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# Train station planning and house prices interaction in Athens via hedonic modeling and spatial analysis

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***Abstract -*** This paper explores a framework that combines Spatial Analysis with the Hedonic Modelling method identifying a possible spatial correlation between house prices and railway station areas. Several studies, regarding European and American cities, showed that properties near the railway stations tend to have higher prices than the properties which are more distant from them. To address this issue regarding Greece, this study focuses on the Athens Central Station (Stathmos Larissis). The study area was defined through a buffer zone of approximately 700 meters around Athens Central Station. Data, was mainly originated from different property sales websites in order to take into account the market prices today. Results were formed via a semi-log model and through the Ordinary Least Squares (OLS) method and Multi-Regression Analysis (MRA). The model results showed that properties near railway infrastructure and especially near the train station, tend to have lower prices than the ones that were distant. Thus, several actions can be proposed for the existing railway infrastructure and the neighboring areas in order to be upgraded and further developed.

***JEL Classification***
N33, N93, O18

***Key-words***
Hedonic modelling
Train Station
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## INTRODUCTION

Property market theories are based on the work of Weber, Lösh and Von Thünen, who mentioned that land values may differ due to their location and the accessibility to the market place (Debrezion et al., 2006 ; Kyriakidis, 2009). Thus, accessibility to the Central Business District (CBD) is considered an attractive characteristic that increases land values. However, the implementation of public transport nodes tends to reduce the significance of this parameter considerably by attracting companies and households to settle in a proximity to the stations (Debrezion et al., 2006). This trend creates high demand thus the value of the properties tends to be higher.

Economists and planners generally accept that property values tend to increase in the proximity of the public transport stations because the access to activity locations is improved (Welch and Gehrke, 2016). However, the literature regarding the effects of railway stations on land values is quite ambiguous in this respect (Diaz, 1999 ; Debrezion et al., 2007).

Given the positive aspect of the correlation between train infrastructure and property values, there is a lot of research supporting the hypothesis presented above. Hess and Almeida (2007), who have studied property market in Buffalo (NY), suggest that the average value of housing units located close to a rail station was increased compared to those away from the line. In another study (Debrezion et al., 2007) it was hypothesized that there is a strong positive relation between property value and distance from railway stations. Specifically, researchers showed that proximity to commuter railway stations would have higher positive impact on land values compared to light and heavy railway. Cervo's study (1996 cited in Diaz, 1999) shows similar outcomes between property values and distance from rail stations in San Francisco Bay Area. According to this study, rental houses in a close proximity to the Bay Area Rapid Transit (BART) system were found to have higher rents compared with those away from the line. The correlation was more obvious in bigger housing units than in smaller.

On the other hand, the negative aspects (noise, traffic, safety, or aesthetics) of the train station that affects property values, are supported from the trend that proximity to train infrastructure has a negative or zero/no impact on land values.

Ma et al. (2013) suggests that train stations have a negative effect in high-income neighborhoods. Furthermore, Bohman and Nilsson (2016), who have conducted a study in Scania Region in Sweden, underline that proximity to a rail station affects more the low-income neighborhoods and less the high-income ones. Diaz (1999) refers to a study conducted in an area of DeKalb County in Atlanta has found varying effects of proximity to rail station. According to this finding, proximity to train station increases property values in high priced neighborhoods. The same variation was found in Gatzlaff and Smith's previous study for Miami Metrorail (1993). Finaly, Zhong and Li's research (2016) suggest that proximity to a rail station does not positively impact single-family property prices, although it is believed that it is quite important. All these studies underline that the impact of a rail station to the property market is quite varied across neighborhood types.

To conclude, there is no widely accepted agreement on how the proximity to a rail station influences property market. Most of the studies suggest that there is not a fixed practice as far as, the impact of a rail station to the property market is concerned. Thus, each area is a unique case which should be studied properly and separately.

To shed light on these topics, a hedonic model is applied because it provides an ideal tool for good understanding of the correlation studied in this case-study of Larissis Station. The hedonic pricing model is a regression technique that is widely used in the real estate market for property prices evaluation. It is a framework that

considers property prices as a direct dependent from the utilities that each residential unit can provide to its owner and is based on the principle of "supply and demand" (Stamou, 2016). Property prices can be affected by various parameters (Lambropoulos, 2013). In this study, variables were selected and aggregated into their structural (e.g. property age, floor, number of bedrooms) and locational (e.g. proximity to green spaces, schools, roads) characteristics (Basu et al., 1998).

## 1. STUDY AREA

The case-study area is located inside the administrative boundaries of the Municipality of Athens. It is regarded as a central area within the city and is mainly populated today by low-income groups (Athens Social Atlas, 2016).

The attractiveness of the area is largely due to its advantage in terms of transport services (many bus and trolleybus lines as well as 3 nearby metro stations, Attica, Larissis and Victoria) and its proximity to downtown Athens.

In the area, the predominant use is mainly residential, with some commercial uses usually in the ground floor. Increased concentration of commercial uses is located at the main axis of Ioulianou, which is a street with a strong multifunctionality character.

The area is characterized by the old building stock and the dense construction, because of the intensive reconstruction of the 1950s and 1970s. Especially during the 1980s, many residents and mainly landowners moved gradually to other less densely populated residential areas and this was a consequence of urban degradation factors. The gaps that were left behind by the residents who left mainly to the new Suburbs of Athens, initially were covered by low income inland immigrants who benefited from low land values. The decline in values began in the 1980s mainly because of the degraded housing conditions, the degraded welfare and education facilities for families, the aging and the abandonment of the built and natural environment combined with the lack of free space. The change in social composition took on other characteristics in the 1990s, when the low economic people of domestic economic migrants gradually replaced economic migrants from other countries. "The escape to the suburbs" was the process that, as shown in the table below, was stabilized since the 1990s, but in some areas of the center there is a version of the "white escape" phenomenon with variations in relation to the way in which the corresponding phenomenon occurred in the United States or the United Kingdom (Maloutas, 2012).This was especially the case during 1990's where the upper and middle class citizens left this area to settle at the suburbs (Kandylis, 2012).

The existence of spatial networks such as the railway stations affects the city, whose structure, way of expansion and appearance change in many ways. The key points of this spatial networks (such as train stations and multi-media interconnection stations) are also key points of the city itself and consequently -they gather a large part of the city's population by changing also its urban structure. Rail stations are paradigmatic spaces where high volumes of passengers, services and new activities are concentrated, thus being able to reshape the social and ethnic compositions of the neighborhood (Maffeo, 2011). This has been generating huge physical, functional and social conflicts whose effects spread out of the space strictly dedicated to railway mobility, by involving not only the surroundings but also a wider urban area (Conticelli et al., 1998).

The station node in view of its central position, in the heart of the served urban systems, represents a key point in which conflicts between city and infrastructure seem to be concentrated with intensity. Main needs, that are expressed by the city and its inhabitants such as moving, meeting, living in a livable and inclusive space

are taking place around the main railway stations and find their synthesis in the stations. On the other hand, the degradation of a space on the train network and especially the central station, may lead to the marginalization of the area around. Lack of direct and easy access to an area makes this last one automatically less reachable, whether it's in the suburbs or not (Beriatos, 2005). The rail station in the history used to be the fulcrum of the urban life and was defined by great vitality, around which important part of the city was structured. On one hand, this new urban structure required a direct connection with the city center, determining a quick filling process of the urban voids between these two centralities. On the other hand, the station as a physical barrier was the fracture in the urban structure and the functional relationships inside the city were interrupted between the one part of the urban space, usually the old city, to the other which usually were the more recent urban expansions that developed behind the station (Conticelli et al., 1998).

The central railway station of Larissis is forming a linear axis that cuts in two parts the urban space right from the beginning of its construction. In addition, this axis marks the districts born on both sides, to the east and west, with inherent social characteristics. The residential area of Larissis station, although is mainly extended to the eastern side of the lines, is marginally located on the "island – dam", created by the two stations (Larissis and Peloponnese) and is burdened by the existence and operation of the Larissis Station, as well as from the installation of uses related to Its operational needs.

## 2. METHODOLOGY

This study focuses on the surrounding area of Athens Central Train Station. Data were selected within a buffer zone of approximately 700 meters that can cinstitute a local range of influence (Zhuang et al., 2014). In order for the effect of the train station to residential prices to be evaluated several parameters should be taken into consideration. Specifically, the Hedonic Multi-Regression Analysis (MRA) model can be described in the formula below. Various linear models have been tested and the semi-log model (Chiarazzoa et al., 2014 & Bohman et al., 2016) was selected as it provided more robust results.

$$\ln(\mathrm{Y}) = b0 + \sum_{i=1}^{n} bi\, xi + \varepsilon i$$

with Ln(Y): natural logarithm of the dependent variable, $b0$: constant, $bi$: slope coefficient, $xi$: independent variable, $\varepsilon i$: error term.

A sample of 90 data records was collected from Greek property sale websites. All the advertisements were posted in 2017 thus the sale prices refer to the same economic period. The price variable used in the model was based on the asking price. It should be mentioned that a 30% of the asking price and 70% of the transaction value can be a satisfactory estimate of the final resident value (Yiorkas, 2017), but the website sampling approach could be also considered sufficient (Stamou, 2016). Analysis was performed via the Ordinary Least Squares (OLS) technique and via the QGIS 2.18 and GRETL software packages. The variables along with their characteristics are further described in Table 1.

## 3. RESULTS AND MODEL EVALUATION

The model was produced through the backward selection process (James et al., 2015). The variables that were assigned a p-value greater than 0.05 (confidence interval), were excluded although some (Train_station, Metro_Hsap, Bedrooms) of them were empirically used as they could improve the accuracy of the model. This

was the point where Adjusted R – factor was minimizing. Furthermore, their p-values were relatively low. One sample value obtained, was omitted as it was considered outlier. The selected variables with their OLS statistical characteristics are further described in table 3.

**Table 1: Variable characteristics**

| | Index | Variables | Unit | Description |
|---|---|---|---|---|
| Structural | V1 | Price (Dependent variable) | Euros (€) | Price of residence |
| | V2 | Area | Square meters ($m^2$) | Total area of residence |
| | V3 | Floor | Integer | Floor (level) of residence |
| | V4 | Construction | Year (Integer) | Construction year |
| | V5 | Bedrooms | Integer | Bedroom number of residence |
| | V6 | Dual-aspect | Dummy (Yes, No) | Dual-aspect characteristics of residence |
| Locational | V7 | Metro_Hsap__station | Meters (m) | Distance from nearest Metro & Hsap station |
| | V8 | Train_station | Meters (m) | Distance from Cental train station |
| | V9 | Green_public_spaces | Meters (m) | Distance from nearest Green space areas and squares |
| | V10 | Major_roads | Meters (m) | Distance from nearest roads that are of significance in the transportation network |
| | V11 | Education_culture | Meters (m) | Distance from nearest universities & museums |
| | V12 | CBD | Meters (m) | Distance from Central Business District |
| | V13 | Bus_stop | Meters (m) | Distance from nearest bus stops |
| | V14 | Schools | Meters (m) | Distance from nearest primary and secondary schools |

**Table 2: Variable summary statistics**

| | Mean | Median | S.D. | Min | Max |
|---|---|---|---|---|---|
| Price | 52556 | 45000 | 31178 | 8000 | 1.450e+005 |
| Area | 68.88 | 67.00 | 30.27 | 25.00 | 280.0 |
| Floor | 2.400 | 2.000 | 1.505 | 0.000 | 6.000 |
| Construction | 1980 | 1972 | 15.83 | 1955 | 2014 |
| Bedrooms | 1.611 | 2.000 | 0.6482 | 1.000 | 3.000 |
| Dualaspect | 1.389 | 1.000 | 0.4902 | 1.000 | 2.000 |
| Metro_Hsap_stati~ | 393.9 | 400.3 | 142.6 | 63.75 | 795.7 |
| Train_station | 540.5 | 506.4 | 239.7 | 102.5 | 1239 |
| Green_public_spa~ | 202.1 | 188.5 | 101.5 | 8.094 | 644.3 |
| Major_roads | 460.4 | 459.9 | 246.2 | 41.29 | 1047 |
| Education_culture | 1085 | 1175 | 382.8 | 362.7 | 1725 |
| CBD | 1721 | 1749 | 426.7 | 699.9 | 2543 |
| Bus_stop | 93.73 | 83.96 | 55.12 | 5.469 | 224.7 |
| Schools | 242.7 | 251.0 | 122.1 | 29.40 | 517.4 |

**Table 3: OLS - MRA Hedonic model results (5% confidence interval)**
**Dependent variable: ln(Price)**

| | Coefficient | Std. Error | t-ratio | p-value | |
|---|---|---|---|---|---|
| **Constant** | −33.699 | 3.93634 | −8.5610 | <0.0001 | *** |
| **(V2) Area** | 0.0119925 | 0.0021246 | 5.6446 | <0.0001 | *** |
| **(V3) Floor** | 0.046778 | 0.020239 | 2.3113 | 0.0234 | ** |
| **(V4) Construction** | 0.0218698 | 0.00200238 | 10.9219 | <0.0001 | *** |
| **(V5) Bedrooms** | 0.0790677 | 0.0675376 | 1.1707 | 0.2452 | |
| **(V7) Metro_Hsap** | 0.000290856 | 0.000232418 | 1.2514 | 0.2145 | |
| **(V8) Train_station** | −0.00014913 | 0.000135516 | −1.1005 | 0.2745 | |
| **(V11) Educ_culture** | 0.000232976 | 8.93791e-05 | 2.6066 | 0.0109 | ** |
| **(V13) Bus_stop** | −0.000971118 | 0.00057168 | −1.6987 | 0.0933 | * |
| **(V14) Schools** | −0.00059033 | 0.000259667 | −2.2734 | 0.0257 | ** |

Several tests were also performed in order to validate the model. The F-test of statistical significance (F=33.9418 [p-value 1.32e-023]) indicated that the n0 hypothesis can be rejected and that the model can be considered statistically significant. The accuracy of the model can be better assessed through the Adjusted $R^2$ indicator, rather than $R^2$, as it takes into consideration the overall complexity of the model. The model achieves an accuracy of (Adjusted $R^2$) 77.1%.

Furthermore, the model has been checked for heteroscedacity through the Breusch-Pagan test for heteroskedasticity (n1: p-value: 0.131222) and the n0 hypothesis about no heteroscedacity can be adopted. In addition, Variance Inflation Factors (VIF) were calculated and no collinearity was detected. The Variance Inflation Factors (VIF) test was performed and no autocorrelation was detected as all the variable's factors ranged from 1.125 to 2.309 (>10).

The chow-test for structural break was performed and the n1 hypothesis was dropped (n1: p-value: 0.395928). So, no structural change can be observed. Normality of residuals was also tested and the n0 hypothesis, that the residuals are normally distributed, was adopted (n1: p-value 0.337322).

To assess the spatial heterogeneity of residuals the Global Moran's I index was estimated (Morans I: 0.0366) . The index is close to zero, so residuals are randomly distributed across space (Yiorkas, 2017).

Residential distance from the train station has a "positive" effect and for every meter the price of the property is decreasing by 0.015% [coefficient back-transformation: (eb-1) * 100]. Thus, for every 100 meters it decreases by 1,5 %, for every 200 it decreases by 3%, etc.

## 4. PLANNING AND POLICIES

The railway is a strategic infrastructure for the European territory development, thanks to the introduction of high speed transport systems and the promotion of rail transport as a more sustainable transportation system which can quickly connect metropolitan central areas, more and more impenetrable by private vehicles, and key functions centers for the contemporary urban systems (Sun, 2016).

The wider area of Larissa station is one of the most central and crowded points of Athens. It is characterized by multiple features, both old and modern and its special character can be perceived immediately (Papatheodorou, 2001).

Historically, the rail station used to be the fulcrum of urban life and was defined by great vitality, around which important part of the city was structured. However,

the development of high-speed trains has led to a transformation not only in the architecture of the train stations but also in the development of (ownership) the estates nearby the area. The places from which these fast trains pass are of value, especially those that have direct access to a station, while the whole area has been upgraded. The most important example of this trend has appeared along the Eurostar line in Europe.

**Figure 1: Fitted linear model**

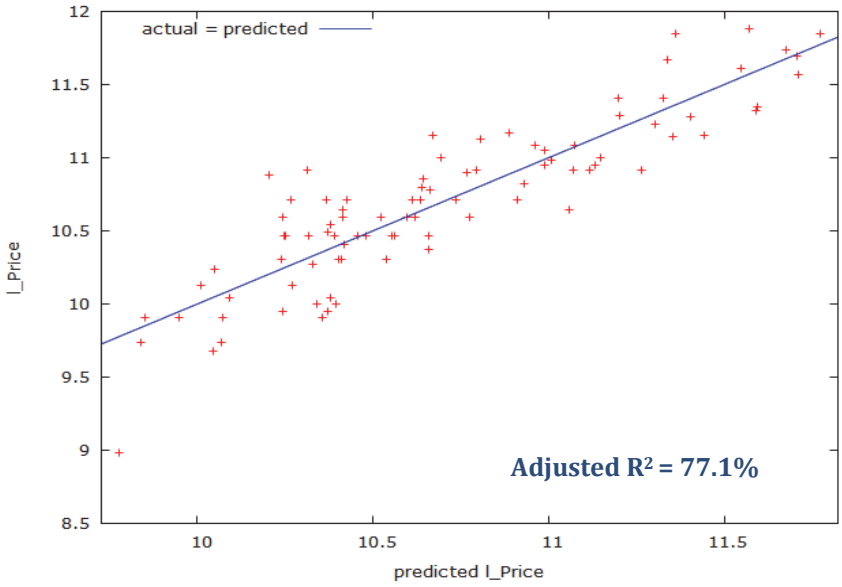



**Figure 2: Residuals graph**

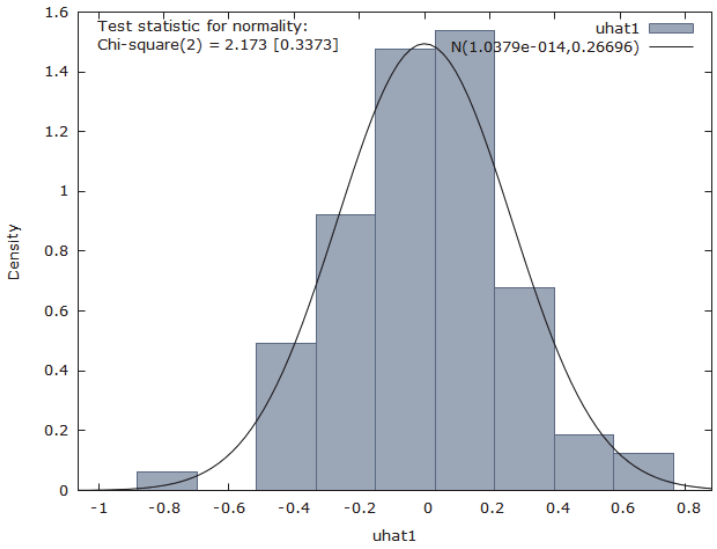
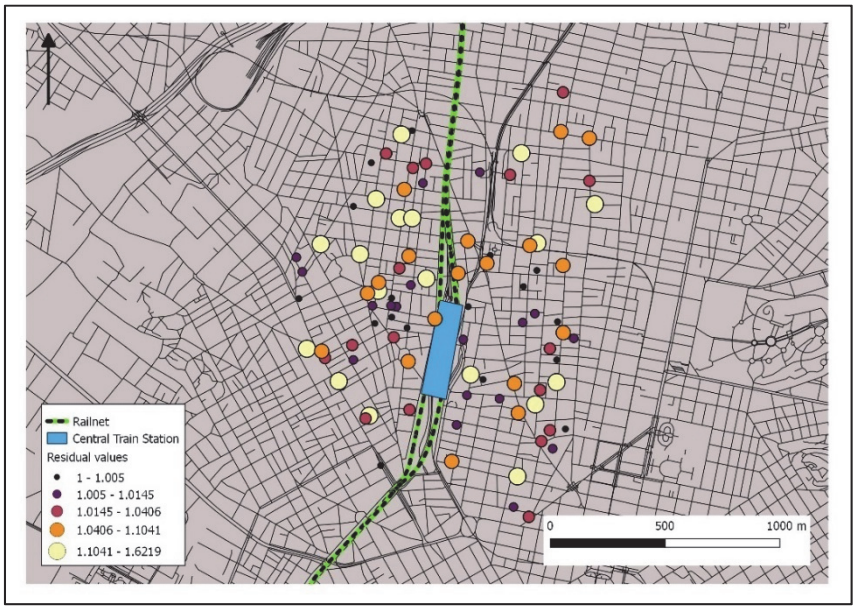


**Figure 3: Residuals value distribution in the study area**




Within the framework of the general upgrading, the construction of new modern high-quality railway stations will provide all modern comforts, better service and safety, as well as maintenance and rehabilitation of some old stations of interest. The easiest way to understand how close is the relationship between the improvements in transport infrastructure and its effect on spatial development is to observe their interconnection at the level of strategic nodes. An example of such an improvement is that a railway station redevelopment could bring urban growth for the adjacent area.

Railways are not just transport network nodes but can also influence other socio-economic parameters, as they have evolved into urban crowding points by integrating multiple city functions and continuously enriching their services. At a node, the larger its size, the greater its socio-economic attraction. If a station grew its dynamic, then it grows economically, and the city can be transformed into a "trans-metropolis" (metropolis - transit center). A typical example of a fast-paced urban hub is the Lille train station, built due to the TGV. Lille is now attracting more than 20 million visitors a year, with a total of 100 guests per inhabitant, meaning that Lille is a transit city, such as airport transfer halls, but on a different scale (Papatheodorou, 2001). Thanks to the introduction of high speed transport systems and the promotion of rail transport as a more sustainable transportation the railway system is a strategic infrastructure for the European and especially for the Greek territory development.

In Attica prefecture, a huge volume of architectural planning projects renovating the city center and its infrastructures has been realized mainly for public purposes even though there is a great criticism on this new landscape. There is a new public space resulting from underground metro stations, the reconstruction of the ISAP stations, suburban railway stations, the airport station and the three stations of Piraeus (OSE, ISAP, SPAP). This new landscape could justify the visions for the new

city where the railway stations (gate station) of the big Railway Axes are infrastructures that should be renovated as they can promote the urban development of the city and the area nearby them. This train station renovations could be the symbols of a new human-train relationship, like the experience abroad (Beriatos, 2005).

The proposed solutions for railways renovations can create exceptional conditions of different scale and scope for the upgrading public spaces in the public transport hubs. Investments in the railway system could be used as a catalyst for further development and upgrading of the urban fabric.

Furthermore, current accessibility to the main station area of Larissis station is insufficient for a railway network node of national and European importance. Larissis Station never responded the requirements of a capital city center of a country and never escaped the image of one Small-to-medium-sized passenger Ture. The rail station in the history used to be the fulcrum of the urban life and was defined by great vitality, around which important part of the city was structured. But today, the station should be upgraded to more than an eight-track railway infrastructure with an electrified connection to SKA (the northern gateway of Athens) and the passenger harbor of Piraeus. The link from SKA via Stathmos Larissis to Piraeus forms a corridor that has strategic importance for the future development of Athens.

## CONCLUSIONS

The main goal of this study was to investigate a possible interaction existence between Athens' Central Railway Station and the value of residences of the station surrounding area. To validate or reject this interaction the hedonic pricing method and OLS was applied in conjunction with spatial analysis. House sale prices were collected from property sales websites and structured on a series of criteria like Age, Floor, Area, Central train station distance, School distance etc. The hedonic pricing method indicated that a 'positive' correlation between house prices and the Central Train Station distance could possibly exist. Therefore, the location of the Railway station could play a crucial role in the development of its neighboring areas that are mainly characterized by low-income groups.

This result can confirm some assumptions that were mentioned in the introduction: railway infrastructures are mostly located near low-income rate residential areas. Moreover, an areas' identity is related to a plethora of other variables like population density, point of interest accessibility, public opinions etc. The Train station can be a growth pole that can lead to the overall development of areas. This potential can be further enhanced through the urban regeneration of these areas, the re-use of abandoned areas and buildings and the promotion of the buildings' architectural heritage. This kind of policies are widely implemented abroad and aim at the overall socio-economic development of the Train station's surrounding areas, given the well-established and well-proven theories of spillover effects (Kyriakidis and Siolas, 2013).

The existing property of the Greek National Railway Company is characterized by a high potential development through investment attraction and real estate management. Train Stations and Rail property in general, could transform through their redevelopment the adjacent areas, transforming them into multidimensional spaces that could be used on a daily and extended basis and which can help promote their viability and the sense of security (Jane Jacobs, 1961).

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## Quartier de gare et effet sur les prix immobiliers : application à la gare centrale d'Athènes d'un modèle hédonique

**Résumé -** Cet article propose de combiner une analyse spatiale exploratoire et l'utilisation d'un modèle hédonique pour étudier les relations entre les infrastructures ferroviaires et les prix immobiliers en milieu urbain. Plusieurs études sur des cas de villes européennes et américaines montrent que la présence de gares a un effet positif sur les prix immobiliers. Cet article examine le cas de la gare centrale d'Athènes et les effets de sa localisation sur les prix immobiliers dans un rayon de 700 mètres autour de la gare. Le travail s'appuie sur une base de données originale, obtenue par le biais des actes notariaux et des offres de vente. Les résultats montrent qu'à Athènes, contrairement à d'autres villes, les prix immobiliers sont inférieurs à proximité de la gare et tendent à augmenter au fur et à mesure que l'on s'en éloigne. Une série de propositions est formulée pour la revalorisation de ces espaces.

***Mots-Clés***
Quartier de gare
Prix immobiliers
Modèle hédonique
Analyse multi-régression
Athènes