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THE RELATIONSHIP BETWEEN HOUSE PRICES AND URBANIZATION IN LEBANON: A GRANGER CAUSALITY APPROACH

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House Price, Urbanization, Lebanon, Granger Causality

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Abstract

The purpose of this paper is to examine the mutual relationship between urbanization and house prices in Lebanon for the period 1993-2017. The underlying argument of this paper is to examine whether house prices affect and is affected by the rate of urbanization. It argues that a significant rise of rural-urban migration can contribute to the rise in house prices. Similarly, a substantial rise in house prices can eventually limit rural-urban migration and slow down the pace of urbanization. In Lebanon, urbanization has increased at varying rates since 1993 and housing prices might have been affected by urbanization, or could, at the same time, might have affected urbanization growth in Lebanon. Although many papers investigate the effect of urbanization on the real estate market and housing prices, papers examining the mutual relationship between both variables are scarce. The Granger causality is used to explore the two-way relationship between urbanization and housing prices in five different areas of the capital Beirut. The preliminary evidence suggests that the rise in house prices in Beirut over the period 2007-2011 seems to have slowed down urbanization growth a mutual effect exist but that the episodes of large increase in house prices in Beirut are not determined by urbanization growth but speculative demand generated by non-residents.

Keywords

House Price, Urbanization, Lebanon, Granger Causality

1. INTRODUCTION

In the last century, migration from remote rural regions to urban areas has grown substantially. In the 1950s, less than a third of the world population resided within urban areas. Today, this figure has nearly doubled, with circa 55% of the world population living in cities which are characterised by their high population density. However, in comparison, the pan-Arab region urbanized at a faster rate, with a stark increase from 25.3% in 1950 to more than 58% as of today. As it stands today, the Arab region shares a similar urbanization rate to the general world average.

Conversely, Lebanon depicts an alternative scenario. First, urbanization patterns in Lebanon have always exceeded the regional rates apparent within the Arab region, and consequently above the world average. Secondly, and more importantly, the urbanization process in Lebanon has substantially escalated since the 1950's. In fact, the gradual shift in residence of the human population from rural to urban areas has nearly tripled and is at almost a staggering 88% (see Figure 1).

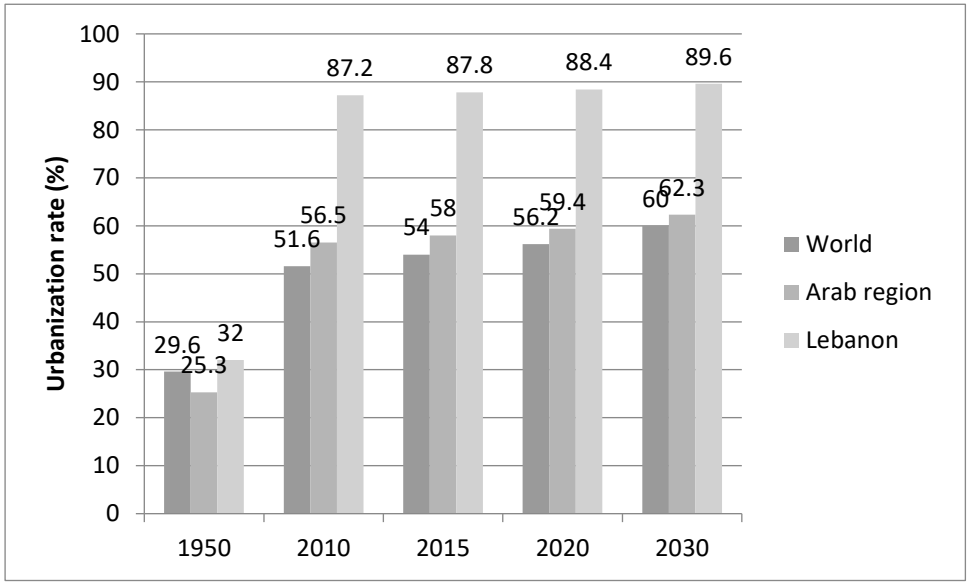

Fig.1: Urbanization in the World, Arab region, and Lebanon

(Source of data: ESCWA, 2017)

The increased levels of urbanization around the globe is considered to be a challenge in regards to the attainment of both adequate health levels and well-being amongst the general population. As a consequence, in 2015, the United Nations General Assembly specified SDG11 as part of its 2030 Agenda for Sustainable Development to address issues related to cities and human settlements and to ensure such goals are sustainable. The concept of urbanization and housing availability are interrelated in the sense that a primary goal of urbanization is to ensure that habitual cities are inclusive, safe, resilient, and sustainable while ensuring the availability of affordable housing.

Housing prices in Lebanon underwent several waves of fluctuations since the reconstruction of the country after the Civil War in 1993. Since 1993, the prices of housing in Beirut have increased at a CARG of 5.23%; however, one of the defining episodes of the alteration in pricing since 1993 comes as a result of the aftermath of the 2006 war. It has been recorded that between 2007 and 2011, the CARG reached nearly a staggering 13.37%. Since then, house prices abated and gradually declined. The sharp increase in house prices has reduced housing affordability, as documented by Nassereddine (2014).

The underlying premise of this paper is to examine whether the change in house prices affects and is affected by the rate of urbanization. For instance, this paper argues that a significant rise in rural-urban migration can potentially contribute to the rise in house prices. Similarly, a substantial rise in house prices can consequently lead to the eventual limit of rural-urban migration and simultaneously slow down the pace of urbanization. To be more precise, urbanization has increased

at fluctuating levels since 1993 which could have possibly had a knock-on effect on house prices as well as urbanization growth in Lebanon. As such, the increased pressure on urban areas contributes to an increase in property prices due to the increased demand, and the eventual saturation of the property market.

Despite that fact that the common denominator amongst a vast majority of research papers is to investigate the effect of urbanization on the real estate market and housing prices, papers which examine the two-way effect between housing prices on urbanization are practically inexistent. Even on a theoretical level, seldom does any framework draw correlations between the two concepts using the two-way causality approach. Using the Granger causality concept, this paper aims to explore the two-way relationship between housing prices and urbanization over the period 1993-2017 in five regions of Beirut in Lebanon, namely Ashrafieh, Beirut Central District (BCD), Mazraa, Moussaytbeh, and Ras Beirut.

This paper is divided into five parts. The next section covers the literature review on urbanization and house prices, followed by a section on the methodology. Section 4 analyses the results, and the last section concludes.

2. LITERATURE REVIEW

The literature incorporated within most papers in regards to the topic of urbanization have focused on the implications of urbanization on the real estate industry in China. This is because the process of urbanization in China has increased rapidly in the last two decades and has had a substantial effect on the Chinese economy and its real estate market. The majority of these papers find evidence that urbanization has a significant effect on the real estate market and plays an instrumental role in the cause of the rise in housing prices.

2.1. Urbanization Effect on Housing Prices

A study by Yong-min (2011) which was based in china, examines the linear and nonlinear effect of urbanization on house prices in a panel of 30 regions within the time frame between 1998 to 2009. The paper argues that the "housing bubble" is caused by many factors, but more fundamentally, by the influence of urbanization policy. In the long term, urbanization can have a substantial effect on house prices in the future due to the enormous demand it generates for the establishment of real estate and the rise in real estate investment. Similarly, the rise in urbanization levels has been fueled by the new urbanization plan in China which in turn has had a positive effect on house prices. This is centered around the notion that the implementation of an urbanization plan propels the establishment of significant infrastructure projects which consequently brings value to real estate and elevate prices. However, in the long term, that effect on real estate prices becomes limited due to the fact that it has already increased and regulated based on the purchase power.

Similarly, Xu and Ouang (2013) investigated the effect of urbanization rates on the real estate market demand in 31 provinces in China between 2000 and 2011. Using a nonlinear threshold variable, urbanization promotes demand in the real estate markets; however, the effect is lessened after certain levels of economic growth.

Huang and Shleifer (2017) argue that the trend characterised by the increase in urbanization accompanied by the rise in incomes in China have ultimately contributed to higher real estate prices. The paper argues that the rise in house prices has occurred in spite of the comparatively conservative mortgage lending practices in comparison to those in the United States housing bubble.

Another study by Xu and Wang (2017) explores the correlation between urbanization, house prices, and the rate of housing sales between 2005 and 2014 in 31 provinces within China. According to the paper, the rise in urbanization leads to a more proportional increase in housing sales, and the increase in house prices raises the housing sales rate.

A study conducted in Melbourne, Australia, examines the relationship between urban consolidation and housing prices for the period 1991-2004. Han and O'Connor (2008) argues that urban consolidation contributes to higher demand but find weak statistical connections between urban consolidation and housing prices.

In Europe, Xue-zeng (2012) examines the relationship between industrialization, urbanization, and the real estate industry. The results of this study show that industrial capitalism fosters an increase in the rate of urbanization, and in turn, urbanization affects the real estate industry. In other words, in terms of causality, it is the real estate industry that depends on urbanization rather than the other way around.

Liu and Roberts (2013) examines the counter-urbanization process in the UK which first emerged in the 1970s. With particular attention paid to the Aberdeen housing market area, this paper argues that there is a spatial price transmission mechanism at play between urban and rural areas of Aberdeen. This paper argues that careful urban planning eases the rise in house prices and affects the mediation of house prices between both rural and urban areas.

2.2. Housing Price Effect on Urbanization

As previously mentioned, the number of papers which are dedicated to exploring the other side of the relationship, from house prices to urbanization, is scarce. The study of Helpman (1998) is one of the earliest attempts at examining the effect of house prices on urbanization levels. The results revealed a substantial negative relationship on the price of urbanization which in turn explains that the increase in house prices correlates positively with the decrease of urbanization. Similarly, Plantinga et al. (2013) show similar results to those of Helpman (1998).

Studying the effect of house prices on urbanization rates in 28 provinces in China within the period 2001-2009, Yong-Le et al. (2017) found that different types of property prices have varying effects on urbanization across time intervals and regions. The results of the study showed a negative effect of residential property prices on urbanization only in the period 2005-2009, but an insignificant effect in the entire period 2001-2009. In contrast, commercial property prices reveal a significant positive effect, while industrial property prices have no effect on urbanization.

On the contrary, Lin et al. (2018) examine the effect of house prices on urbanization in 31 provinces within China. The results vary between the national and regional levels. For instance, whilst the results disclose a positive effect at a national level, on a regional level they reveal a negative effect and this is explicitly within the Midwest region. It is important to note that the aggregation of data at a national level played an instrumental role in converting the effect from a negative to a positive one. The paper argues that the effect of house prices on urbanization operates through labor mobility. Greater house prices tend to slow down labor mobility from rural to urban areas and, as a result, reduces urbanization. In other words, the substantial price of houses is essentially what raises the cost of urbanization.

2.3. The Two-Way Effect between Urbanization and House Prices

One of the very few studies that examined the two-way relationship between urbanization and real estate prices found a significant relationship in regards to the reverse relationship between both urbanization and real estate prices. In a study within the Zhejiang province of China in the period between 1991-2009, Chen et al. (2007) examined the long-term correlation between urbanization and real estate prices. The results found a positive effect of urbanization on real estate prices. In other words, an increase in urbanization levels has a long term positive effect on the price of houses. On the other side of the relationship, the rise in real estate prices has not led to increased urbanization. One could consequently conclude that house prices seem to have a "dumping" effect on the level of urbanization.

3. RESEARCH METHODOLOGY

A multitude of variables are probed in order to show whether they contain useful information for predicting house prices in this study. Once the stationarity of a variable is validated by a unit root test and the optimal lag lengths are selected respectively, these selected variables can be used in a pairwise Granger causality test.

As we know, the Granger causality test is applicable in time series by which it causes and help predict its effect. Granger causality allows for stating out the prevalent causal variables. The main prognosis of the Granger causality test is based on the VAR model. In cases where one is

interested in considering two dimensional systems, then Granger causality is most useful and applicable (Barnett and Seth, 2014). This paper aims to explore the two-way relationship between housing prices and urbanization over the period 1993-2017 in Beirut, Lebanon.

3.1. Model Specification

Theoretically, since we are using the rate of urbanization growth, it would be more apt to use the percentage change in house prices. We interchangeably utilised the house prices of the five areas of Beirut, (which are considered to be the most considerably urbanised areas in Lebanon) namely Ashrafieh (Ash), Beirut Central District (BCD), Mazraa, Moussaytbeh (Mous), and Ras Beirut (RB). In addition to the house prices in the aforementioned areas, the average house price in those areas was also utilised.

Moreover, the variables which are measured in nominal terms will be kept as such as opposed to utilising the real values since the aim of the study is to examine the two-way causality with the rate of growth of urbanization. In other words, the current study explores the influence of the rate of growth of urbanization with the rate of growth of house prices rather than its level.

3.2. Data Sources

The data in regards to the rate of growth of urbanization was collected from the World Development Indicators dataset for the period of the study between 1993 and 2017. The shortage of data for house prices in Lebanon was discernible. It is important to note that the data was gathered from Infopro and is based on the price per square meter for the five areas within Beirut. Since the data for certain time frames in the current study is missing (mainly in the period between 1993-2003) a confirmatory approach is used to fill the gaps by relying on real data from real estate agents who have operated in the market over the whole period and have extensive experience of the real estate market in Beirut. Five real estate agents were questioned in order to collect data on the price of houses in the five areas in Beirut over the whole time period. Despite the potential limitations of this approach, it is the only option available in order to realize the current study. As such, this study is limited to 25 observations.

3.3. Data Analysis

3.3.1. Descriptive statistics:

The summary statistics make it possible to predict the two-way relationship between housing prices and urbanization. The measures used are the measures of tendency and measures of spread. The used central tendency measure is the mean and the measure of the spread includes the median, in addition, to the minimum and maximum variables, which are included in Table 1. The data reveals a wide variation in house price per square meter ranging from a circa $1,400 in Mazraa to almost $4,190 in Beirut Central District. The same applies to the median of the house prices. The annual growth of urban population has an average of 3.32% over the period 1993-2017 while the median is slightly lower at 2.9%.

Table 1: Summary Statistics, using the observations 1993 – 2017

Variable	Mean	Median	Minimum	Maximum
Ashrafieh	2025.25	1350.00	1000.00	3680.00
Beirut Central District	4189.60	4000.00	2000.00	6650.00
Ras Beirut	2783.38	2050.00	1000.00	5150.00
Mazraa	1399.36	850.000	500.000	2635.00
Mousaytbe	2399.18	1900.00	1000.00	4250.00
Urban population annual growth	3.32474	2.90786	0.737811	7.20048

3.3.2 Time-Series analysis

Time-series analysis is concerned with the investigation of single or multiple observations over separated intervals of time. Time-series analysis help to predict the future behavior of measurement based on observations of its past behavior. The core aim of the time-series here is to explain the relationship between observations during past periods, and how these observations are correlated and then induce future predictions based on any hit and error in explanatory variables (Hill,2008 pp.338).

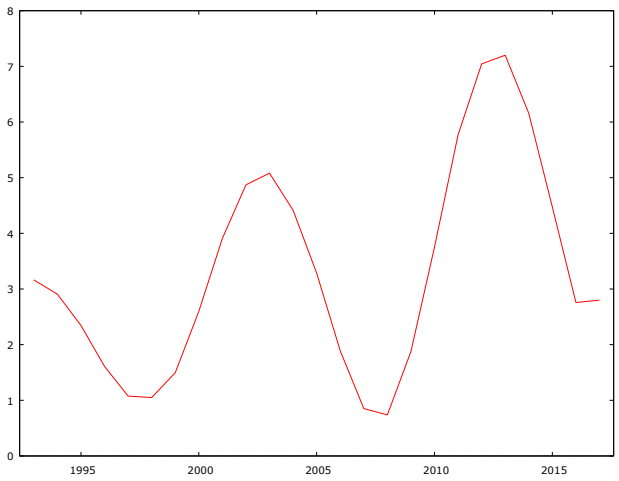

Fig.2: Annual Growth of Urban Population

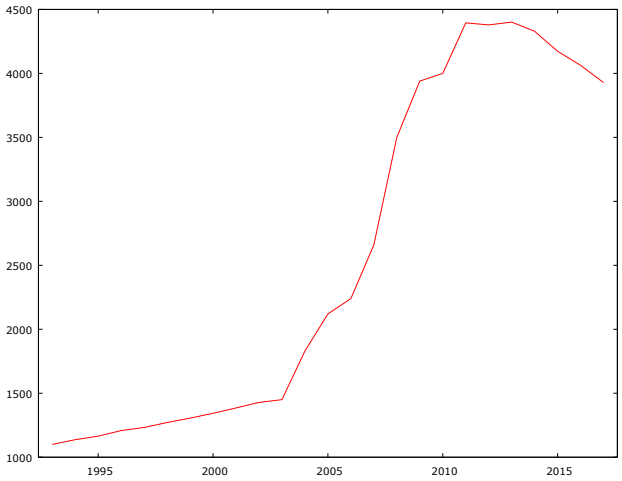

Fig.3: Average House prices in Beirut

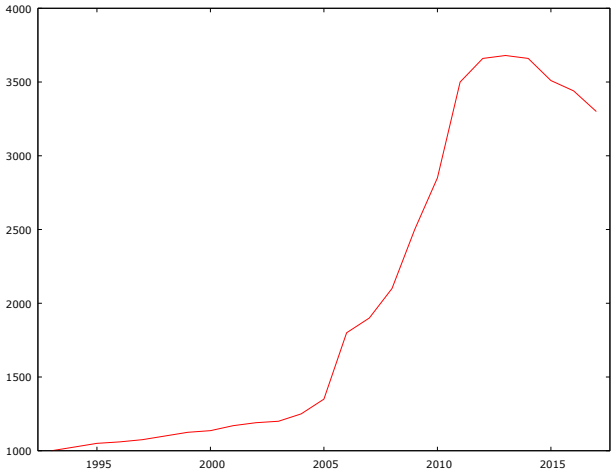

Fig.4: House prices in Ashrafieh

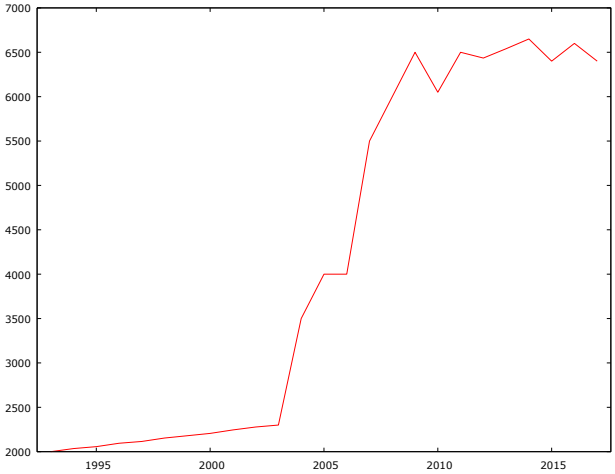

Fig.5: House prices in Beirut Central District

Fig.6: House prices in Moussaytbeh

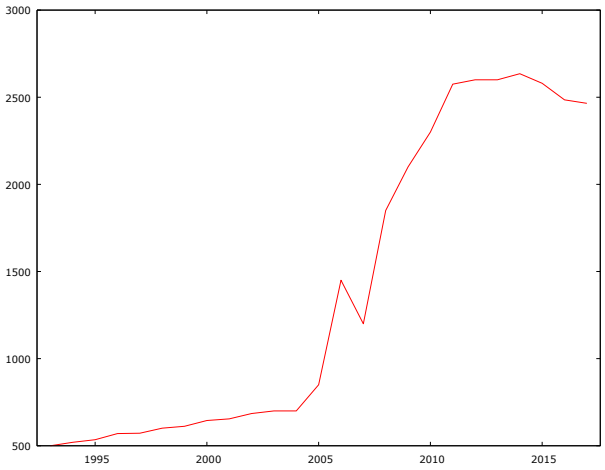

Fig.7: House prices in Mazraa

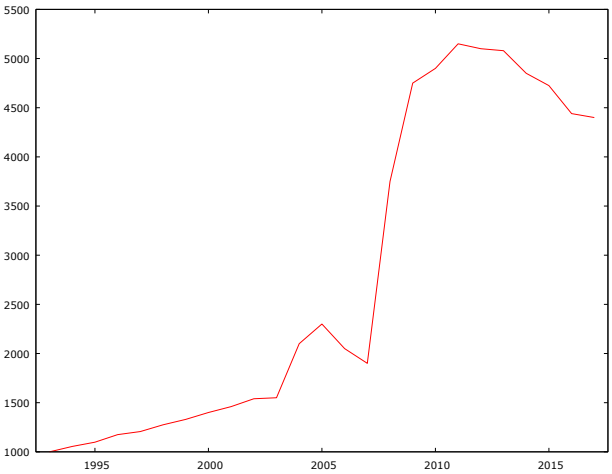

Fig.8: House prices in Ras Beirut

In Figure 2, the annual growth of urbanization fluctuation around the mean of 3.32%. As for the house prices in the five areas of Beirut, Figure 2 to Figure 8 show similar trends. This trend is reflected in the average house price which also show a sharp increase after 2006 followed by the start of reverse trend since 2011. Despite the similarity, there are some differences: the level of prices, fewer fluctuations in Ashrafieh, and BCD (Fig. 2).

3.3.3. Unit root test

The first step lies in checking the stationarity of the data used. Using non-stationary variables in the Granger causality test will produce spurious results. As such, the Augmented-Dickey-Fuller (ADF) unit root test is used to check for the stationarity of the variable. Because the percentage change of the variables is used, these variables show no trend, and as a result, the trend option for the test will not be used. The results of the ADF test without and with constant is provided in Table 2.

Table 2: ADF unit root test

Variables	ADF unit root tests			
	Without constant		With constant	
	tau_nc(1)	P-value	tau_nc(1)	P-value
U_Growth	3.06949	0.9996	2.27755	1
Percent-Aver	-0.167366	0.3202	-2.52265	0.1234
Percent_Ash	-2.34949	0.02115	-2.79394	0.07468
Percent_BCD	-3.69207	0.0007558	-4.21068	0.003554
Percent_RB	-3.79356	0.0005792	-4.14015	0.004174
Percent_Maz	-1.17281	0.2206	-5.33203	0.0002665
Percent_Mous	-3.43851	0.00146	-3.77118	0.009598

The results in Table 2 shows all variables are stationary without constant expect Urbanization growth (U_Growth) and the percentage change in house prices (Percent_Av), and percent change of house prices in Mazraa (Percent_Maz). When a constant is added to the test, all variables are stationary except Urbanization growth (U_Growth) and the percentage change in house prices (Percent_Av) that remain non-stationary. In light of the graphs for the variables, the test with constant seems more relevant since the variables are not fluctuating around zero.

As such, we run the ADF test on the first difference of the non-stationary variables. The results in Table 3 and 4 shows that U-Growth and Percent-Av both turn stationary with and without constant.

Table 3: ADF unit root test (1st Difference)

Variables	ADF unit root tests			
	Without constant		With constant	
	tau_nc(1)	P-value	tau_nc(1)	P-value
Diff1_U_Growth	-1.98737	0.04686	-2.81063	0.05673
Diff1_Percent-Aver	-2.07711	6.123e-008	-2.2915	0.01828

Table 4: ADF unit root test (2nd difference)

Variables	ADF unit root tests			
	Without constant		With constant	
	tau_nc(1)	P-value	tau_nc(1)	P-value
Diff2_Percent-Aver	-6.12018	0.0387	-5.91177	1.895e-006

The test is based on the null hypothesis that the variable follows a unit root process. The null hypothesis is rejected when the p-value is less than or equal to a specified significance level, often 0.05 (5%), or 0.01 (1%) and even 0.1 (10%). The approximate p-value is 0.2924, so would fail to reject the null in all cases.

3.3.4. Cointegration test

Before running regressions based on the above unit root results, the methodological approach implies to check for cointegration between variables. The results of the Johansen test of cointegration in Table 5 show that variables are not cointegrated based on the Trace test and maximum Eigenvalues. This implies that the VECM model is not applicable, and a VAR model is pursued instead.

Table 5: Cointegration results

	Rank	Eigenvalue	Trace test	p-value	Lmax test	p-value
d_U_Growth and d_Percent_Av	0	0.61899	24.067	0.0016	21.228	0.0026
	1	0.12104	2.8384	0.0920	2.8384	0.0920
d-U_Growth and Percent_Ash	0	0.30800	11.494	0.1853	8.4679	0.3409
	1	0.12329	3.0262	0.0819	3.0262	0.0819
d-U_Growth and Percent_BCD	0	0.47415	17.637	0.0218	14.783	0.0393
	1	0.11669	2.8537	0.0912	2.8537	0.0912
d-U_Growth and Percent_RB	0	0.53274	20.869	0.0060	17.500	0.0131
	1	0.13626	3.3692	0.0664	3.3692	0.0664
d-U_Growth and Percent_Maz	0	0.60328	24.264	[0.0014]	21.264	[0.0026]
	1	0.12229	3.0002	0.0833	3.0002	0.0833
d-U_Growth and Percent_Mous	0	0.44654	16.764	0.0303	13.606	0.0617
	1	0.12830	3.1582	0.0755	3.1582	0.0755

4. RESULTS

We ran the Granger-Causality test using the vector autoregressive model between the following pair of variables: the first difference of urbanization growth and interchangeably with the second difference of the average housing price, the percentage change of house prices in Ashrafieh, Ras Beirut, Beirut Central District, Mazraa, and finally Moussaytbeh. We chose three lags in light of the VAR lag selection test. Table 6 shows the result of the Granger-Causality test between the first difference of urbanization growth and the second difference in the average housing price. The remaining results for each of the five regions in Beirut are provided in Appendix sections 1 to 5.

The results reveal that the direction of causation is more statistically significant from housing prices to urbanization. For instance, the effect of house prices on urbanization is considered to be lagged. The first and second lags of average house prices have a significant negative effect on urbanization growth. House prices have one to three years delayed effect on urbanization growth. The results have also proved that each of the five regions in Beirut provide similar insights. The lagged values of house prices have a negative effect on subsequent values of urbanization growth. These results are mostly for the first and second lagged values of house prices.

On the other hand, urbanization growth does not seem to have a significant effect on house prices. The signs of the coefficients for the effect of urbanization growth on the average house prices and across the five regions of Beirut are inconsistent. This might be due to the lack of data for urbanization in every specific region. One would expect that higher urbanization increases demand on house prices and subsequently raises house prices. But it seems that house prices in Lebanon were not fuelled by the increase in urbanization but by speculation instead. In that sense, the demand on real estate is not generated by urbanization but by non-residents entering the market to gain from the rising momentum of house prices.

Table 6: Granger Causality of d_U_Growthannual and d_d_P_AvPrice

Equation 1: d_U_growthannual (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.16925	0.0754994	2.2417	0.0447	**
d_d_P_AvPrice_1	- 0.00673241	0.00272488	2.4707	0.0295	**
d_d_P_AvPrice_2	- 0.00671442	0.00277339	2.4210	0.0323	**
d_d_P_AvPrice_3	- 0.00295322	0.00224056	1.3181	0.2121	

R-squared	0.966552		Adjusted R-squared	0.949827
F(6, 12)	312.6570		P-value(F)	1.83e-12

Equation 2: d_d_P_AvPrice (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.102034	1.1495	0.0888	0.9307	
d_Urbanpopulationgrowthannual_1	−16.6874	12.3672	−1.3493	0.2021	
d_Urbanpopulationgrowthannual_2	25.491	20.3203	1.2545	0.2336	
d_Urbanpopulationgrowthannual_3	−13.078	12.6734	−1.0319	0.3225	

R-squared	0.741208		Adjusted R-squared	0.11812
F(6, 12)	39.14557		P-value(F)	3.39e-07

5. CONCLUSION

The literature on the relationship between house prices and urbanization is largely inconclusive. Some studies have identified a two-way relationship, while other studies have identified support for a one-way relationship running from house prices to urbanization and from urbanization to house prices. This paper examines the aforementioned hypotheses with regards to a Lebanese context. The relationship between urbanization growth and house prices in Beirut, including its five different regions Ashrafieh, Ras Beirut, Beirut Central District, Mazraa, and Moussaytbeh was examined. The Granger-Causality test provides evidence of a significant negative effect of house prices on urbanization growth and no effect on the other side of the relationship.

The rise in house prices in Beirut over the period 2007-2011 seems to have slowed down urbanization growth, and its decrease can contribute to an increase in urbanization growth. However, it seems that the large increase in urbanization has been matched with housing supply deterring its effect on house prices and that the episodes of large increase in house prices in Beirut are not determined by urbanization growth but speculative demand generated by non-residents.

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WEBSITES

- https://datacatalog.worldbank.org/dataset/world-development-indicators
- www.infopro.com.lb

Appendix 1

Granger Causality of d_U_Growth and P_Ash

Equation 1: d_Urban population growth annual (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.20351	0.0965342	2.1082	0.0535	*
P_Ashrafieh_1	−0.0128492	0.00497185	−2.5844	0.0216	**
P_Ashrafieh_2	−0.00351739	0.00355468	−0.9895	0.3392	
P_Ashrafieh_3	−0.0093501	0.00370761	2.5219	0.0244	**

R-squared	0.970798		Adjusted R-squared	0.958282
F(6, 14)	1626.093		P-value(F)	4.45e-19

Equation 2: P_Ashrafieh (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	1.64586	1.86413	0.8829	0.3922	
d_Urbanpopulationgrowthannual_1	17.2791	18.7294	0.9226	0.3719	
d_Urbanpopulationgrowthannual_2	−28.5042	32.9734	−0.8645	0.4019	
d_Urbanpopulationgrowthannual_3	16.3422	22.7979	0.7168	0.4853	

Appendix 2

Granger Causality of d_U_Growth and P_BCD

Equation 1: d_Urban population growth annual (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.234866	0.0931707	2.5208	0.0245	**
P_BCD_1	−0.000235655	0.00160858	−0.1465	0.08856	
P_BCD_2	−0.00576286	0.00309838	−1.8600	0.0840	*
P_BCD_3	−0.00691663	0.00289288	−2.3909	0.0314	**

R-squared	0.970944		Adjusted R-squared	0.958491
F(6, 14)	588.1674		P-value(F)	5.38e-16

Equation 2: P_BCD (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	3.93126	2.76034	1.4242	0.1763	
d_Urbanpopulationgrowthannual_1	−34.8357	14.8205	−2.3505	0.0339	**
d_Urbanpopulationgrowthannual_2	54.2587	23.5476	2.3042	0.0371	**
d_Urbanpopulationgrowthannual_3	−30.8859	15.1497	−2.0387	0.0608	*

R-squared	0.282565		Adjusted R-squared	-0.024907
F(6, 14)	8.399138		P-value(F)	0.000542

Appendix 3

Granger Causality of d_U_Growth and P_RB

Equation 1: d_Urban population growth annual (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.204373	0.0976889	2.0921	0.0551	*
P_RB_1	−0.000360029	0.00173203	−0.2079	0.08383	
P_RB_2	−0.00290913	0.00130591	−2.2277	0.0428	**
P_RB_3	−0.00262598	0.002565	−1.0238	0.3233	

R-squared	0.965168		Adjusted R-squared	0.950239
F(6, 14)	376.7761		P-value(F)	1.19e-14

Equation 2: P_RB (HAC standard errors, bandwidth 2, (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	13.0587	8.06344	1.6195	0.1276	
d_Urbanpopulationgrowthannual_1	17.343	33.4014	0.5192	0.6117	
d_Urbanpopulationgrowthannual_2	−23.3629	52.3784	−0.4460	0.6624	
d_Urbanpopulationgrowthannual_3	5.50751	27.117	0.2031	0.8420	

R-squared	0.197738		Adjusted R-squared	-0.146089
F(6, 14)	6.257482		P-value(F)	0.002285

Appendix 4

Granger Causality of d_U_Growth and P_Maz

Equation 1: d_Urban population growth annual (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.233316	0.11208	2.0817	0.0562	*
P_Mazraa_1	−0.00597227	0.00277969	−2.1485	0.0497	**
P_Mazraa_2	−0.00414412	0.00261971	−1.5819	0.1360	
P_Mazraa_3	−0.00166973	0.00150864	1.1068	0.2870	

R-squared	0.970925		Adjusted R-squared	0.958464
F(6, 14)	646.5187		P-value(F)	2.78e-16

Equation 2: P_Mazraa (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.476558	3.02601	0.1575	0.8771	
d_Urbanpopulationgrowthannual_1	37.4275	33.2077	1.1271	0.2787	
d_Urbanpopulationgrowthannual_2	−70.4916	60.241	−1.1702	0.2615	
d_Urbanpopulationgrowthannual_3	46.2787	40.9811	1.1293	0.2778	

R-squared	0.338733		Adjusted R-squared	0.055333
F(6, 14)	14.02810		P-value(F)	0.000033

Appendix 5

Granger Causality of d_U_Growth and P_Mous

Equation 1: d_Urban population growth annual (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.251751	0.100094	2.5151	0.0247	**
P_Mous_1	−0.00372767	0.00319856	−1.1654	0.02633	
P_Mous_2	−0.00514017	0.00403767	−1.2731	0.02237	
P_Mous_3	−0.00607153	0.00301386	−2.0145	0.0636	*

R-squared	0.969167		Adjusted R-squared	0.955952
F(6, 14)	370.6397		P-value(F)	1.34e-14

Equation 2: P_Mous (HAC standard errors, bandwidth 2, Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	2.48571	3.16859	0.7845	0.4458	
d_Urbanpopulationgrowthannual_1	−60.8541	31.6652	−1.9218	0.0752	*
d_Urbanpopulationgrowthannual_2	94.3721	48.5967	1.9419	0.0725	*
d_Urbanpopulationgrowthannual_3	−59.2622	29.7718	−1.9905	0.0664	*

R-squared	0.450941		Adjusted R-squared	0.215630
F(6, 14)	1.861719		P-value(F)	0.158453