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Investigating the impact of recession on transportation cost capitalization: a spatial analysis

D. Efthymiou *, C. Antoniou

National Technical University of Athens, Laboratory of Transportation Engineering, 9, Iroon Polytechneiou, Zografou, 15780 Attica, Greece

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ABSTRACT

The unprecedented economic crisis experienced by Greece is fertile ground for research at myriad levels. In this paper, the authors aim to investigate the effects of the crisis on real estate prices by measuring the impact of transportation infrastructure location. For the purposes of this research, on-line real estate data collected in 2011, when the consequences of the crisis were still uncertain, and in 2013, when a significant decline had been observed, are combined.

The analysis is based on various spatial statistical methods. In order to identify potential common price patterns, G spatial clustering is first performed. Spatial error models (SEM) are then developed to parameterize the real estate prices. The results show that, overall, purchase prices have been reduced by 18.2% and rents by 15.2%. More specifically, the positive impact of metro station locations (<500 m) has declined 42.5% for purchase prices and 62.5% for rents. Moreover, dwellings located in the Inner Ring are still more expensive than others; however, the impact of the crisis has been reduced by 30.3% for purchases and 50.7% for rents. On the other hand, the negative impact of ISAP station locations (<500 m) has declined by 53.5% for purchase prices.

The findings of this paper could be of great interest to the transportation policy research community and could be used to better predict the benefits and costs of public transport investment under extremely uncertain conditions, such as a long-lasting recession.

1. Introduction

1.1. Land-use and transport interaction

In the era of increasing data availability and computational power, the interaction between transport and land-use has become a leading research objective. The need to better understand the direct and indirect effects of urban planning policies on the environment, society and economy has led to the development of different integrated land-use and transport models (Waddell, 2002). In these systems, location choice, transition, development, real estate price, and transportation models interact in a complex way. They are employed to forecast urban area structures under different policy scenarios, taking into consideration demographic, social, economic, and environmental characteristics.

Significant effort has been invested to improve the modeling framework of the agents' (households and jobs) location choice, which is highly affected by the implementation of a new transport policy. The preference of locating in higher accessibility areas in order to reduce commuting costs leads to increasing levels of real estate demand around transportation infrastructure locations. The generated competition results in the capitalization of transportation costs in real estate (Cervero and Landis, 1993).

The impact of transportation infrastructure locations on real estate prices has been explored by a number of researchers, demonstrating variation depending on the local characteristics, the quality and age of the transportation infrastructure, and the side-effects/externalities that are generated. For example, in Europe Debrezion et al. (2006) found that rail stations have positive impacts on Dutch house prices, while the closer to the railway a property is, the lower the prices due to noise pollution. Martinez and Viegas (2009) found that prices are higher in areas with better accessibility to metro stations; however, this is not always the case near rail stations, where the impact varies by route. In Madrid, Dorantes et al. (2011) concluded that a new metro line had positive impacts on house prices in south Madrid. In another case study, Ibéas et al. (2012) found that, in Santander (Spain), proximity to

* Corresponding author. Tel.: +30 210 77216 75.
E-mail addresses: defthym@mail.ntua.gr, dimitrios.efthymiou09@alumni.imperial.ac.uk (D. Efthymiou), antoniou@central.ntua.gr (C. Antoniou).
URLs: http://users.ntua.gr/defthym (D. Efthymiou), http://users.ntua.gr/antoniou (C. Antoniou).

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train stations drives house prices lower. In Atlanta, Bowes and Ihlanfeldt (2001) found that rail stations have both positive and negative impacts on house values: positive due to the accessibility increase, and negative due to the externalities that are generated. In Santa Clara (California), Weinberger (2000) investigated the impact of light rail and found that houses located closer to the stations are leased at higher prices than others. In Washington, DC, Cervero and Landis (1993) and Benjamin and Sirmans (1996) found that the metro affects house prices positively. Similar effects are found for light-rail stations in Buffalo (NY) (Hess and Almeida, 2007), in Dallas (Clower and Weinstein, 2002), and in Toronto (Canada) (Bajic, 1983). In contrast, Haider and Miller (2000) found that transportation infrastructure does not determine property values in Toronto.

Other studies reviewing the impact of rail transport infrastructure on residential and commercial values include a technical report by Parsons Brinckerhoff Quade and Douglas (PBQD, 2001). In order to deal with the large number of studies that investigate the impact of rail investments on real estate values, Debrezion et al. (2007) and Mohammad et al. (2013) applied meta-analysis and found that the variation in results depends on many factors, such as the type of rail, distance of stations, maturity of the system, and accessibility. Mohammad et al. (2013) performed publication bias tests and found that the positive/negative results reported by researchers are sometimes biased towards statistically significant estimates. In addition, proximity to airports usually has negative impacts on house prices due to noise (see Nelson, 2004; Crowley, 1973; Cohen and Coughlin, 2008). However, there are cases where airport construction has led to higher prices following the increase in accessibility (Lipscomb, 2003).

1.2. Economic crisis and real estate prices in Athens

Greece has been highly affected by the financial crisis post-2008/2009. As in every market, the impact of the crisis is apparent on real estate. According to the Bank of Greece (2012a), real estate purchase prices in Athens have declined since 2008 (4.5% in 2009, 3.2% in 2010, 6.4% in 2011, 11.8% in 2012, and 12.7% during first quarter of 2013). In a recently published report about the expectations of real estate agencies (Bank of Greece, 2012b), the respondents (agents) stated that they expected a deterioration of market conditions, despite the relative financial stabilization forecasts for 2013. Brokers assumed that prices had declined 11–24% since the last quarter of 2012, while they noted that more people were looking for smaller, second-hand residencies. On average, dwellings were sold for 22% lower than the initial list price, after being advertised for 10 months on average. The aforementioned studies indicate that changes in real estate prices are based on aggregated data. In this paper, we present a methodology that uses disaggregated information to measure the impact of the crisis on two levels: holistic (total reduction between two time periods) and local (impact of transportation infrastructure).

1.3. Previous research

This paper builds upon previous research by Efthymiou and Antoniou (2013), who measured the impact of transportation infrastructure locations on purchase prices and rents of dwellings in Athens, Greece. The data used in that research were collected from on-line sources, using a tool developed in R (R Development Core Team (2014)). Different modeling methodologies were then applied – such as ordinary least squares, spatial econometric models, and geographically weighted regression (GWR) – and their results were compared. The estimations show that dwellings have higher prices when located within 500 m of a metro or tram station, 1500 m of a suburban rail station, 50 m of a bus stop, or 1500 m of a marina. Those dwellings located within 500 m of an urban or the national rail station, 7000 m of the airport, and closer to the port have lower prices. The models were compared in terms of goodness of fit (R^2 and AIC (Akaike, 1974)) and spatial autocorrelation (Moran's I). The authors concluded that spatial econometric models effectively remove the spatial autocorrelation, and suggested that their use should be further investigated with next generation LUTI models. Moreover, they found different elasticities of the impact of transportation infrastructure locations, depending on the type of model being used. Therefore, policy planners should be aware

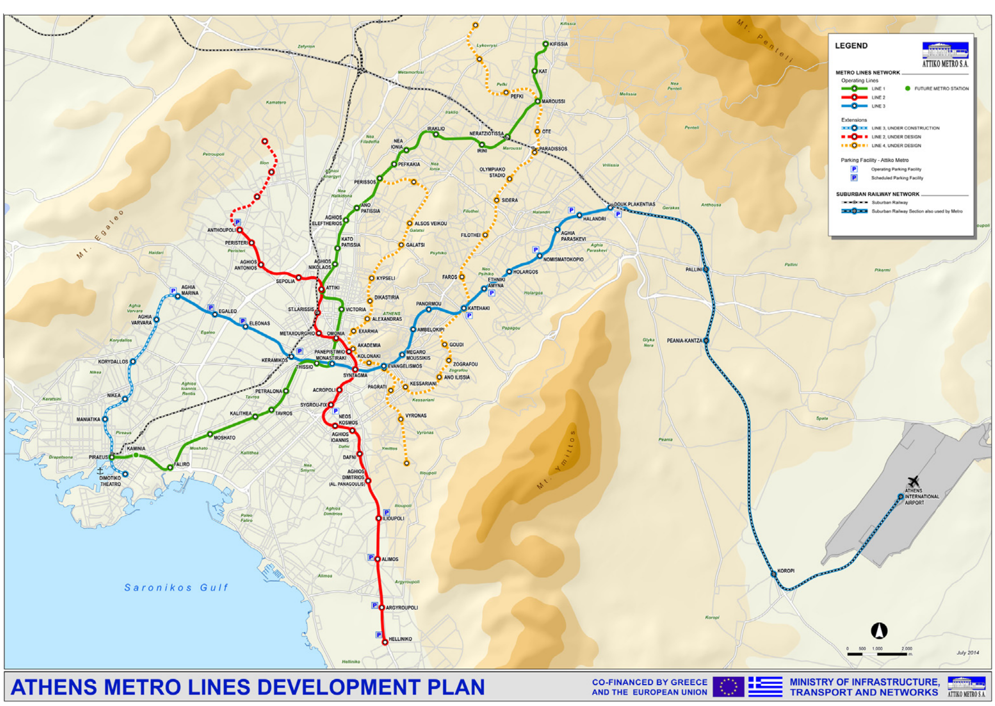


Fig. 1. Central transport network. *Source*: http://www.ametro.gr/files/maps/AM_Athens_Metro_map_July14_en.pdf, inset source: Google Maps.

of these potential differences when assessing an investment. Efthymiou and Antoniou (2014) examined the future impact of a planned metro line (currently under construction) in Thessaloniki, Greece, using a similar dataset. The results show that, despite the possible future benefits of the line, the prices of dwellings around the stations are lower due to the construction works underway. Concerning rents, the impact is insignificant. Moreover, proximity to the airport and the national rail station has a negative impact on the property prices, while dwellings closer to the port are more expensive. The purchase and rent models developed in the aforementioned studies were used to compute the rent and purchase prices for the equivalent datasets. The aim was to analyze, at an agent-level (dwelling), a price-to-rent ratio to investigate the prospects of government real-estate investments around planned transport infrastructure locations in order to determine the maximum benefits. Both studies (Efthymiou and Antoniou, 2013, 2014) were performed using data collected between December, 2010, and February, 2011, when the effects of the crisis on the real estate market were still not apparent.

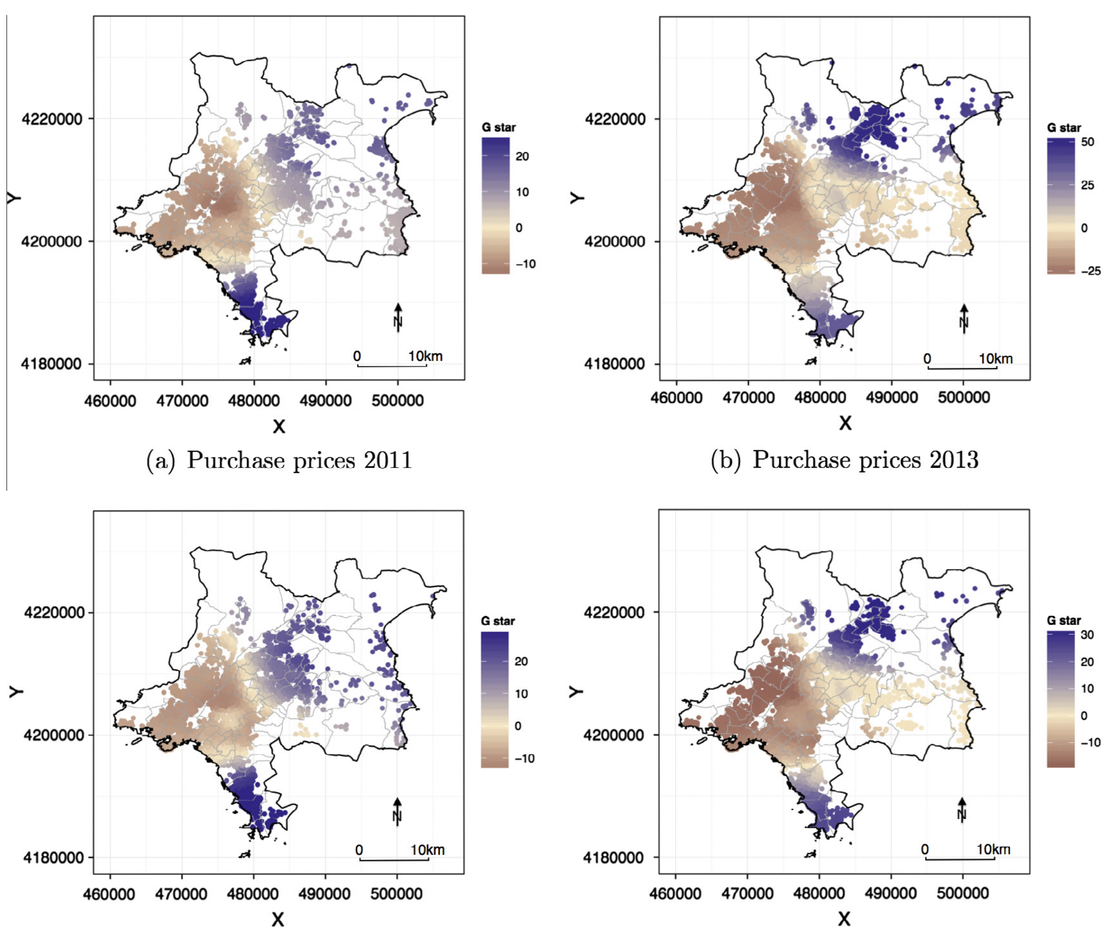
1.4. Research objective

The objective of this current research is to measure the impact of the economic crisis on real estate prices and rents by attempting to answer the following questions: How much has the crisis affected the purchase prices and rents of dwellings? Do the transportation infrastructure locations maintain real estate prices of proximal dwellings at higher levels? The analysis is performed both at a 'global' (i.e., total effect) and 'local' (i.e., around transportation infrastructure) level, using disaggregate information. Similar to Efthymiou and Antoniou (2013, 2014), recent on-line real estate data were first collected. Spatial error price models were then developed using both datasets (2011 and 2013) jointly.

The rest of this paper is structured as follows: Section 2 describes the spatial analytical tools –such as SEM – that are employed in this research. Section 3 describes the methodology that has been followed and the results of the analysis, and Section 4 offers conclusions and recommendations for the future.

2. Methodological background

In contrast to ordinary least squares (OLS) linear regression, spatial econometric models can deal with spatial dependence and heterogeneity. This is achieved by including spatial 'lags' (weighted averages of each data point with neighbors) in the model. The number of the required neighbor data points to be used for the construction of the weight matrix differs depending on the spatial allocation, and is defined by the user. These 'lagged' variables are used either for the response, the explanatory variables, or the error term. Depending on the component of the model to which the lag term is applied, the points are named accordingly: in the spatial error model (SEM), the lag is applied at the error term; in the spatial autoregressive model (SAR), it is applied on the response variable; and in the spatial mixed model (SDM), both on the response and the explanatory variables. In their research, LeSage and Pace (2009) describe these – and other spatial models



(a) Purchase prices 2011 (b) Purchase prices 2013

(c) Rent prices 2011 (d) Rent prices 2013

Fig. 2. G* spatial clustering. *Source*: Data generated by the authors

Table 1
Specification of variables.

Variable	Variable specification	Name
Dependent		
Price	Logarithm	
House Attributes		
m^2	Logarithm	Xsqm
Before 1950	Dummy, 1 if TRUE	X<50
1950–1960	Dummy, 1 if TRUE	X50
1960–1970	Dummy, 1 if TRUE	X60
1970–1980	Dummy, 1 if TRUE	X70
1980–1990	Dummy, 1 if TRUE	X80
1990–2000	Dummy, 1 if TRUE	X90
2000–2010	Dummy, 1 if TRUE	X00
>=2010	Dummy, 1 if TRUE	X > 10
Basement	Dummy, 1 if TRUE	Xbase
Ground floor	Dummy, 1 if TRUE	Xgf
1st floor	Dummy, 1 if TRUE	Xf1
2nd floor	Dummy, 1 if TRUE	Xf2
3rd floor	Dummy, 1 if TRUE	Xf3
4th floor	Dummy, 1 if TRUE	Xf4
5th floor	Dummy, 1 if TRUE	Xf5
6th floor or more	Dummy, 1 if TRUE	X > f6
Parking	Dummy, 1 if TRUE	Xparking
Open parking	Dummy, 1 if TRUE	XopenP
Storage place	Dummy, 1 if TRUE	Xstorage
Fireplace	Dummy, 1 if TRUE	Xf irep
Auto heat	Dummy, 1 if TRUE	XAH
A/C	Dummy, 1 if TRUE	XAC
Single family house	Dummy, 1 if TRUE	Xsf h
View: sea	Dummy, 1 if TRUE	Xseaview
Orientation: front	Dummy, 1 if TRUE	Xfront
Northern suburbs	Dummy, 1 if TRUE	XNS
Distance from coastline	Dummy, 1 if TRUE	Xcoast
Transport attributes		
Distance from CBD	Logarithm	Xcbd
In the inner ring	Dummy, 1 if inside	Xring
Distance from bus station	Dummy, 1 if <50 m	Xbus
Distance from metro station	Dummy, 1 if <500 m	Xmetro
Distance from ISAP station	Dummy, 1 if <500 m	Xisap
Distance from Rail station	Dummy, 1 if <500 m	Xnatl
Distance from railway	Dummy, 1 if <100 m	Xrailway
Distance from suburban rail station	Dummy, 1 if <2000	Xsub
Distance from tram station	Dummy, 1 if <500 m	Xtram
Distance from airport	Dummy, 1 if <7000 m	Xair
Distance from port (Pireaus/Rafina)	Logarithm	Xport
Distance from marina	Dummy, 1 if <1500 m	Xmar
Distance from ring-road	Dummy, 1 if <1500 m	Xrroad

– in detail. An extensive description, literature review, and application of these models are presented in the first part of this research published recently (Efthymiou and Antoniou, 2013, 2014).

The spatial error model (SEM) assumes that the spatial autoregression term is applied at the error term. It is defined by the formula:

$$Y = X\beta + (\lambda W)u + \varepsilon \tag{1}$$

where Y is a vector of the dependent variables, β is the $k \times 1$ vector of coefficients, X is a $n \times k$ matrix of the explanatory variables, λ is the spatial autoregression coefficient that is applied at the spatial error term u, W is the weights matrix, and ε is the error term.

3. Methodology and results

3.1. Transportation infrastructure in Athens

About four million people reside in Athens, Greece. During the last fifteen years, major transportation infrastructure has been constructed. The organization and hosting of the Olympics in 2004 contributed to this improvement in accessibility, with the metro network extending 51 km in total, suburban rail extending 128 km, and the tram network covering 27 km. Extensions to these networks are currently in the planning or construction phase. Furthermore, one of the country's oldest urban-rail networks is located in Attica, the Athens–Piraeus Electric Railway (ISAP), which connects Piraeus (the major Greek port) with the northern suburbs.

The bus system serves the highest demand for transport in Attica, despite the constant delays, because of its extensive network coverage (HMPW, 2009). In 2003, a ring-road of 65 km, the Attica Tollway, was completed and, before the current economic/financial crisis, more than 300,000 cars used this route daily (Halkias and Tyrogianni, 2008). The Athens International Airport is located approximately 30 kms from the central business district (CBD). Furthermore, a traffic control scheme (the "internal ring") was implemented in the 1980s to restrict the number of cars that entered the city center daily, based on the last digit of vehicle license plates. Fig. 1 shows the main transportation infrastructure in Athens.

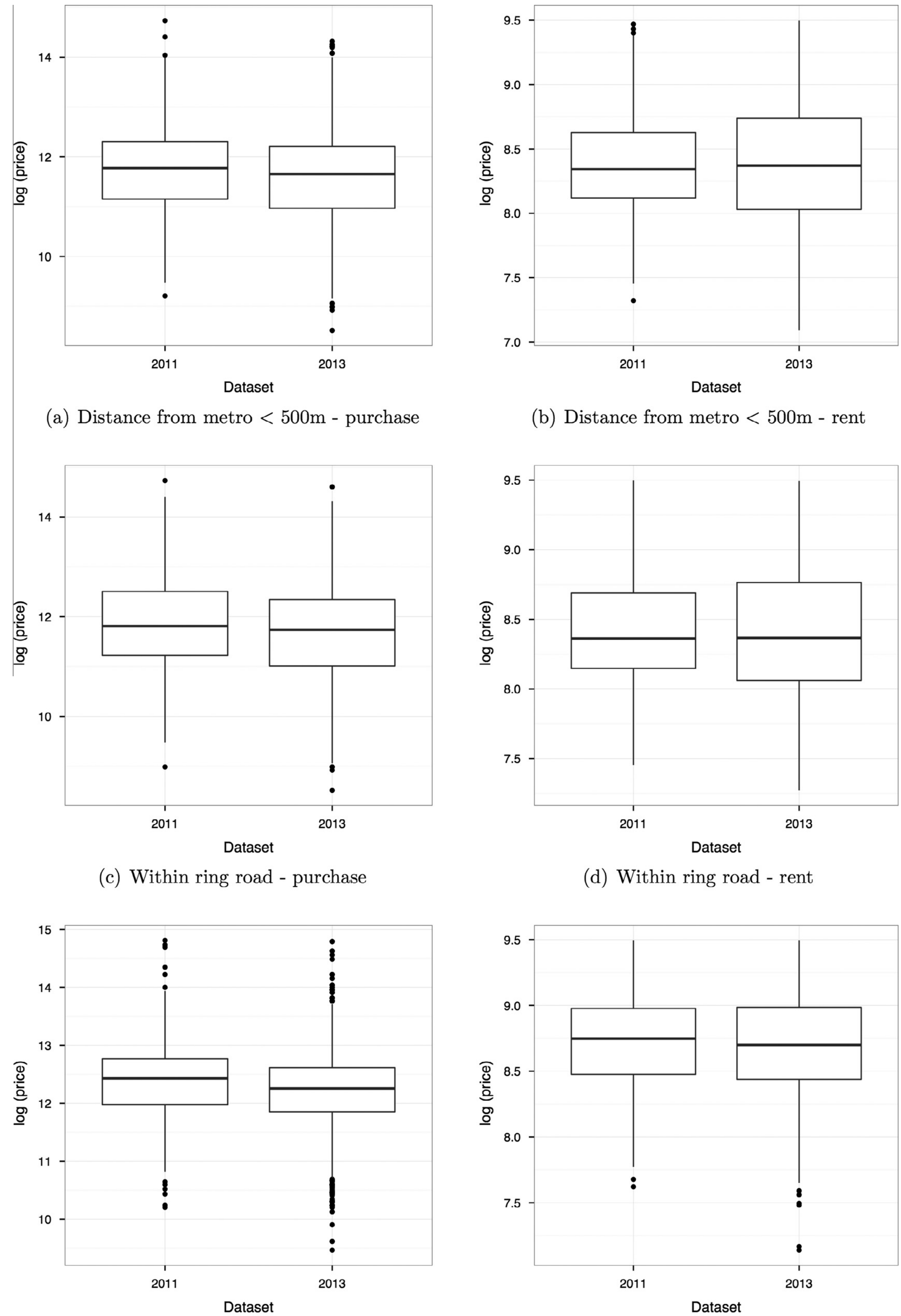
3.2. Data collection

Real estate data usually are not available from the authorities. However, there are numerous on-line real-estate data sources. For the purposes of this research, a tool that reads and stores data from a real estate website was developed. A detailed description of the tool can be found in Efthymiou and Antoniou (2013). Minor modifications have been made to the tool, mainly with respect to how the data are read and stored, in order to minimize the required runtime. Apart from the dwellings' structural characteristics and price, the updated tool stores the number of visits to each advertisement, the time it came online, and the time that it was last modified. The data used in Efthymiou and Antoniou (2013) (and, therefore, the first point of comparison for this paper) were collected in 2011, three years after the beginning of the real estate price decline according to Bank of Greece (2012b). One could argue, therefore, that the impact of the recession in this research is underestimated, since the original point already includes some of the recession effects.

The limitations of using listed prices have been highlighted in Efthymiou and Antoniou (2013): A large number of data are duplicated and many advertised houses have unusual sizes and prices. Having 'cleaned' the data from any obvious source of error, a bias that should be taken into consideration remains: the transaction price often is lower than the listed price (Bank of Greece, 2012a). However, listed prices can be used as a proxy for the real prices. Lyons (2013) found a high correlation between these two values in Dublin. After structuring the dataset, the observations that were initially listed in 2012 were removed, in order to avoid potential overlap with the 2011 dataset (Efthymiou and Antoniou, 2013). Dwellings with extreme prices and duplicates were also removed. The spatial statistical analysis presented in this research has been performed in R (R Development Core Team (2014)), using the package 'spdep' (Bivard, 2014).

3.3. Spatial cluster analysis

The G^* statistic is used with the aim of identifying the presence of local spatial price clusters. The four maps presented in Fig. 2, one for each dataset (purchase prices and rents for 2011 and 2013), depict the output of the G^* –namely the Z-values – that can be used for diagnostic purposes. High Z-values indicate the potential of a cluster with high prices to be present and, similarly, low negative Z-values indicate a cluster of low prices. The closer the Z-value is to zero, the less likely is the presence of a cluster. The weight matrices required for the test have been structured using 10% of the neighboring data points for each dataset.



(a) Distance from metro < 500m - purchase

(b) Distance from metro < 500m - rent

(c) Within ring road - purchase

(d) Within ring road - rent

(e) Distance from tollway <1500m - purchase

(f) Distance from tollway <1500m - rent

Fig. 3. Exploratory analysis.

The results verify the presence of spatial price clusters in all the examined periods (2011 and 2013) and prices (purchase and rent). In all cases, clusters with higher prices (blue color) are formed far from the city center, in the northern suburbs and along the southern coastline, where people of higher incomes and education level usually reside. On the other hand, the presence of a lower price

Table 2
Price Model Estimations – dummy.

Name	Purchase 1 n = 19,703 k = 8		Rent 1 n = 18,311 k = 6	
Variable	Value	t-test	Value	t-test
Intercept	6.655	(46.57)	5.527	(65.03)
House attributes				
Xsqm	1.009	(204.89)	0.709	(171.08)
X < 50	0.235	(6.69)	0.123	(3.37)
X50–80	Reference category for year of construction			
X80	0.151	(19.18)	0.038	(6.98)
X90	0.277	(28.25)	0.120	(17.81)
X00	0.433	(52.91)	0.258	(41.18)
X > 10	0.516	(60.47)	0.369	(43.81)
Xbase	−0.299	(−23.71)	0.133	(10.19)
Xgf	Reference category for floor			
Xf1	0.076	(11.20)	0.019	(3.69)
Xf2	0.105	(14.76)	0.023	(4.13)
Xf3	0.143	(18.72)	0.063	(9.79)
Xf4	0.194	(23.32)	0.068	(8.88)
Xf5	0.238	(23.11)	0.102	(10.26)
X > f 6	0.290	(23.23)	0.133	(10.19)
XNS	0.341	(15.77)	0.286	(22.03)
Xparking	0.063	(9.82)	0.053	(10.29)
Xgarden	0.021	(3.14)	0.024	(4.33)
Xstorage	0.045	(8.03)	0.013	(2.74)
Xf irep	0.034	(6.03)	0.075	(13.88)
XAH	0.038	(6.42)	0.010	(2.11)
XAC	0.026	(4.97)	0.076	(17.91)
Xseaview	0.022	(2.23)	0.090	(9.62)
Xcoast	−0.063	(−9.53)	−0.044	(−9.99)
Transport attributes				
Xcbd	0.096	(7.60)	0.024	(3.50)
Xmetro	0.051	(2.59)	0.054	(4.21)
Xisap	−0.037	(−1.86)	−0.028	(−2.16)
Xtram	0.082	(4.18)	0.083	(6.30)
Xnatl	−0.098	(−2.20)	–	–
Xrailway		–	−0.071	(−2.72)
Xmar	0.068	(2.87)	0.043	(2.67)
Xair	−0.159	(−3.48)	−0.159	(−4.53)
Xring	0.234	(6.93)	0.214	(12.15)
Xrroad	−0.061	(−2.74)	−0.139	(−10.19)
Xdd = 2	−0.201	(−45.91)	−0.165	(−44.54)
λ	0.744			
R^2	0.91		0.87	
AIC	7078	(OLS: 16131)	460	(OLS: 4183)
Moran's I	0.001		−0.001	

cluster is observed on the west side of the city (red color). Interestingly, the city center (Municipality of Athens) does not form a single cluster. Dwellings located in the northern city center are co-clustered at low prices, while those located in the south result in Z-values closer to zero, indicating the absence of clear clustering. This is easier to interpret for an Athenian resident, since south of the city center is a conglomeration of 'prestigious' (e.g., Kolonaki, Plaka, etc.) and 'degraded' areas (e.g., Metaxourgeio) that share common boundaries. The differentiation of clustering in the city center is less evident in 2013, when the 'prestigious' areas seemed to be partially incorporated into the lower-price cluster of the west, indicating a decrease of prices as an effect of the crisis.

Another remarkable difference between 2011 and 2013 is that the 'unclustered' area (ivory color) between the city center and the northern suburbs increases, with parallel limiting of the northern suburbs' cluster extent, both in purchase prices and rents. A similar effect is noticed in the area between the city center and the southern coastline. This indicates that the 'elite' (extremes) areas have resisted the crisis and maintain higher prices, while the prices of the southern part of the northern suburbs (previously wealthier) have declined. Similarly, the housing values of 'poor' areas have declined, creating a more apparent cluster of low prices. In other words, the range of Z-values in 2013 is higher than in 2011 (−26 to 51 instead of −12 to 25 for purchase prices, and −19 to 31 instead of −12 to 28 for rents).

3.4. Price model development – aggregate analysis

Aiming to measure the impact of the crisis on real estate prices, spatial error models were estimated for purchases prices and rents. For this purpose, the two available datasets (2011 and 2013) were merged and used jointly. Table 1 shows the specification of the variables used in the presented models. Fig. 3 depicts the distribution of the variables: distance to metro <500 m, inner-ring, and tollway <1500 m, over the natural logarithm of purchase and rent prices in the two examined years. In both cases, the mean price around transportation infrastructure decreases, while an increase of the range between the 1st and 3rd quantile of rents is observed, probably due to the larger amount of data collected in 2013 (2011: 7629 for rent, 7703 for sales; 2013: 11,974 for rent, 42,198 for sales).

Prices are modeled in two ways: 'holistically' or 'globally', and 'locally'. Two SEM models, one for purchase prices and one for rents, were first developed using as explanatory variables the

Table 3
Price Model Estimations – Interaction variables.

Name	Purchase 1 n = 19,703 k = 8		Rent 1 n = 18,311 k = 6	
Variable	Value	t-test	Value	t-test
Intercept	6.215	(51.96)	5.457	(64.00)
House attributes				
X1sqm	1.019	(161.15)	0.730	(172.13)
X2sqm	1.013	(152.92)	0.696	(166.78)
X < 50	0.255	(7.03)	0.125	(3.39)
X50–80	Reference category for year of construction			
X90	0.279	(27.51)	0.120	(17.68)
X00	0.422	(50.03)	0.258	(40.93)
X > 10	0.507	(57.19)	0.369	(43.46)
Xbase	−0.296	(−22.78)	−0.081	(−7.38)
Xgf	Reference category for floor			
Xf1	0.080	(11.47)	0.018	(3.36)
Xf2	0.107	(14.71)	0.022	(3.89)
Xf3	0.146	(18.59)	0.062	(9.45)
Xf4	0.195	(22.89)	0.066	(8.58)
Xf5	0.228	(21.72)	0.101	(10.04)
X > f 6	0.280	(22.30)	0.131	(9.96)
XNS	0.336	(18.15)	0.287	(22.08)
Xparking	0.065	(9.93)	0.053	(10.26)
Xgarden	0.030	(4.34)	0.024	(4.14)
Xstorage	0.045	(7.76)	0.013	(2.75)
Xf irep	0.042	(7.27)	0.076	(13.90)
XAH	0.041	(6.80)	0.010	(1.99)
XAC	0.032	(5.91)	0.076	(17.80)
Xseaview	0.023	(2.35)	0.090	(9.64)
Xcoast	−0.048	(−8.36)	−0.044	(−10.00)
Transport attributes				
Xcbd	–	–	0.022	(3.07)
Xcbd1	0.129	(12.28)	–	–
Xcbd2	0.106	(12.28)	–	–
Xmetro1	0.072	(3.59)	0.078	(5.40)
Xmetro2	0.042	(1.90)	0.030	(2.01)
Xisap			−0.029	(−2.20)
Xisap1	−0.069	(−3.39)	–	–
Xisap2	−0.108	(−5.18)	–	–
Xtram1	0.147	(7.22)	0.075	(4.74)
Xtram2	0.126	(6.65)	0.083	(5.87)
Xrail			−0.074	(5.87)
Xbus1	0.029	(2.95)	–	–
Xbus2	−0.041	(−3.94)	–	–
Xmar	–	–	0.040	(2.51)
Xmar1	0.087	(3.97)	–	–
Xmar2	0.070	(3.42)	–	–
Xair1	−0.191	(−4.53)	−0.127	(−3.01)
Xair2	−0.196	(−4.65)	−0.178	(−4.67)
Xring1	0.338	(11.49)	0.228	(11.91)
Xring2	0.247	(7.45)	0.199	(10.12)
Xrroad1	−0.093	(−4.35)	−0.124	(−7.97)
Xrroad2	−0.100	(−4.95)	−0.151	(−10.37)
λ	0.651		0.533	
R_2	0.90		0.87	
AIC	8028	(OLS: 16,175)	676	(OLS: 4336)
Moran's I	0.020		−0.001	

structural characteristics of the dwellings, accessibility indicators (distances to main transportation infrastructure and policy locations), and a dummy variable that takes a value of 1 when the observation belongs to the new dataset (2013) and 0 otherwise (2011). The model estimation results are presented in Table 2. The number of the nearest neighbor points, to be used for the construction of the weighted matrices, has been selected based on the Akaike information criterion (AIC) minimization, maintaining the transportation variables significant to the model. The results show that the newer the dwelling, the higher the price, while those constructed before 1950 are more expensive because they are of architectural significance. Moreover, the higher the floor, the more expensive the dwelling, while the availability of any extra facilities, such as parking, garden, storage room, fire place, auto heat and air-conditioning, provides added value. Dwellings with a sea view and those closer to the coastline are more expensive. Concerning the transportation attributes, dwellings closer to the CBD, within 500 m of a metro or tram station, within 1500 m of a marina, and within the inner-ring, are more expensive. On the other hand, dwellings within 500 m of an ISAP station or the national railway terminal, 7000 m from the airport, and 1500 m from the Attica Tollway, all have lower prices. The aforementioned findings are in accordance with Efthymiou and Antoniou (2013), who performed similar research using the 2011 dataset.

Table 4
Percentage impact of transportation infrastructure location.

	Effect on prices			Effect on rents		
	2011 (%)	2013 (%)	Difference (%)	2011 (%)	2013 (%)	Difference (%)
Xcbd	+13.8	+11.2	−18.8	–	–	–
Xmetro	+7.5	+4.3	−42.5	+8.1	+3.0	−62.5
Xisap	−6.7	−10.2	−53.5	–	–	–
Xtram	+15.8	+13.4	−15.2	+7.8	+8.7	+11.1
X[a]bus	+2.9	−4.0	−236.5	–	–	–
Xmar	+9.1	+7.3	−20.2	–	–	–
Xair	−17.4	−17.8	−2.4	−11.9	−16.3	−36.71
Xring	+40.2	+28.0	−30.3	+25.6	+12.6	−50.7
Xrroad	−8.9	−9.5	−7.2	−11.7	−14.0	−20.2

[a] Note the sign of impact changes.

What is worth noting is the scale of the crisis-related variable coefficient: it takes the value −0.201 at the purchase model, which indicates that the purchase prices have been reduced by 18.2% since 2011 (1−e−0.201), and −0.165 at the rent model, indicating a 15.2% reduction (1−e−0.165). This price decline is higher than reported by Bank of Greece (2012a,b) and probably does not represent the actual reduction. However, this outcome was expected since the listed prices are lower than the final sale price (Bank of Greece, 2012a). The objective of this research is not to measure the absolute reduction, but propose a methodology for its computation based on disaggregate data. The significance of the spatial error variable in both models and the low AIC and Moran's I verify the appropriateness of using the SEM model.

3.5. Price model development – disaggregate analysis

Having measured the 'global' reduction using disaggregate data, we now attempt to quantify the impact of the proximity to transportation infrastructure locations before and after the reference year (2012). The aim is to measure the importance – or not – of transportation infrastructure in maintaining a dwelling's price at higher levels. In order to facilitate a direct comparison, it was decided to specify models from the beginning – using both datasets – instead of estimating only for 2013 and then comparing results with those of Efthymiou and Antoniou (2013).

Using interaction variables for each transportation infrastructure location, two SEM models were estimated: one for the purchase prices and one for the rents. The results are presented in Table 3. The estimated coefficients of the structural characteristics of the buildings are similar to the joint model (Table 2). Concerning the proximity to transportation infrastructure locations, the results show that the impact differs between the two periods.

Table 4 shows the percentage impact of transportation infrastructure on dwelling prices, and its change (increase/decrease) between the two examined periods. It is observed that, overall, the positive impact has been reduced, with the exception of the location of a tram stop within 500 m for rented dwellings. Dwellings located within 500 m of a metro station have 4.3% higher purchase prices than the rest, when the respective percentage in 2011 was 7.5%, resulting in a 42.5% decrease in the metro's impact. Similarly, dwellings located within 500 m of an ISAP station are less expensive by 10.2%, compared to 6.7% in 2011 (a 53.5% increase in the reduction). Moreover, proximity to the CBD was 18.8% less important for purchase prices in 2013 than in 2011 – the further the dwelling is located from the CBD the higher the price – while the impact on rents remained unchanged. The highest reduction is observed with the impact of bus station locations, the proximity to which turns from positive to negative. However, it is possible that this large change is not directly related to the crisis, but might include some bias due to the small radius considered (50 m). Concerning the rents, dwellings located within 500 m of a metro station were 3% more expensive than the others in 2013, while, in 2011, they were 8.1% more expensive, which indicates a 62.5% decrease in the impact. The negative effect of the proximity to the airport increases by 36.7% in the rent model, significantly higher than the 2.4% in the price model. Moreover, dwellings located within a 1500 m radius of the Attica Tollway are 14% less expensive than the others in 2013, which is interpreted as a 20.2% increase in the negative impact compared to 2011.

4. Conclusions and discussion

Real estate prices have been highly affected by the financial crisis that Greece has been experiencing. The impact of transportation infrastructure locations on the purchase prices and rents of dwellings is a subject that has been widely investigated during the last few years. But how does the crisis affect the values of properties and can transportation infrastructure help to maintain them at higher levels? In this research, we attempted to provide answers to these questions.

The results indicate that, overall, from 2011 to 2013, the purchase prices of dwellings in Athens have decreased by 18.2% and rents by 15.2%. Online real estate data have been used for the analysis, which makes the results somewhat biased since the real transaction prices are likely lower than the advertised/listed ones. However, the reduction is not expected to be homogeneous and may be a function of the conditions in the area.

The impact of transportation infrastructure locations on real estate prices and rents differs between 2011 and 2013. For example, the impact of metro stations (<500 m) on purchase prices has declined by 42.5% and on rents by 62.5%; the effect of ISAP (light rail) stations (<500 m) on purchase prices has been reduced by 53.5%; the impact of airport proximity (<7000 m) on purchase prices is lower by 30.3% and by 50.7% for rents. However, despite the reduction, the impacts have maintained their positive or negative sign, similar to results reported by Efthymiou and Antoniou (2013), depending on the transportation system.

The findings demonstrate the direct and indirect effects of the current financial crisis on the relationship between transport location and real estate prices in Athens, Greece; in particular, the impact variation of transportation infrastructure locations on dwelling values before and at the peak of the crisis has been explored. While the impact of transportation infrastructure and policies on property values has been extensively investigated before, the research is usually based on static metrics, while the dynamic and spatial elements often are absent.

The results of this paper support the argument that the sensitivity of property values to economic conditions varies spatially. As expected, transport facilities – usually strong determinants of real estate prices – lose part of their impact. The increased unemployment rate has led to a reduction in commuting activities (less home-work-home trips are performed daily), rendering the need to be located close to transportation infrastructure less important for households. Thus, it is important to exploit the increasingly available spatial and real estate data over time in transport policy research to better understand the changing relationships between transport provision and property prices. Although the dire economic conditions in Greece recently may be considered an extreme case, it does provide important opportunities to conduct research that could prove useful for transport planning and policy agencies faced with similar conditions.

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