzes the impact of residential investment on real house prices and points to a strong relationship between these two variables in the cases of Ireland, Spain, Canada, and the Nordic economies. Our results also confirm the existence of a relationship between these elements in the case of Spain and Norway.

To continue with the review of our results, we compare our short-run estimations with those of Igan and Loungani (2012).[42] Specifically, Igan and Loungani (2012) find that housing prices are explained by the evolution of population and long-term interest rates in Belgium, while in France, the determinants are income, population, and long-term interest rates. However, our estimations point to taxation and unemployment as the explanatory elements in Belgium and France, respectively. We note that the lack of an impact of credit in France and Belgium, which is found by Igan and Loungani (2012) and also by Hilbers et al. (2008), support our estimations.

Igan and Loungani's (2012) results advance some findings that are along the lines suggested by our estimations as reported in the previous relevant section. For example, in the

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[42] Igan and Loungani (2012) model housing prices as a function of housing affordability, income per capita, working-age population, stock prices, credit, short-term interest rates, and long-term interest rates. Their sample spans from 1970 to 2010. The inclusion of housing affordability, lagged one period, is considered as an error-correction term. This is in view of the use of their contribution to compare it with our short-run models.

case of Australia, New Zealand, and Norway, both contributions consider a positive relationship between housing prices and population. The common driver, which is identified by both studies for the German and the Japanese markets, is credit. There is also a positive common effect of income in the UK and Japan. Moreover, the effect of interest rates that is suggested by our empirical findings in the cases of Sweden, the UK, and the US is supported by the above-mentioned study.

However, our results do not exhibit common elements with Igan and Loungani (2012) in the case of Canada, Denmark, Finland, Ireland, Italy, the Netherlands, Spain, and Switzerland. For instance, our empirical results show how in the short run, the error-correction term and lagged housing prices are the unique drivers of housing price dynamics in Canada, Ireland, and the Netherlands. However, Igan and Loungani (2012) find that housing prices are explained by income, credit, short-term interest rates in the Netherlands; by income and credit in Ireland; and by long-term interest rates and income in Canada. In the Spanish case, the Igan and Loungani's (2012) model concludes that housing prices are determined by means of the evolution of working-age population and credit, while our estimations capture the impact of real residential investment. Moreover, in the case of Switzerland, Igan and Loungani (2012) highlight income and long-term interest rates as the important explanatory elements; in the case of our results, a significant positive impact of the rate of growth of population is found.

7. SUMMARY AND CONCLUSIONS

A model for the determination of housing prices is proposed in this contribution. The impact of traditional variables such as income, interest rates of loans for housing, and demographics is found important. Our theoretical proposition also includes the role of two participants in this particular market, i.e., fiscal and monetary authorities. The validity of our testable hypothesis is checked by means of cointegration analysis.

The results of our research show different channels through which public authorities can influence the housing market. First, the most important instrument that they can utilize is fiscal policy. Specifically, they can alter income, which is the key determinant of the demand for housing, the engine of the model, by means of taxation over income, e.g., personal income tax and imputed rental levies, such as subsidies such as mortgage interest deductibility, and public expenditure. This tool becomes very important after the recent bust of the housing market, since any kind of public attempt to contribute to the recovery of the sector should emanate from an improvement of households' income. Second, taxation over

property cannot be ignored as a relevant factor to change households' preference for real residential assets. As pointed out by Muellbauer (2003), these sorts of policies are much more effective than regulation of the use of land. In particular, a high level of property and wealth taxation could discourage households from purchasing real estate assets, since renting properties becomes a more attractive option. At the same time, the acquisition of a second or a third residence could be curbed by a relevant levy. Another powerful instrument that could also be used is capital gains taxation. Moreover, fiscal authorities should encourage the rental market as another measure to curb demand for housing among those households who would be more inclined to default if the conditions of the economy were to change unfavorably, i.e., low-income individuals who are more likely to become unemployed.

On the other hand, our results point to the ineffectiveness of monetary policy, in the form of interest rate manipulation. In this sense, interest rates should be set as low and stable as possible, since the banking sector has to provide the liquidity, which is required to permit the functioning of the sphere of production without creating distortions. At first sight, this policy recommendation could be controversial. However, monetary authorities should develop prudential policy instruments in order to guarantee a credit-worthy demand for credit and as a result the solvency of the banking sector.

Finally, monetary authorities should also consider the evolution of housing prices in order to define their objectives and the instruments that they can utilize to achieve them. This recommendation is easily justified by the recent "great recession" outcomes, which clearly reveal that financial and macroeconomic instability is related to sharp fluctuations in asset prices.

APPENDIX

Unit Root/Cointegration Tests

Table A1 ADF unit root tests

	L_P$_H$	L_Y$_D$	L_I$_R$	L_C$_B$	R$_M$	L_T	L_D$_{UN}$	L_D$_{PO}$
Australia	-5.2982*** (4)	2.8507 (2)	-3.0046 (4)	-1.8183 (0)	-1.3664 (0)	-2.5085** (1)	-3.2112** (0)	-1.9483 (1)
Belgium	-1.9236 (1)	-2.1387 (1)	-3.1985* (2)	-1.9048 (0)	-1.2442 (0)	-2.6511 (0)	-5.0267*** (3)	4.0261 (6)
Canada	-1.9527 (1)	-2.9846 (1)	-2.2427 (0)	-2.5910 (0)	-1.2622 (1)	-2.0765 (1)	-2.5685*** (1)	-2.0788 (1)
Denmark	-2.1652 (1)	-3.5972** (1)	-2.3749 (1)	-1.3862 (0)	-2.2578 (0)	-3.4438* (1)	-3.0947** (1)	-2.1944 (3)
Finland	-3.5550** (1)	1.5589 (1)	-0.8840 (2)	-3.5621** (3)	-2.3028 (0)	-2.3944** (0)	-3.2104* (1)	3.3692 (2)
France	-2.1129 (1)	-2.7555 (1)	-2.2725 (1)	-0.4765 (9)	-4.3638*** (5)	-1.8727* (1)	-3.2812** (0)	3.7014 (2)
Germany	-1.7289 (1)	-1.8246 (1)	-2.7355 (1)	-1.9252 (0)	-3.7681*** (0)	-2.1154 (0)	-2.7397* (4)	-2.2269 (5)
Ireland	-2.8944 (1)	-2.1575 (1)	-2.2796 (2)	0.4095 (0)	-3.2084** (0)	-2.5119 (1)	-2.2447 (1)	-3.0614 (4)
Italy	-4.0186** (2)	-3.1770** (1)	-2.8449 (1)	-0.7788 (1)	-1.3782 (0)	0.5694 (2)	-2.3195 (1)	-2.3691 (5)
Japan	-0.4896 (1)	-2.0642 (1)	-2.4718 (1)	0.0255 (1)	-2.9577** (0)	-2.192392 (0)	-2.6748 (1)	0.1779 (3)
Netherlands	-2.8046 (1)	-2.1906 (1)	-2.4260 (1)	-0.2040 (0)	-0.7889 (1)	-2.0560** (1)	-0.6375 (2)	0.6078 (3)
New Zealand	-2.3279 (1)	-1.7200 (0)	0.6546 (0)	-1.6181 (0)	-1.3500 (1)	-0.9109 (0)	-2.5938 (3)	9.8908 (0)
Norway	-1.8988 (1)	4.2215 (0)	-2.4629 (1)	-2.9146 (1)	-3.9414*** (0)	-1.3153 (0)	-2.1364 (2)	2.5942 (7)
Spain	-5.2982 (4)	-3.1179 (1)	-2.4507 (1)	-1.1083 (2)	-1.9446* (0)	-1.8180* (0)	-1.3114 (1)	-3.6149** (3)
Sweden	-1.9236 (1)	-2.1387 (1)	-3.1985* (2)	-2.6286 (1)	-1.2442 (0)	-1.7784* (1)	-1.0481 (2)	-2.8573 (3)
Switzerland	-3.1067** (1)	-3.6571** (1)	-4.4112*** (1)	-0.9041 (0)	-2.6670* (0)	-0.6591 (0)	-3.0330 (1)	2.3807 (4)
UK	-3.2409* (1)	-1.8444 (1)	-3.7694** (4)	-1.0527 (0)	-3.9414*** (5)	-3.5008* (1)	-2.2180 (1)	0.1731 (1)
US	-3.6876*** (4)	-4.0024*** (1)	-2.9723 (1)	-2.1399 (0)	-0.7972 (0)	-3.0964 (1)	-3.3553** (1)	-3.4019* (1)

Note: *, **, and *** indicate statistical significance and rejection of the null at the 10-percent, 5-percent, and 1-percent significance levels, respectively. Numbers in parentheses show the lag(s).

Table A2 PP unit root tests

	L_P$_H$	L_Y$_D$	L_I$_R$	L_C$_B$	R$_M$	L_T	L_D$_{UN}$	L_D$_{PO}$
Australia	1.2548	3.6532	-3.6700**	-1.9854	-1.4142	-2.1255	-2.5275	-3.9359**
Belgium	2.3425	-1.6859	-2.3145	-2.0152	-1.2059	-2.6728	-2.1406	4.5198
Canada	2.1357	-2.5512	-2.5907	-2.5640	-1.5024	-0.7504	-2.2257	-3.3161*
Denmark	1.3458	-2.5051	-2.0444	-1.4538	-2.1041	-2.6968	-2.9726	5.1887
Finland	-1.5856	-2.4659	-2.3806	-1.5962	-2.3147	-1.6973	-2.1353	13.2134
France	1.7714	-2.6358	2.0110	-5.3414***	-0.9212	-1.9943**	-1.6198	-1.9510
Germany	-1.5441	-2.5057	1.5860	-1.7097	-3.7681***	-2.3388	-3.7432*	1.1653
Ireland	0.9552	1.9107	-0.7761	0.4095	-3.0253**	-1.6191*	-0.8230	4.5151
Italy	1.0434	0.5517	-2.2624	0.2402	-1.3683	0.9328	-1.9986	3.0464
Japan	-0.1551	-2.3242	-2.4382	-2.0162	-2.9577**	-2.5143	-2.3805**	3.1115
Netherlands	1.3464	3.3170	1.5892	-0.2040	-1.0443	-1.7624*	-1.4375	9.9951
New Zealand	2.0443	-1.7601	0.4314	-1.7802	-1.7130*	-1.3810	-2.6198*	7.7153
Norway	-1.3014	4.3478	0.9945	-2.1658	-3.7533**	-1.4626	-1.8575	2.8295
Spain	1.2548	-1.0645	1.0127	0.6697	-2.0825**	-1.7295	-2.0918**	4.5768
Sweden	2.3425	-1.6859	-2.3145	-4.0937**	-1.2059	-1.7467*	-1.2369	1.4030
Switzerland	0.6506	-2.9847	-2.4126	-0.9407	-2.7447*	-0.7894	-1.3230	2.3064
UK	2.0946	3.5358	1.2009	-1.0553	-3.1832**	-2.5472	-2.2351	2.3898
US	0.8208	-2.6700	-1.8573	-2.1399	-0.8694	-1.4585	-2.1132	-1.4551

Note: *, **, and *** indicate statistical significance and rejection of the null at the 10-percent, 5-percent, and 1-percent significance levels, respectively.

Table A3 KPSS unit root tests

	L_P_H	L_Y_D	L_I_R	L_C_B	R_M	L_T	L_D_{UN}	L_D_{PO}
Australia	0.0828	0.1638**	0.0812	0.7598***	0.1590**	0.1049	0.2586***	0.8172***
Belgium	0.1720**	0.8011***	0.6802**	0.7430***	0.1574	0.6401**	0.3824*	0.7742***
Canada	0.1183	0.1036	0.0867	0.6990**	0.1673	0.4394**	0.1895**	0.1846**
Denmark	0.1753**	0.7850***	0.1796**	0.1649**	0.1680**	0.1479**	0.1800**	0.1671**
Finland	0.5690**	0.7717***	0.7011**	0.4796**	0.1837**	0.1205*	0.1199*	0.1531**
France	0.1494**	0.1605**	0.1706**	0.4768**	0.1682**	0.1819**	0.1996**	0.1217*
Germany	0.1742**	0.1802**	0.0926	0.7429***	0.2174	0.1916**	0.3629*	0.6604**
Ireland	0.1437*	0.1293*	0.5652**	0.7138**	0.1373*	0.4067*	0.1679	0.1260*
Italy	0.0638	0.2092**	0.1543**	0.2008**	0.1563**	0.1355*	0.1841**	0.1541**
Japan	0.1935	0.7158**	0.3685*	0.1655**	0.1937	0.1324*	0.7493*	0.7405***
Netherlands	0.1463**	0.1491**	0.1944**	0.1360*	0.1689	0.1895**	0.1828**	0.1770**
New Zealand	0.1761**	0.1579**	0.1209*	0.1191*	0.1845**	0.1636**	0.1961**	0.1504**
Norway	0.1670**	0.1482**	0.3640*	0.6568**	0.2047**	0.5087**	0.1786**	0.1922**
Spain	0.0828	0.1166	0.1323*	0.1755**	0.1873	0.1339*	0.1706**	0.1212*
Sweden	0.1720**	0.8011***	0.6802**	0.6055**	0.1578**	0.6193**	0.6526**	0.1220*
Switzerland	0.1250	0.7695***	0.7614***	0.1728**	0.1486**	0.0822	0.6134**	0.1669**
UK	0.1089	0.1002	0.1091	0.7483***	0.1659**	0.5837**	0.1687**	0.2071**
US	0.0828	0.0579	0.6648**	0.1650*	0.1836	0.6421**	0.1128	0.8108***

Note: *, **, and *** indicate statistical significance and rejection of the null at the 10-percent, 5-percent, and 1-percent significance levels, respectively.

Table A4 DF GLS unit root tests

	L_P_H	L_Y_D	L_I_R	L_C_B	R_M	L_T	L_D_{UN}	L_D_{PO}
Australia	-3.3434** (2)	1.1423 (2)	-3.6010** (0)	-1.6032 (0)	-1.9360 (0)	-1.8083 (0)	-1.4236 (0)	-2.4147 (1)
Belgium	-2.0048 (1)	-2.1111 (1)	-2.6687 (1)	-1.9716 (0)	-2.0735 (0)	-2.7368 (0)	-1.3443 (2)	0.7741 (1)
Canada	-2.1178 (1)	-2.4168 (1)	-2.0962 (0)	-2.5001 (0)	-2.2776 (0)	-2.6380 (1)	-2.2917 (1)	-0.2323 (1)
Denmark	-2.2287 (1)	-3.5565 (1)	-2.2909 (1)	-1.3344 (1)	-1.2409 (1)	-3.4572** (1)	-1.7794 (1)	-2.6407 (3)
Finland	-0.8754 (2)	-0.1569 (1)	-0.2047 (2)	-1.0337 (1)	-2.4291 (0)	-1.6634 (0)	-1.9408 (2)	0.7674 (3)
France	-2.2348 (1)	-1.7994 (1)	-2.3828 (1)	-2.1686 (9)	-3.5029** (5)	-2.1383 (1)	-1.0903 (1)	-2.1144 (3)
Germany	-2.2903 (1)	-1.8512 (1)	-2.7920 (1)	-2.2148 (3)	-3.0444* (0)	-2.6613 (1)	-0.6728 (2)	-2.7134 (5)
Ireland	-1.1051 (2)	-2.3189 (1)	-2.0048 (1)	1.4717 (0)	-2.6496 (1)	-2.0251 (1)	-2.2024 (1)	-2.0772 (2)
Italy	-3.7382** (2)	-0.4867 (1)	-2.4839 (1)	-1.0405 (1)	-1.9224 (0)	0.7314 (2)	-1.7716 (1)	-1.9400 (6)
Japan	-1.4141 (1)	-0.4805 (1)	-1.2742 (1)	-0.8347 (1)	2.2093** (0)	-2.2777 (4)	-2.4307 (1)	-0.0403 (3)
Netherlands	-2.8477 (1)	-2.2512 (1)	-2.4307 (1)	-1.5596 (0)	-1.8574 (0)	-1.3214 (1)	-1.9553 (1)	-0.2803 (3)
New Zealand	-2.4246 (1)	-1.8206 (0)	-1.5781 (0)	-1.7367 (0)	-1.5606 (1)	-2.2838 (1)	-1.6523 (3)	-2.2003 (1)
Norway	-2.0006 (1)	1.4193 (0)	-2.6210 (1)	-2.7619 (1)	-1.6099 (2)	-2.3884 (5)	-1.4106 (2)	-1.9465 (9)
Spain	-0.9843 (1)	-3.2967** (1)	-2.7727 (1)	-1.9023 (0)	-2.0731 (0)	-2.4631 (1)	-1.6671 (1)	-0.5844 (2)
Sweden	-2.0048 (1)	-2.1111 (1)	-2.6687 (1)	-2.7371 (1)	-2.0735 (0)	-1.5157 (1)	-0.8992 (2)	0.8594 (4)
Switzerland	-3.3277** (1)	-3.6350** (1)	0.6439 (2)	-1.0659 (0)	-3.0205* (0)	-1.3375 (0)	-0.9702 (1)	-1.0799 (5)
UK	-3.3294** (1)	-2.1384 (1)	-3.0074* (1)	-1.5648 (0)	-3.3030** (5)	-1.3238 (2)	-1.8282 (1)	-2.1073 (1)
US	-4.0891*** (4)	-3.9661*** (1)	-3.1131* (1)	-1.8145 (0)	-1.5798 (2)	-1.0921 (1)	-2.1861 (2)	-0.7498 (2)

Note: *, **, and *** indicate statistical significance and rejection of the null at the 10-percent, 5-percent, and 1-percent significance levels, respectively. Numbers in parentheses show the lag(s).

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