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Abstract:
We present the first hedonic house price indexes for Costa Rica at the national and provincial level, and for both the public and private sectors. Our indexes, which focus on building costs, show that the real quality-adjusted price of new residential structures rose by 10 percent over the period 2000-2013. Important differences emerge when we compare the public and private sectors. The average quality of private housing rose strongly during our sample period, while the average quality of public housing fell. Recipients of public housing therefore became worse off. The fall in quality was matched by a fall in price in the public sector, and hence generated cost savings for the government. Also, by estimating separate hedonic models for the public and private sectors, we show that public sector housing would not be produced more cheaply in the private sector. In this sense the public sector seems quite efficient. (*JEL*. C43; E31; R28; R31)

Keywords: Housing market; Hedonic index; Quality change; Public housing

We thank the National Institute of Statistics and Census (NISC) in Costa Rica for supplying the data used in this article.

1 Introduction

Housing is among the most prominent markets in terms of its impact on welfare and its connectedness to other sectors of the economy. Adequate housing supports quality of life via poverty reduction, improvements in public health and education (Kling, Liebman and Katz 2007), and by fostering social capital and economic growth (Immergluck and Smith 2006). Housing is also the biggest component of household wealth (Case, Quigley and Shiller 2013).

Beyond the direct impact on households' well-being, strong connections exist between the housing sector and the rest of the economy, in particular through the financial system (Greenspan and Kennedy 2007). In many developing countries, where financial systems are shallow, homes constitute the most important or even the only collateral of households' credit activities and consequently fluctuations in house prices affect households' investment decisions. For housing to be used as collateral, however, it is necessary to be able to determine the market value of real estate properties.

When price data and relevant physical and location characteristics of homes are available (e.g., size, amenities, and geographical position), quality-adjusted house price indexes can be constructed. Such indexes allow appraisers to value properties more accurately, improve lenders' ability to reclaim their loans, and facilitate borrowers' access to credit (see Warnock and Warnock 2008). Also, housing ministries may combine home price information with household income data to address issues related to access of low-income segments to housing finance instead of alternative mechanisms that risk distorting financial systems (e.g., subsidized interest rates). In general, house prices transmit information potentially relevant for welfare enhancing public policy and to the macroeconomy. Data collection and analysis may therefore be regarded as key policy objectives.

Realizing the numerous benefits derived from adequate housing and concomitant data, developed countries put a lot of effort into constructing house price indexes that (to varying degrees) attempt to account for possible distortions such as changes in the average quality of housing (see Table 1). However, it is widely observed that in a large proportion of emerging economies, like those in Latin America (LAC), there is less of a tradition of collecting such information and generating appropriate measures. Even in

such cases where they do so, housing time series are often handicapped by the lack of reliable data sources and limited coverage, as the existing information is mainly available for only a few years and only in large urban areas (see Parrado, Cox and Fuenzalida 2009; DANE 2013). These limitations can be extended upstream; publicly available data on housing starts/construction permits and construction cost indexes exist in only a few LAC countries (i.e., Brazil, Chile, Colombia, Costa Rica and Uruguay) and many authors point out that this inability to produce adequate information is a potential cause of the observed shallowness and inefficiency of housing finance systems in Latin America (Cubeddu, Tovar and Tsounta 2012; Cuevas, Lee and Bonilla 2011; Sancho, Rivera and Rosales 2012).

Insert Table 1 Here

In this study we try to take a step towards addressing these concerns for the case of Costa Rica. Every house is different both in terms of its physical characteristics and location. Simple median indexes confound changes in prices with changes in the quality of the median transacted dwelling. Hedonic indexes, which by construction adjust for quality change, are more informative about developments in the housing market. Our goal is to construct hedonic house price indexes for Costa Rica at national and provincial level, and for both the public and private sectors of the market.

To implement our hedonic regression analysis, we use quarterly observations for the period 2000-2013 from a dataset of construction permits for new houses obtained from the National Institute of Statistics and Census (NISC). The newly-built housing market represents an important share of the stock of existing units in many emerging economies (Wu, Deng and Liu 2014). We compute hedonic and median house price indexes, and then compare them with the NISC construction cost index which is based on monthly average prices of the most common materials used by the housing-construction industry. Our period of analysis includes a housing boom and bust characterized by high volatility in the real estate market. While land prices are not available for Costa Rica, the boom and bust can be seen in the number of permits issued in Figure 1(a), by the trend in real construction expenditure and total construction area in Figure 1(b), and by the level of housing credit in Figure 1(c).

Insert Figure 1 Here

While hedonic methods have been applied previously to monitor the quality of urban

life in Costa Rica (see Lora and Powell 2011, and Hall, Madrigal and Robalino 2008), to the best of our knowledge there have been no previous attempts to construct hedonic house price indexes for Costa Rica. We find that the quality-adjusted real price of newly built housing has stayed more or less constant during our sample period. It is also interesting to consider how the average quality of new-builds is changing over time. Comparing hedonic and median indexes, we find that the quality of newly built private housing rose strongly, while the quality of public housing fell during our sample period. Recipients of public housing therefore became worse off. The fall in quality was matched by a fall in price in the public sector, and hence generated cost savings for the government. Also, by estimating separate hedonic models for the public and private sectors, we are able to ask counterfactual questions such as: how much would each public sector house have cost if instead it had been built by the private sector? Using such an approach we demonstrate that public sector housing would not be produced more cheaply in the private sector. In this sense the public sector seems quite efficient.

The remainder of the paper is structured as follows. In section 2 we provide a brief description of the evolution of the economy during the period of interest. In section 3 we describe the methodologies employed for computing house price indexes. Section 4 describes the data set used in the empirical analysis. Section 5 presents our estimated house price and quality indexes at national and provincial level, as well as separate indexes for public and private housing. Also presented are indexes measuring changes in the average quality of new builds. Section 6 concludes.

2 The Costa Rican Economy and Housing Market 2000-2013

Universal access to suitable housing is a right granted by the Constitution of Costa Rica and it has been the flagship of administrations' social agendas for many years. Resources spent by the government have emphasized the expansion of coverage by seeking universal housing access for the poor. That emphasis on coverage has proved to be beneficial but insufficient to provide the quality that households require. As per the National Housing Census of 2000, Costa Rica recorded a housing stock of

935 000 units serving 960 000 households, leaving a deficit of about 25 000 units (3 percent). The estimated qualitative deficit – which includes houses not meeting the minimum acceptable conditions – reached about 150 000 units or 15 percent (MHHS 2013). The National Housing Census of 2011 reported a stock of 1 212 000 units for 1 237 000 households, representing a quantitative deficit of 25 000 units (2 percent) and a qualitative deficit of 145 000 units (12 percent).

Historically, the Costa Rican government has addressed housing deficits via free public housing for the poor and funding to authorized institutions to administer this system and encourage the growth of private sector housing. The system is supervised by the Real-Estate Mortgage Bank of Housing (BANHVI by its Spanish acronym), a second-tier bank that provides resources, norms, and surveillance to the entities that comprise the Housing Financial System, which includes banks and other public and private financial institutions. The BANHVI implements the national housing policy, managing public housing programs, and setting the minimum capital needed to underwrite mortgages in the private sector and functioning as a secondary market and administrator of grants.

In the last decades Costa Rican governments adjusted housing financial policies from traditional direct intervention schemes to acting mostly as a facilitator of private action (see Delgadillo 2007; Gonzales-Arrieta 2005). Government efforts to broaden participation of the private sector have played an important role in expanding the housing market. During the mid 1990s the country enacted changes in the regulatory measures of its financial system to level the playing field between private and public banks, strengthening competition in the market and allowing the participation of international institutions (see Sancho, Rivera and Rosales 2012). International standards and modernized credit information systems were implemented to better gauge the credit worthiness of debtors. As a result of these structural reforms, the aggregate value of the financial sector increased from 3.7 percent of GDP in 1991 to 6.4 percent in 2012.[1] As a consequence, housing credit in the private sector showed a steady growth during the 1990s with an

[1]Despite the rapid growth in credit during the last decade, financial intermediation levels in Costa Rica remain well below those of many other emerging countries, even after accounting for income per capita. Mortgage credit in Costa Rica stands on average at about 15 percent of GDP (22 percent of total credit), while its neighbor country Panama registers 29 percent of GDP (and 27 percent of total credit).

unprecedented expansion during the first half of the 2000s owing to favorable external conditions, internal sustained economic growth and stronger fundamentals, thus setting the conditions for a boom in construction activity (see Figure 1(c)).

The bar plot in Figure 1(b) shows total construction expenditure and total construction area in Costa Rica in the period Q1:2000–Q4:2013. It can be seen from Figure 1(b) that total construction area in square meters rose from about 100 000 per quarter in 2000 to about 500 000 in the final quarter of 2007 before falling back to under 300,000 one year later. This contraction in 2008 was caused by the global financial crisis, and ushered in a liquidity drought. Commercial banks and other financial intermediaries in the country reduced total housing credit in the economy as a share of GDP from 7 percent in 2008 to only 3 percent in 2012 and households suddenly faced more difficult conditions to get a mortgage. The international crisis eventually led to a brief domestic recession (see Figure 1(c)).

3 Methodologies for the Construction of House Price and Quality Indexes

3.1 Median house price indexes

Median indexes track the change in the price of the median dwelling built in each period. While this is relatively straightforward both conceptually and computationally, median indexes suffer from the disadvantage that they confound price changes with changes in the quality of the median dwelling over time. For example, coastal urbanization in Costa Rica, particularly along the Pacific coast, was triggered by an increased emphasis on high-quality and expensive houses in beach districts. During the period 2000-2008, particularly from 2005 on, the average dwelling was constructed in these exclusive areas, while after 2010 beach construction plummeted and new construction permits were mainly issued for public housing. Thus, a median index will exhibit high volatility over this period, with changes in the underlying price level being swamped by changes in the quality of the median dwelling.[2]

[2]The volatility of median indexes can be attenuated to some extent using a stratification procedure that combines more or less homogeneous groups in the data (see de Haan and Diewert 2013).

3.2 Hedonic price indexes

A hedonic model regresses the price of a product on a vector of characteristics (whose prices are not independently observed). The hedonic equation is a reduced form that is determined by the interaction of supply and demand. Hedonic models can be used to construct quality-adjusted price indexes for residential housing. One can distinguish between a house's physical and locational attributes. Examples of the former include the number of bedrooms, construction size, and the quality of materials. Locational effects in our context are captured by provincial and district dummy variables.

Hedonic price indexes for housing can be constructed in a number of ways (see Diewert 2011 and Hill 2013). Here we focus exclusively on the adjacent period (AP) method. The AP method uses a hedonic model to compare two adjacent periods. A longer time series is then obtained by splicing together the results of bilateral comparisons (e.g., $P_{t,t+2} = P_{t,t+1} \times P_{t+1,t+2}$, where $P_{t,t+1}$ denotes a price index comparing periods t and $t+1$). The AP method is a special case of the time-dummy method (see Hill 2013). However, the AP method has the advantage of greater flexibility in that it allows the characteristic shadow prices to change for each rolling bilateral comparison.

We assume a semi-log functional form for the hedonic model.[3] A standard semi-log formulation is as follows:

$$y = Z\beta + d\delta + \varepsilon, \tag{1}$$

where y is an $H \times 1$ vector of log prices p_h (i.e., $y_h = \ln p_h$), and $h = 1, \ldots, H$ indexes all the houses sold in say periods t and $t+1$. Z is an $H \times C$ matrix of characteristics (some of which may be dummy variables), β is a $C \times 1$ vector of characteristic shadow prices, d is a dummy variable for period $t+1$, δ is the estimated coefficient on the period $t+1$ dummy variable, and ε is an $H \times 1$ vector of random errors. Finally, H and C denote respectively the number of houses that sell in the two periods being compared and the characteristics on these houses included in the data set. The first column in Z consists of ones, and hence the first element of β is an intercept.

When the objective of the exercise is to construct a quality-adjusted price index, the primary interest lies in the δ parameter which measures the period-specific fixed effect

[3] See Diewert (2003) and Malpezzi (2003) for a discussion of some of the advantages of the semi-log model in this context.

after controlling for differences in the attributes of the houses. One attraction of the semi-log AP model is that the price index between periods t and $t+1$, $\hat{P}_{t,t+1}$, is derived by simply exponentiating the estimated coefficient $\hat{\delta}$ obtained from the hedonic model:

$$\hat{P}_{t,t+1} = \exp(\hat{\delta}). \tag{2}$$

4 The Data Set

We use a data set obtained from the National Institute of Statistics and Census (NISC) of Costa Rica that contains 228 306 observations. It consists of potential costs and characteristics of houses and dwellings with a construction permit for the years 2000-2013. For each dwelling we have (or in some cases construct) the following characteristics: the planned construction cost in Colones (COST), month of permit, number of floors (FLOOR), number of rooms (ROOMS), number of bedrooms (BEDS), high quality floor material (FLMQ), high quality wall material (WAMQ), construction area (AREA), geographical district (D), and BEACH for districts that have access to the beach. Some summary statistics are provided in Table 2.

Insert Table 2 Here

For a robust analysis it was necessary to remove some outliers. This is because there is a concentration of data entry errors in the tails, caused for example by the inclusion of erroneous extra zeroes. These extreme observations can distort the results. The exclusion criteria and statistics on the number of observations deleted are provided in the Appendix in Tables A1, A2 and A3.

The geographical distribution of the available data is summarized in Table 3 which includes the observations per province and the number of districts with access to the beach. More detailed information is provided in the Appendix in Table A4. We broke down our hedonic indexes at province level, three of them with coastlines (Guanacaste, Puntarenas, and Limon) and at district level to account for the impact of the beach on our results (one of the most desired characteristics for a high-quality house).

Insert Table 3 Here

5 Empirical Strategy

5.1 Regression results

Table 4 summarizes the results of the 55 adjacent period hedonic regression models that we estimated. Each regression is estimated over a pair of adjacent quarters. The first regression focuses on the first and second quarters in 2000, while the last focuses on the third and fourth quarters in 2013. The fit of the semilog functional form is good. The adjusted R squared coefficient is on average 0.93 and ranges between a minimum of 0.89 and a maximum of 0.95. This means that on average the included characteristics account for 93 percent of the cost variability of houses.

The coefficient on FLOORS fluctuated from positive to negative across the 55 hedonic model values and was not significant (i.e., the p-value > 0.05) in 21 of 55 cases. The coefficients on all other explanatory variables had the expected sign and were statistically significant. We also recorded a sizeable rise in the estimated coefficients over time, particularly the ones corresponding to the quality of materials, probably in part because of the boom in construction activity.

Insert Table 4 Here

The estimated coefficients of the hedonic model imply that:

- An extra square meter of construction area adds about 0.7 percent to the cost of a house.
- Each additional bedroom adds about 9 percent to the cost of a house.
- Each additional room adds about 6 percent to the cost of a house.
- Using high-quality floor materials adds about 18 percent to the cost of a house.
- Using high-quality wall materials adds about 9 percent to the cost of a house.
- A house being publicly built lowers its price by 11 percent.

5.2 National level price indexes

Real house price indexes for Costa Rica are depicted in Figure 2. (Corresponding nominal indexes are provided in the Appendix in Figure A1). Hedonic, median, and

NISC construction materials indexes are included in Figure 2. The volatility of the median index is quite striking. It is noticeable that the NISC series (which is only available up to 2012) is much smoother than the median series, suggesting that the NISC index is doing some kind of implicit quality adjustment. The nominal and real annual percentage growth rates are shown in Table 5.

Insert Figure 2 Here

Insert Table 5 Here

Our hedonic index and the NISC building cost index both show that over the whole period real building prices rose about 10 percent (see Figure 2). Nevertheless, there are important differences between the two indexes. In particular, our hedonic index shows that building costs fell by 30 percent from 2004 to 2005. Over this period the NISC index does not show any change in building costs.

5.3 Province level and beach district indexes

Real house price indexes for the seven provinces and for beach districts are depicted in Figure 3. The NISC index is only available at the national level, and hence it is not included in Figure 3. (Corresponding nominal indexes are provided in the Appendix in Table A2).

Insert Figure 3 Here

The hedonic indexes for each province in Figure 3 look quite similar to the national index in Figure 2. The median indexes are even more volatile for the provinces than at the national level. The year to year changes in the median indexes are seriously distorted by the lack of quality adjustment. A large discrepancy arises between the hedonic and median real house price indexes in Figure 3 for Heredia, due to a big increase in the share of private housing. Heredia aside, the longrun trends of the hedonic and median indexes are similar.

5.4 Changes in the quality of public and private housing

Price indexes for public and private housing are shown in Figure 4. From Figure 4 it can be seen that the median real price index for private housing rose by more than 60 percent, while the median real price index for public housing fell by about 10 percent.

By contrast, no such differences between public and private real price trends emerge for either the NISC or hedonic indexes. According to the NISC and hedonic indexes, real public and private prices both rose by about 10 percent during our sample period. As with Figure 2 though the NISC and hedonic indexes differ quite significantly on a year-to-year basis, particularly in 2004-5 where the hedonic index falls by about 30 percent while the NISC index is steady.

Insert Figure 4 Here

The divergent trends for public and private median indexes in Figure 4 can be attributed to changes in the average quality of public and private housing over this period. A measure of average quality of new structures is obtained by dividing a median house price index by its corresponding hedonic price index. As can be seen from Figure 5, the quality of private housing improved by nearly 50 percent, while the quality of public housing deteriorated. The decline in the quality of public housing predominantly takes the form of smaller structures and lower quality building materials. Corresponding graphs for the provinces are depicted in Figure 6.

Insert Figure 5 Here

Insert Figure 6 Here

The rise in average quality of private housing apparent in Figures 5 and 6 can be attributed largely to foreign investors. The decline in the quality of public housing after 2002 (also apparent in Figures 5 and 6) may have been a consequence of deliberate government policy (i.e., cost cutting), or reflect a lack of monitoring by the government of activities in the construction sector. The next subsection investigates this matter further.

5.5 Value for money in the public housing market?

Hedonic models can be used to ask counterfactual questions, such as how much would a particular publicly built house have cost if it had been built by the private sector. By comparing this hypothetical price with the actual building cost we can get a sense of whether the public sector is providing value for money.

This approach requires us to estimate a hedonic model specifically for the private sector. To ensure that the resulting imputations are relevant to the public sector, we restrict attention to private housing with not more than 60 square meters of living

space (since almost all public housing is smaller than this).[4] The private sector hedonic model, which is estimated separately for each year t, takes the following form:

$$y_t = Z\beta_t + Qq_t + \varepsilon_t, \tag{3}$$

where y_t is an $H_t^{priv} \times 1$ vector of log prices p_h (i.e., $y_h = \ln p_h$) of private houses sold in year t, H_t^{priv} is the total number of private houses sold in year t, Z_t is an $H_t^{priv} \times C$ matrix of characteristics (some of which may be dummy variables), β_t is a $C \times 1$ vector of characteristic shadow prices, Q_t is an $H_t^{priv} \times 3$ matrix of quarterly dummy variables, q_t is a 3×1 vector of quarterly shadow prices (for the second, third and fourth quarter), and ε is an $H_t^{priv} \times 1$ vector of random errors.

Once the hedonic model has been estimated, a counterfactual private sector price for each public sector house can be imputed from (3), by inserting that house's characteristics into the estimated hedonic model. This imputed price is denoted here by $\hat{p}_h^{priv}(pub)$, while the actual price of this house is denoted by $p_h(pub)$. For each quarter s (e.g., 2005 quarter 2) we calculate the geometric mean across all public sector houses completed in that quarter of this ratio as follows:

$$R_s^{priv}(pub) = \prod_{h=1}^{H_s^{pub}} \left(\frac{\hat{p}_h^{priv}(pub)}{p_h(pub)} \right)^{1/H_s^{pub}}. \tag{4}$$

We also consider the reverse counterfactual, where we impute what the price of private sector housing would have been if it had been built by the public sector (again restricting attention to private sector housing with a floor space not exceeding 60 square meters). This requires the estimation of a public sector version of the hedonic model in (3).

$$R_s^{pub}(priv) = \prod_{h=1}^{H_s^{priv}} \left(\frac{\hat{p}_h^{pub}(priv)}{p_h(priv)} \right)^{1/H_s^{priv}}. \tag{5}$$

The $R_s^{priv}(pub)$ and $R_s^{pub}(priv)$ indexes are shown in Figure 7. The key result in Figure 7 is that in almost all quarters both indexes exceed 1. This means that public housing would not be cheaper if it was built by the private sector (perhaps due to economies of scale deriving from the use of standard designs), and that private housing would not be cheaper if it was built by the public sector (perhaps due to the greater discipline of free market competition).

[4]Most public housing has a standard floor space of 42 square meters.

Insert Figure 7 Here

One must therefore be careful interpreting the performance of the public housing market. At first glance the decline in average quality looks problematic. However, the quality-adjusted price has not risen. In other words, the decline in quality has been matched by a decline in price. Furthermore, public housing would not be produced more cheaply in the private sector.[5] Hence this suggests that the decline in quality can be attributed to cost cutting efforts by the government rather than contracting and monitoring problems between the government and construction companies.

6 Conclusion

Fluctuations in the housing sector play an integral part in overall economic well-being of countries, as they affect decisions of households and financial institutions and the government. Therefore, identifying and understanding the factors that drive residential housing prices is of critical importance to policymakers and scholars. Even so, the state of existing house price indexes in Costa Rica is still poor. There is no national database of all real estate sales, and hence it is hard to assess the movement of house prices. The same situation is observed in many other countries in Latin America.

This paper presents the first hedonic price indexes for the Costa Rican housing market. Indexes are computed at the national and provincial level, and for both the public and private housing sectors of the market using quarterly data based on construction permits from 2000-2013. Our results demonstrate the importance of quality adjustment. Median house price indexes, which are not quality adjusted, fluctuate significantly from year to year, thus seriously undermining the information content of the index.

Our hedonic index shows that the real quality-adjusted price of new residential structures rose by about 10 percent from 2000-2013. This is broadly consistent with the existing NISC building cost index. However, the two indexes differ significantly on a year-to-year basis. In particular, according to our hedonic index building costs fell by 30 percent from 2004-2005. By contrast the NISC index was stable over this same period.

[5]One further consideration is the location of public housing. Public housing is typically located in less desirable locations, such as the outer suburbs of cities (see for example Dohnke, Heinrichs, Kabisch, Krellenberg, and Welz 2015 for the case of Chile). We do not explore this avenue here.

We find that the quality of private housing improved over time (at least partly due to a surge in foreign investors), while the quality of public housing deteriorated over the same period. The fall in quality of public housing mainly took the form of smaller structures and a decline in the quality of building materials in the floor and walls. The fall in quality, however, was matched by a fall in price, and hence the quality-adjusted price did not rise. Furthermore, we show that public housing would not be produced more cheaply in the private sector. This suggests that the decline in quality can be attributed more to cost cutting (presumably instigated by the government) rather than contracting and monitoring problems between the government and construction companies.

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Table 1: North America/Australia versus Latin America: data availability on house prices, housing permits and construction costs

Country	Available since	House Prices Frequency	Coverage	Housing Starts/ Permits	Construction Cost Index
Australia	1980	monthly	national	Yes	Yes
Canada	1999	monthly	national	Yes	Yes
United States	1987	monthly	national	Yes	Yes
Brazil	2010	monthly	urban	No	Yes
Costa Rica	2000	NA	NA	Yes	Yes
Chile	2004	quarterly	national	Yes	Yes
Colombia	1997	quarterly	urban	Yes	No
Mexico	2005	quarterly	national	No	No
Peru	1998	quarterly	urban	No	No
Uruguay	2000	monthly	urban	No	Yes

Sources: National Institute of Statistics and Census (NISC); Departamento Administrativo Nacional de Estadstica de Colombia (DANE) http://www.dane.gov.co; Cubbedu et al. (2012); Real Estate Institute of Australia.

Table 2: Summary of characteristics (after outliers removed)

	COST	ROOMS	BEDS	FLOORS	AREA	BEACH	FLMQ	WAMQ	PUB	CSM
Min	1 286 000	1.000	1.000	1.000	30.00	0.000	0.000	0.000	0.000	28 741
1st Q.	4 619 664	4.000	2.000	1.000	42.00	0.000	0.000	0.000	0.000	90 063
Median	6 820 000	5.000	2.000	1.000	54.00	0.000	0.000	1.000	1.000	121 535
Mean	11 195 440	5.519	2.438	1.075	77.95	0.076	0.396	0.708	0.533	132 214
3rd Q.	12 778 395	6.000	3.000	1.000	89.00	0.000	1.000	1.000	1.000	164 706
Max.	121 461 600	12.000	6.000	3.000	558.00	1.000	1.000	1.000	1.000	351 852

Note: COST is the cost of the structures measured in Colones. ROOMS denotes the number of rooms. BEDS denotes the number of bedrooms. FLOORS denotes the number of floors. AREA measures the area of land covered by the structure (including the walls). BEACH indicates whether the district is on the coast. FLMQ indicates high floor quality. WAMQ indicates high wall quality. PUB indicates public housing. CSM is the cost per square meter. CSM is used to identify outliers but is not one of the explanatory variables in the hedonic model.

Table 3: Number of observations per province (after outliers removed)

Province	San Jose	Alajuela	Cartago	Heredia	Guanacaste	Puntarenas	Limon
Districts	121	113	51	46	59	58	28
Obs	47 297	50 968	29 031	25 039	22 537	22 246	18 210
Beach districts	0	0	0	0	15	24	8
Obs	0	0	0	0	6 852	8 066	1 363

Table 4: Summary of econometric results from 55 adjacent period hedonic regressions

Estimated Coefficients and adjusted R-sq.										
	CONST	D	FLMQ	WAMQ	PUB	AREA	ROOMS	BEDS	FLOORS	Adj. R-sq.
Min	13.594	-0.088	0.088	0.033	-0.169	0.006	0.035	0.042	-0.091	0.887
Max	15.542	0.107	0.244	0.150	-0.037	0.008	0.079	0.160	0.051	0.950
Avg	14.714	0.022	0.166	0.085	-0.116	0.007	0.055	0.090	-0.019	0.920
p-values										
	CONST	D	FLMQ	WAMQ	PUB	AREA	ROOMS	BEDS	FLOORS	
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Max	0.000	0.789	0.000	0.000	0.000	0.000	0.000	0.000	0.984	
Avg	0.000	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.198	

Note: D is a district dummy variable. FLMQ indicates high floor quality. WAMQ indicates high wall quality. PUB indicates public housing. AREA measures the land area covered by the structure (including the walls). ROOMS denotes the number of rooms. BEDS denotes the number of bedrooms. FLOORS denotes the number of floors. The p-values indicate whether the estimated coefficient value is significantly different from zero. For example, a p-value of 0.01 indicates that the null hypothesis that the true value of a coefficient is zero would be rejected at the 99 percent significance level.

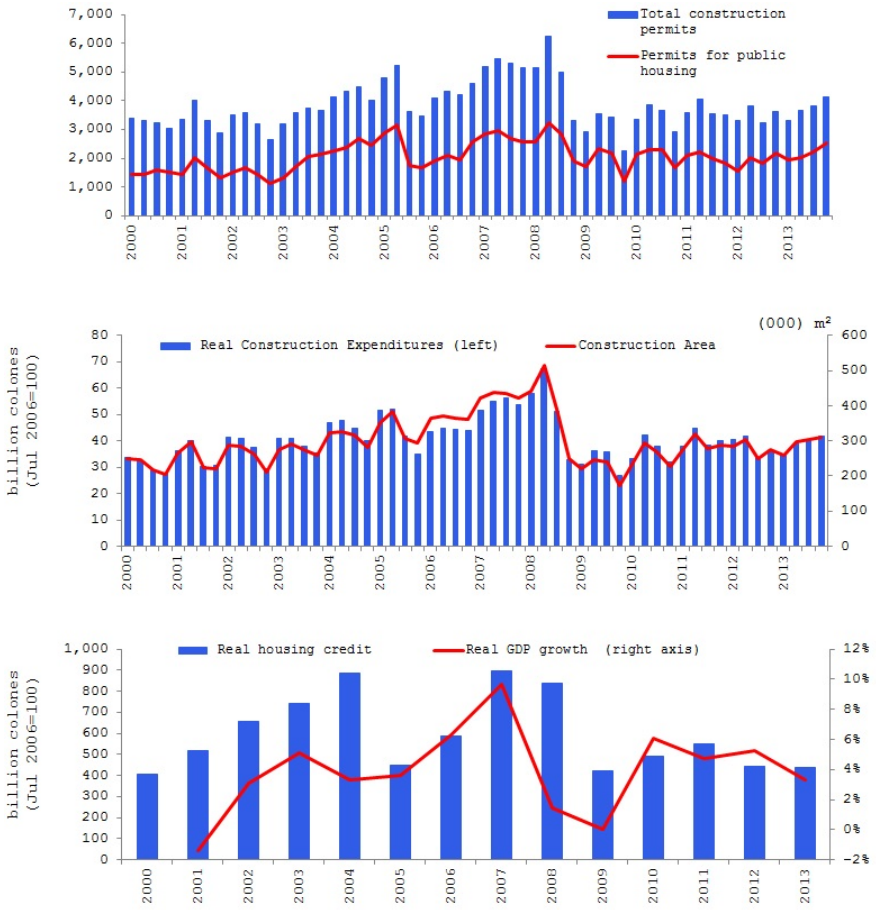
Table 5: Annual percentage real growth rates: Hedonic and median indexes

	2000-2013			2000-2007			2007-2013		
	Hedonic	Median	NISC*	Hedonic	Median	NISC	Hedonic	Median	NISC*
Costa Rica	0.0983	0.0861	0.1032	0.1112	0.1074	0.1145	0.0653	0.0278	0.0926
San Jose	0.0981	0.0859		0.1162	0.0990		0.0671	0.0398	
Alajuela	0.0980	0.0930		0.1075	0.1040		0.603	0.0226	
Heredia	0.0939	0.1430		0.1065	0.1914		0.0607	0.1059	
Cartago	0.0991	0.1152		0.1210	0.1261		0.0474	0.0790	
Guanacaste	0.0949	0.1127		0.0972	0.0936		0.0741	0.1068	
Puntarenas	0.1012	0.0917		0.1136	0.1128		0.0760	0.0361	
Limon	0.0910	0.0745		0.0996	0.0999		0.0777	0.0611	
Beach**	0.1233	0.1023		0.1085	0.1225		0.1758	0.0128	

*Data available only for 2000-2012

**Data available only for 2000-2010

Figure 1: Boom and bust in the Costa Rican economy and housing sector



a) Total construction permits and permits for public houses 2000 Q12013 Q4; b) real construction expenditure and construction area; c) Real housing credit and real GDP growth

Figure 2: Costa Rica: Real price indexes for newly-built housing

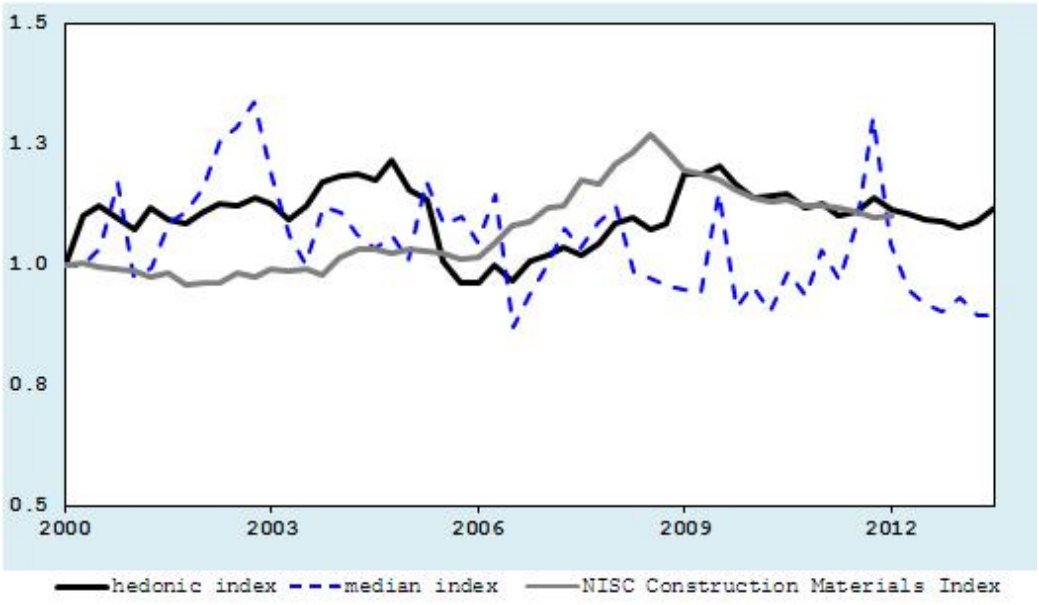


Figure 3: Provincial real price indexes for newly-built housing

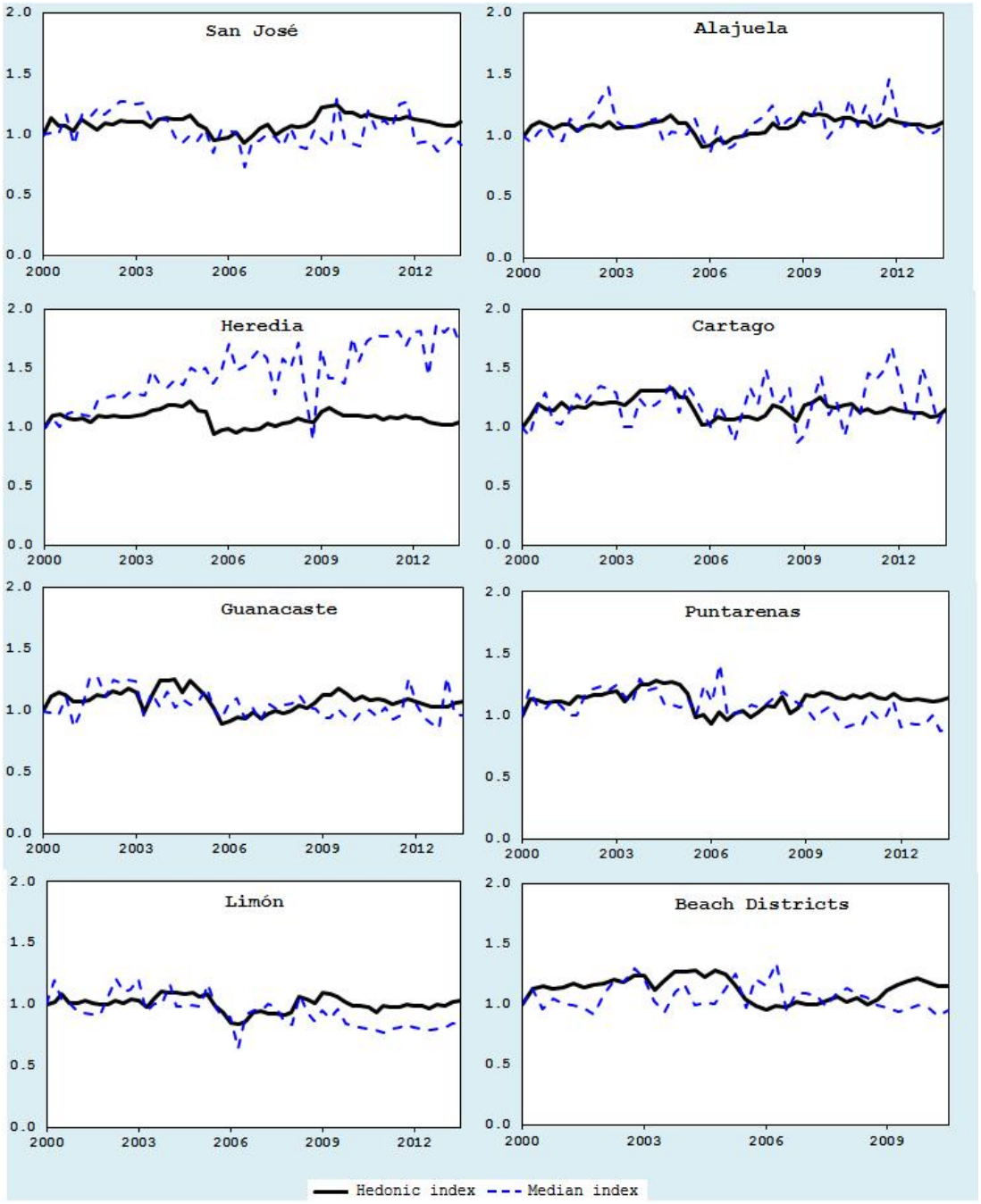


Figure 4: Costa Rica: Real price indexes for public and private housing (2006Q3=100)

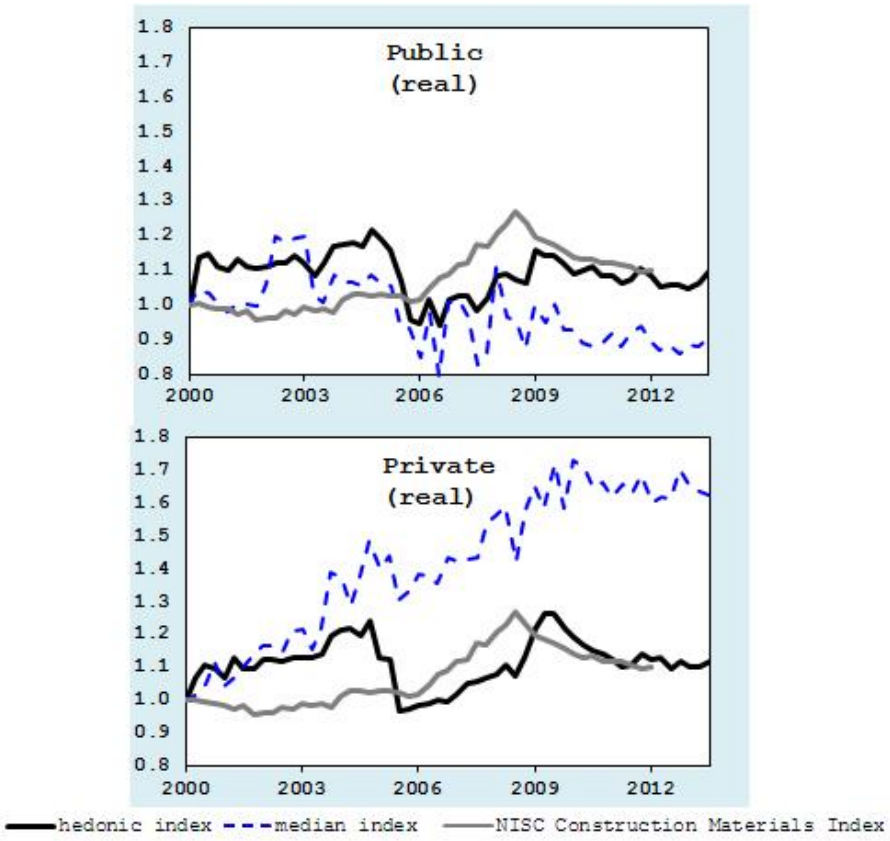


Figure 5: Costa Rica: Changes in the average quality of newly-built housing

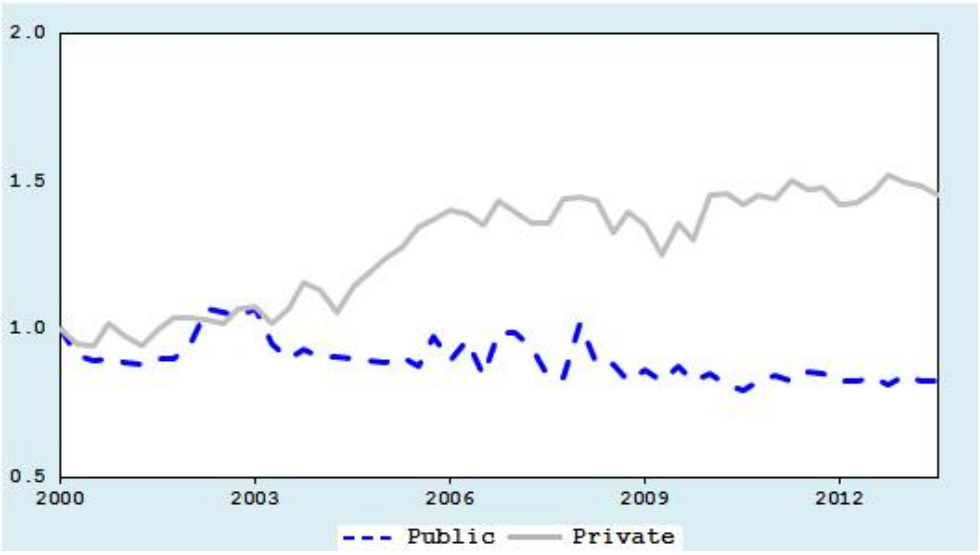


Figure 6: Changes across provinces in the average quality of newly-built housing

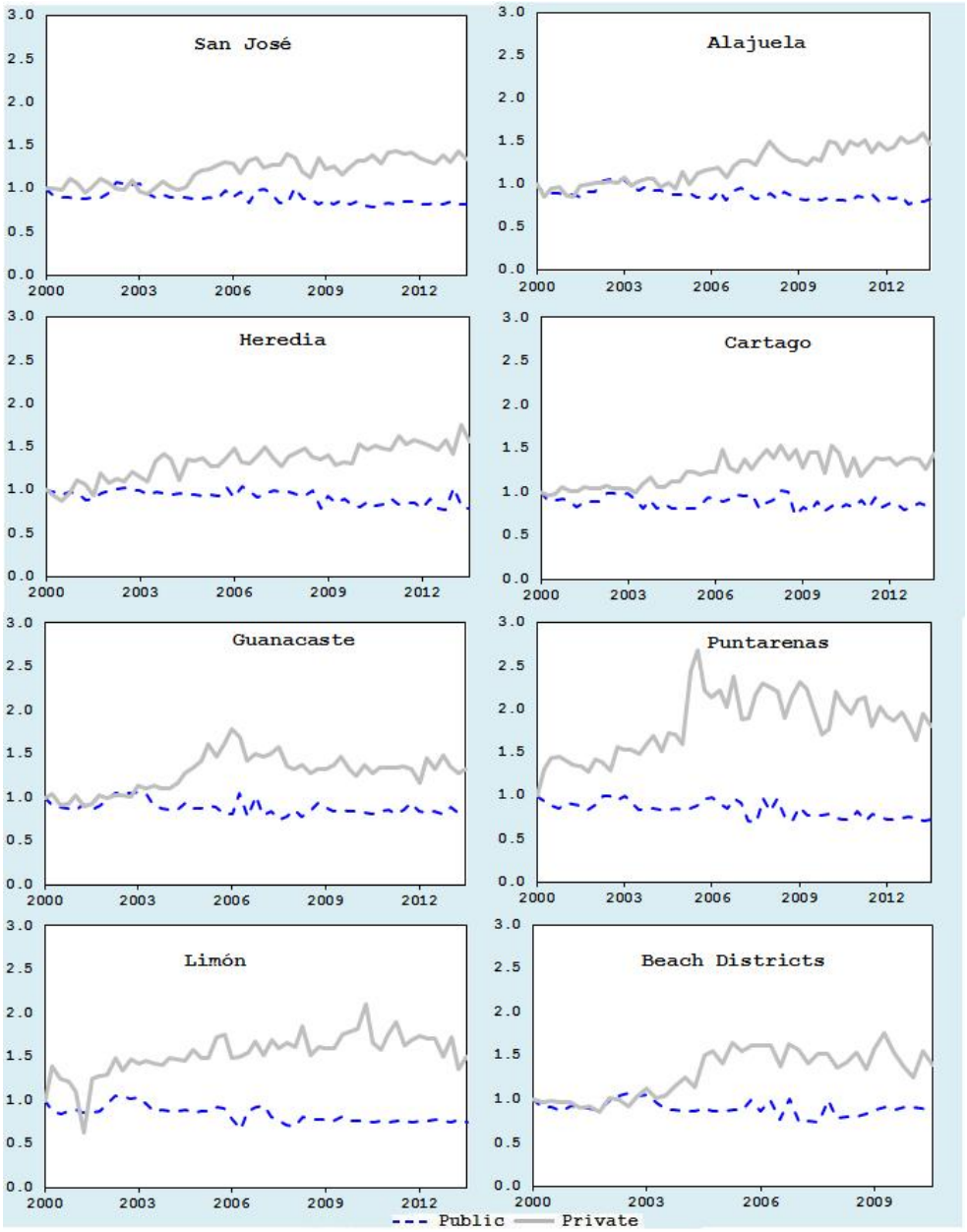
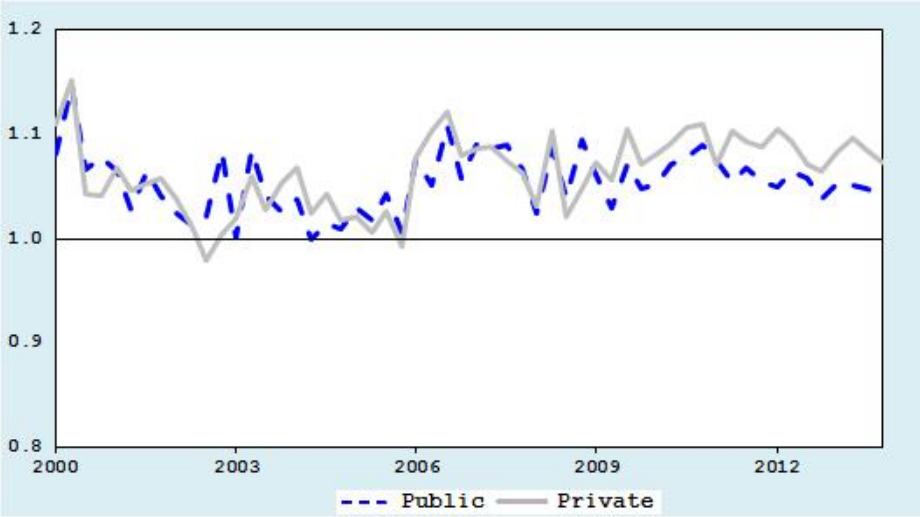


Figure 7: Costa Rica: Comparing the cost of building in the public and private sectors



Note: The series $R^{priv}(pub)$ asks the counterfactual question: How much would it have cost to build public sector housing in the private sector? If $R^{priv}(pub) > 1$ then it is cheaper in the public sector. If $R^{priv}(pub) < 1$ then it would have been cheaper in the private sector. The series $R^{pub}(priv)$ asks the reverse counterfactual question: How much would it have cost to build private sector housing in the public sector? If $R^{pub}(priv) > 1$ then it is cheaper in the private sector. If $R^{pub}(priv) < 1$ then it is would have been cheaper in the public sector.

Appendix (to be made available online)

The exclusion criteria we applied for *rooms*, *bed*, and *floor* are shown in Table A1.

Table A1: Criteria for removing outliers

	ROOMS	BEDS	FLOOR
Minimum Allowed	1	1	1
Maximum Allowed	12	6	3

For *area*, *csm*, and *cost* we excluded in each year the lower and upper 1%-quantile, see Table A2.

Table A2: Lower and upper 1%-quantile as criteria for removing outliers

	quantile	2000	2001	2002	2003	2004	2005	2006
AREA	1%	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	99%	483.36	640.00	504.00	510.98	492.29	473.04	517.00
COST	1%	1282260	1820500	1950756	2200000	2200000	2914243	2400000
	99%	42979340	54877000	60740118	64274184	70539295	67474457	83785265
CSM	1%	28636.36	42308.75	44000.00	46078.43	52380.95	72257.31	58000.00
	99%	109784.1	118943.3	132685.0	143558.0	163589.0	181187.0	210388.5
	quantile	2007	2008	2009	2010	2011	2012	2013
AREA	1%	30.00	30.00	30.00	32.00	30.00	30.00	32.00
	99%	467.76	476.00	466.12	447.66	458.00	414.00	450.62
COST	1%	3099497	3465000	3858800	4146400	4443801	4500000	4809461
	99%	88470000	102032100	125938080	120000000	128000000	112871032	123233095
CSM	1%	73261.79	78333.22	88888.89	92372.60	95107.25	105138.35	97187.36
	99%	241430.1	266163.7	344232.3	343286.4	341133.7	346748.8	352400.7

Note: The variable cost per square meter (CSM) is used to help delete outliers. However, it is not used as an explanatory variables in our hedonic models.

After the exclusion of outliers our we are left with a data set consisting of 215 328 observations. Table A3 shows the number of observations and the distribution of characteristics per year.

Table A3: Number of observations per year

	2000	2001	2002	2003	2004	2005	2006
Total	13 767	14 611	13 722	15 052	17 872	17 997	18 295
Removed							
ROOMS	454	647	409	438	427	357	415
BEDS	294	521	238	185	184	114	157
FLOOR	20	7	4	5	3	0	11
AREA	159	177	174	202	247	260	259
COST	276	293	276	251	225	360	359
CSM	274	294	263	289	323	360	365
Included	12 928	13 554	12 955	14 182	16 978	17 110	17 277
	2007	2008	2009	2010	2011	2012	2013
Total	22 257	20 800	12 989	14 735	15 722	14 748	15 739
Removed							
ROOMS	500	543	398	345	456	317	180
BEDS	151	164	124	65	86	55	48
FLOOR	3	2	4	1	0	1	0
AREA	278	252	169	295	220	213	311
COST	446	415	260	294	315	285	316
CSM	446	416	262	296	316	296	316
Included	21 097	19 674	12 142	13 810	14 731	13 963	14 927

The number of observations per province per year are shown in Table A4.

Our main focus is on real price indexes. The corresponding nominal versions of Figures 2 and 3 are shown below in Figures A1 and A2.

Table A4: Number of observations per province per year (after outliers removed)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
San Jose	3 255	3 482	3 431	3 419	3 902	4 091	3 845	4 368	4 207	2 493	2 889	2 705	2 595	2 615
Alajuela	3 489	3 611	2 762	3 499	4 216	3 766	3 525	4 803	4 637	2 832	3 229	3 548	3 429	3 622
Cartago	1 668	1 893	1 878	1 816	2 323	2 068	2 543	3 074	2 522	1 546	1 776	2 063	1 898	1 963
Heredia	1 582	1 661	1 845	1 991	2 000	2 102	2 222	2 297	2 141	1 203	1 358	1 631	1 518	1 488
Guanacaste	1 309	947	1 055	1 294	1 856	1 992	2 109	2 670	2 467	1 449	1 453	1 310	1 343	1 283
Puntarenas	1 018	1 020	1 125	1 237	1 558	1 822	1 947	2 294	1 958	1 364	1 678	1 629	1 698	1 898
Limon	607	940	859	926	1 123	1 269	1 086	1 591	1 742	1 255	1 427	1 845	1 482	2 058
Beach	948	991	1 042	1 136	1 545	1 861	1 982	2 206	1 929	1 251	1 390	0	0	0

Figure A1: Costa Rica: Nominal price indexes for newly-built housing

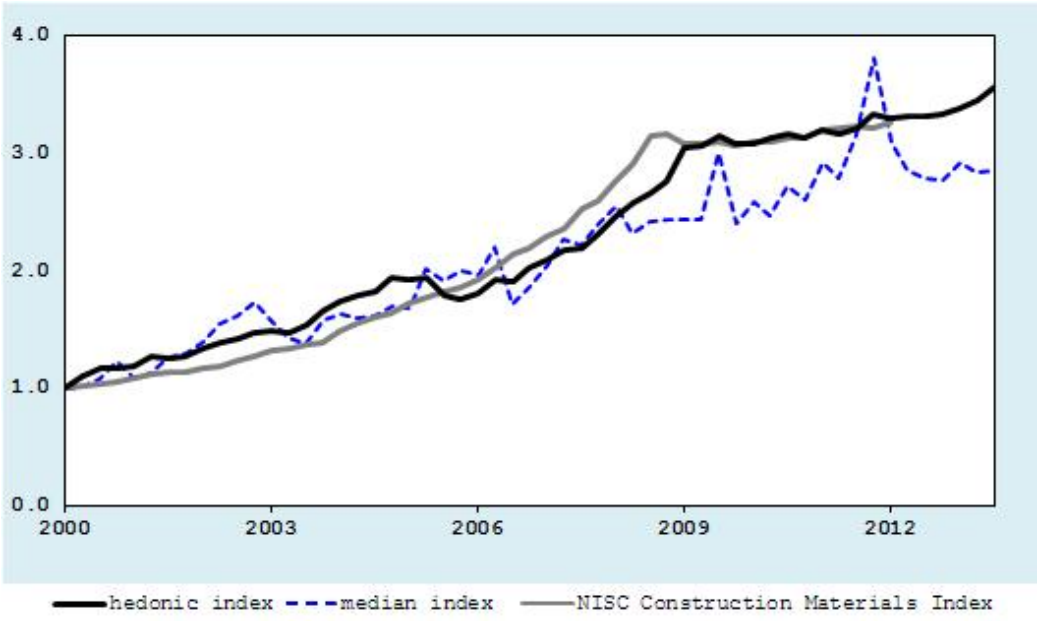
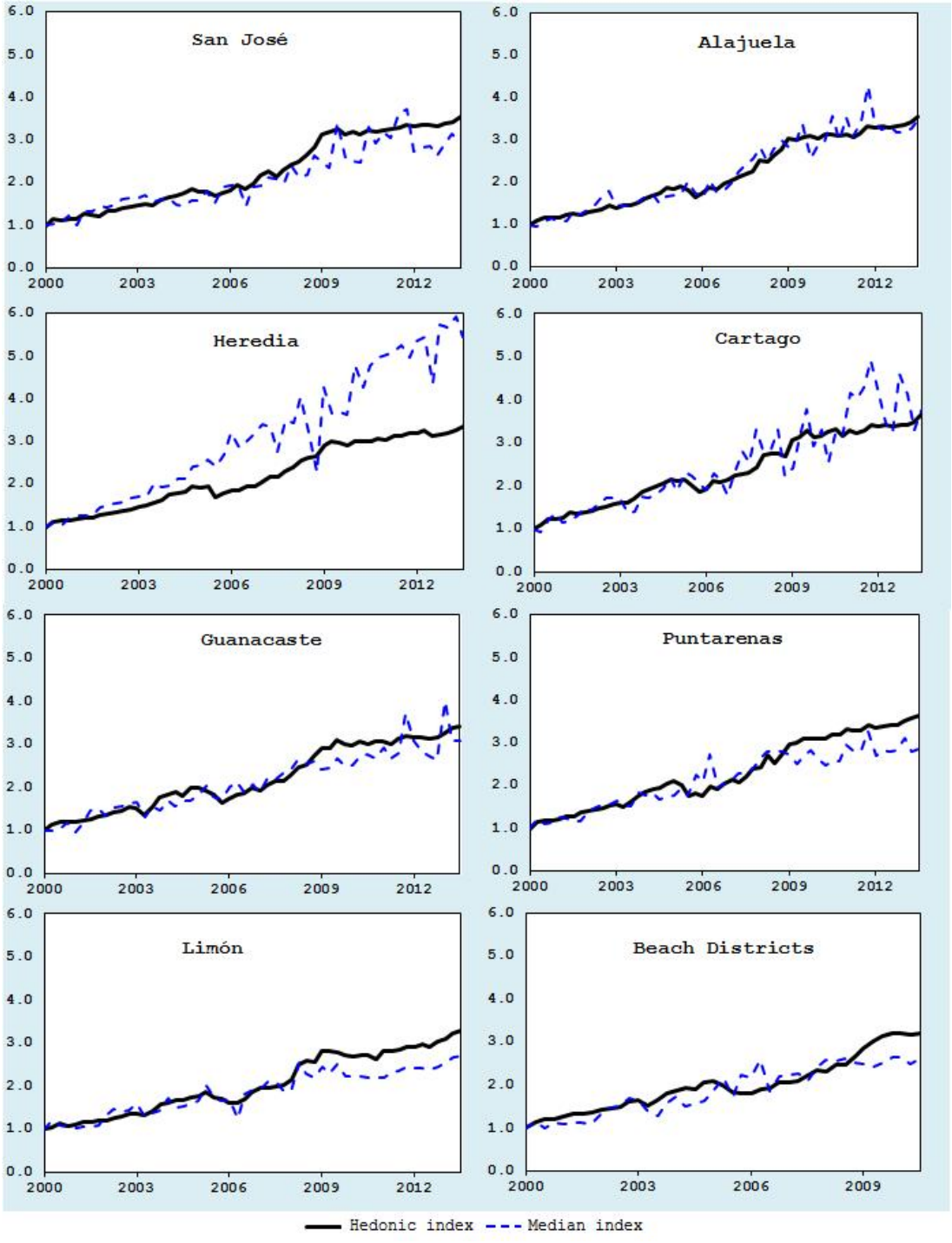


Figure A2: Provincial nominal price indexes for newly-built housing



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