Effect of externalities on investment in urban renewal: a Game Theory application

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EXTENDED ABSTRACT

Abstract: Urban Renewal is an increasingly urgent need in the city of Lisbon. The buildings have evolved into old, damaged, lacking maintenance and a very high percentage of vacant and blighted buildings is still a reality. Efforts have been made so that urban rehabilitation processes are more accurate but given the workload, those efforts are still well below the suppression of all aspects that are required for them to cover.

It is well known that rehabilitation gives rise to externalities, both public and private. In this paper, starting from a global vision, are studied those externalities related to owners namely the ones related to rehabilitation investment, are the ones in focus.

The focal point of this study arises from externalities classification to the study of the decision-taking processes in rehabilitation involving several owners with the application of Game Theory. Was proved by the theoretical and empirical model that there is no incentive to rehabilitate although its appearance from the time that exogenous factors force or pressure it to take place is a reality. From this evidence is that it is increased as buildings are rehabilitated. From that point on, is as big as more buildings are rehabilitated.

That incentive comes from externalities that influence the rehabilitation values increasing in the first instance, the book value of the properties. This increase evolves in the motto for a better development of urban regeneration projects contributing to a more interesting Lisbon from investment’s, job creation or tourism’s point of view.


1. Introduction

According to the Estratégia de Reabilitação Urbana de Lisboa project that started in 2011 and ends in 2024, Lisbon today is consolidated at 82% so the new paradigm of city planning and management involves giving priority to regenerate the existing city, rehabilitate what is in poor condition, reuse which is vacant and qualify the consolidated city. It stands that it is necessary to extend tax incentives to all the works of conservation and rehabilitation, regardless of their location in the city to give new impetus to the works in private buildings. This position requires clarifying the concept of work in private buildings so that public resources are applied in a fair and effective way.

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This paper attends that question by analyzing all the externalities arising from the subject particularly the ones related to private investment and gives it a new approach by applying Game Theory to the decision-taking in investing in urban renewal.

Game Theory is a mathematical theory that solves decision-taking situations involving various stakeholders and whose development brings the highest possible return to each of them. So, knowing that there have been studies correlating game theory and urban renewal and that empirically externalities influence the decision-taking in rehabilitation, in a total different approach, this study applies Game Theory to that decision-taking process based on the profit that investors or homeowners have when they decide to invest. It explains if there is or there isn’t a natural incentive on buildings rehabilitation among other blighted buildings.

Then, the theoretical model analyses a rehabilitation situation involving several of that hypothetic blighted buildings in which a rehabilitation process takes place when the first homeowner decides to rehabilitate his property to understand the differences on profit when the investment is made on an already rehabilitated area. Afterwards, the theoretical model goes on testing by having a list of several buildings in Lisbon according to data provided by companies on the market. Starting from an area classification based on area conservation criteria and cost/gain quantification, we can now obtain the profit percentage on the value spent on the process. From that point on, relating the percentage of profit to the classification criteria, we can reach a conclusion confirming or not if there is an incentive in rehabilitation.

In other words, the aim of this paper is to study the effect of private externalities, including the effect on higher or lower valuation of the property by the surrounding environment (rehabilitated or not) and their impact on the decisions and outcomes of investing in urban regeneration processes. It also aims to understand the inertia of private investment in the rehabilitation of buildings in degraded areas, using a game theory model to model decision-making.

The problem of externalities in urban renewal

It is a fact that, in Lisbon, the attention to the issues of urban renewal has increasingly become a priority on the city’s agenda due to both the gradual worsening of the buildings - especially in historic and poor areas - as the situation of the sector of construction in Portugal. This is clear by the appearance of programs like RE-HABITA LISBOA, RE9-9, RER – Programa de Segurança Sísmica e Aumento da Eficiência Energética and Reabilita Primeiro Paga Depois.

Also, looking beyond national borders, we can see that this trend is evident in Europe and elsewhere in the world, so people have been developing studies in order to quantify the benefits and losses caused by urban regeneration process both on economic, environmental or social areas. Those are externalities, widely studied in terms of identification although the number of investigations regarding the economic quantification reduces significantly.

Rosenthal (2008) states that up to a quarter of the change in a neighborhood social status can be anticipated (those, 80% are influenced by externalities and 20% by the age of the
buildings) and the economic situation of the district follows a curve consistent with the decline and renovation of buildings.

The fact is that rehabilitation is a form of intuitively improve people’s living, so it could soon be carried out by the population itself without government’s intervention (Davis and Whinston, 1957). However according to Davis and Whinston (1957) owners overlook possible improvements of existing structures because they expect the emergence of new uses that can bring gains adding the value of the property. In addition, the subjective utility or derived enjoyment of certain property depends not only on project status, etc. of this property but also the characteristics of nearby properties.

It is known and referred by Miceli et al. (1998) that externalities occur in the housing market when the behavior and characteristics of a household alter another household behavior and characteristics. For all that, quantifying externalities is the starting point to the improvement of those relations between neighborhoods, improving the city in which it belongs.

2. Classification and quantification of externalities

According to Rossi-Hansberg et al. (2010) externalities amplify the effects of rehabilitation programs and are much more pronounced near the area of investment, falling as it moves away from that core.

Nevertheless and as evidenced by Chau and Wong (2013), the level of positive externalities of a given project depends on its scale as well as the number of business areas including and in addition it is emphasized that an urban renewal project does not necessarily produce positive externalities depending on this type of building or infrastructure building.

So, there is an innumerable amount of externalities known that arise from urban renewal as it is such a recognized phenomenon. In the review of existing literature we can find examples for economic externalities emerging from rehabilitation programs as those are the ones that interest us the most. Yau (2014) for example found that after the revitalization of abandoned properties in the neighborhood the price of home sales in Camden, New Jersey increased by 26.6 %. On the other hand, there are contradictory situations - Chau and Wong (2013) prove that the value of old buildings decreases faster with the announcement of a project. To 10% increase in the age of the buildings, the price declines 1.2% which is higher than the previous depreciation of 0.7% before the announcement.

A negative externality of rehabilitation can be found on the increase of the income and consequent injury to the inhabitants of lower income (Vigdor, 2010) and the increase of the tax burden (Malpezzi, 1996).

For all this, quantifying the magnitude of externalities is fundamental to understand the impact of urban policy (Rossi-Hansberg et al., 2010). Yet the positive externalities are ignored on a large scale in maintenance decisions and this explains the decision of the owners of neglecting the rehabilitation of their properties (Yau, 2014).

From this statement, we can conclude that even if the externalities generated are not positive, they happen in each and every rehabilitation project and can be divided into three
categories: Social, Environmental and Economical Externalities. Below, Table 1 shows a list of economical externalities because those are the ones that better serve the purpose of this study.

<table>
<thead>
<tr>
<th>Table 1 – Economical externalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
</tr>
<tr>
<td>Increase in the price of land per m²</td>
</tr>
<tr>
<td>Increased revenue and property value</td>
</tr>
<tr>
<td>Trade development</td>
</tr>
<tr>
<td>Employment creation</td>
</tr>
<tr>
<td>Improvement of industrial relations</td>
</tr>
<tr>
<td>Catalyst for economic activity</td>
</tr>
<tr>
<td>Increase on wealth perception</td>
</tr>
</tbody>
</table>

The case of private externalities

Private externalities are in fact the focus here. Mainly within the quantifiable externalities are the ones related to private investment and the benefits that such investment can bring to owners.

So, an externality that can stand out as a private one is for example the increase of the price of land per m² and the increase of the income and property value. Rossi-hansberg et al. (2010) stand that over a period of six years, a dollar rehabilitation of housing generates $2 to $6 of land value. In other words, it is an increase in the land prices per square meter which obviously translates into an asset for the owner as a positive externality. Collins and Shester (2010) report too an increase of income and value of the property even though a possible negative externality of rehabilitation is in the consequence of the increase in this income: rising rents and consequent injury to the inhabitants of lower income (Vigdor, 2010) and the increasing tax burden (Malpezzi, 1996).

3. Game theory applied to urban renewal – theoretical model

Silva et al. (2011) stand that Game theory is a powerful tool on social sciences and it was used for example by Lin and Lin (2014) to analyze the strategic interaction and the negotiation processes between owners and promoters of a rehabilitation project in Taipei.

But there hasn’t been a study that solves the decision-taking processes involving Nash Equilibrium, so in this case, particularizing the Nash equilibrium for Urban Renewal, we will study the issue of the decision to rehabilitate or not and if this happens naturally by market pressure. This application is important because it is a mathematical theory to corroborate the importance of incentives by third parties standing that rehabilitation does not happens by itself and making it much more credible and a very strong case facing the investors.

Therefore, it can successfully be explained by a situation where we have two owners. In a case where there is two players and if Table explains the constitution of Table, knowing that $V_{p}>V_{i}>V_{p_{ind}}$, Nash equilibrium can be found if we explain that the two owners - x and y - neighbors in indecision to invest or not in rehabilitation of their property build the payoff matrix of this situation – Table 3Table.
Knowing that what they are willing to spend to rehabilitate is a total of C and that value is equal to \( V_{pi} \) (property value) because it is part of a theoretical model and thus a cost of works equal to the book value assumes a more heavily form (the conservative side of the study) within the boundary of economically viable, the data presented in the matrix consists of the difference between the final value of the property and C invested in order to perform a comparison between investing or not.

If the owner X invests, his property is worth a total of \( V_{pi} + V_i \) which withdraws the amount invested (C). In this case, if the owner Y invests also, his property will be worth the same \( V_{pi} + V_i \) in which is also removed C. On the other hand, if Y does not invest, his building will gain by being next to the property rehabilitated so it is now worth of \( V_{pi} + V_{pind} \) (less than \( V_{pi} + V_i \)) and this time, as he did not invest, he does not subtract C.

### Table 2 – Explanation of Table 3

<table>
<thead>
<tr>
<th>Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{pi} )</td>
<td>Initial book value of the buildings</td>
</tr>
<tr>
<td>( V_i )</td>
<td>Initial value gained in rehabilitation</td>
</tr>
<tr>
<td>C</td>
<td>Cost of works</td>
</tr>
<tr>
<td>( V_{pind} )</td>
<td>Indirect book value</td>
</tr>
</tbody>
</table>

### Table 3 – Game theory applied to rehabilitation

<table>
<thead>
<tr>
<th>Owner x</th>
<th>Invests</th>
<th>Doesn’t invest</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{pi} )</td>
<td>( V_i ) - C</td>
<td>( V_{pind} )</td>
</tr>
<tr>
<td>( V_{pind} )</td>
<td>( V_{pi} )</td>
<td>( V_i )</td>
</tr>
</tbody>
</table>

If the owner X chooses not to invest and Y invests the same situation happens as described above - the property of Y takes effect \( V_{pi} + V_i - C \) and the one of X, \( V_{pind} \). If no one invests, the properties continue to be worth \( V_{pi} \) - the initial book value. It so happens that the more logical decision having the profit in sight is indeed to not rehabilitate, as Table 4 explains.

### Table 4 – Most beneficial decision / Nash equilibrium

<table>
<thead>
<tr>
<th>Owner x</th>
<th>Most beneficial decision</th>
<th>Owner y</th>
<th>Most beneficial decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invests</td>
<td>( V_{pi} + V_{pind} ) &gt; ( V_{pi} + V_i - C )</td>
<td>Does not invest</td>
<td>( V_{pi} + V_i - C )</td>
</tr>
<tr>
<td>Does not invest</td>
<td>( V_{pind} ) &lt; ( V_i )</td>
<td>Does not invest</td>
<td>( V_{pind} )</td>
</tr>
</tbody>
</table>

What in fact Game Theory proves is that there is no natural incentive to rehabilitate.

As an example, we have the fictional X Street where all buildings are blighted. The street is composed of 6 buildings and 6 different owners. It is important to notice that all buildings have the same areas, the design is very similar and all of them were built at the same time. The model is built this way to enable the comparison.

Now, we assume that the first owner has some money to invest and he is not doing so in order to have profit but to altruistically preserve heritage. Thus he decides to rehabilitate his property. Spending hypothetically C, he allows his property to be worth \( V_{pi} + V_i \). In this case, to Building’s 2 (right next door) value is added \( V_{pind} \), where \( V_{pind} < V_i \) - Figure 1. This happens because Building 2 gets enrich by staying next to a rehabilitated building.
Owner 2 realizes that in Owner’s 1 case, profit was greater because once again $V_{\text{p}_\text{ind}} < V_i$ so $(V_{\pi} + V_i) < (V_{\pi} + V_{\text{p}_\text{ind}})$ and soon decides to do the same. Attending that the workload is the same and the properties are equal, Building 2 would also worth $(V_{\pi} + V_i)$ but now that property is next door with a rehabilitated property so it is going to worth $V_{\pi} + V_{\text{p}_\text{ind}} + E$ where $E > V_i > V_{\text{p}_\text{ind}}$ – Figure 2

The following owners see a business opportunity and too decide to rehabilitate their properties, so the same as previous occurs. From now on, all owners want to rehabilitate. According to Figure 3, it is easy to understand that there is a difference between rehabilitate a building flanked by two. The difference in appreciation goes from $V_{\text{p}_\text{ind}}$ to $2V_{\text{p}_\text{ind}}$.

At this point we can ask: what is the most reasonable attitude for Owner 6? Given that X St. is totally rehabilitated, for him to obtain an appreciation similar to $V_i$ besides $V_{\text{p}_\text{ind}}$ it is enough to invest a total of $F$ (minor than $C$). Although $V_i$ is minor than $E$, it is in fact more advantageous to wait that all the building are rehabilitated because then he could invest less and have the same profit. It is important to notice too that the work cost does not change from buildings 1-5 to 6 because that value does not depend on the neighborhood conditions but the
buildings state and materials used which were the same in all cases. The thing is that, in Building’s 6 case, the value alters from C to F because the owner had to invest less to obtain the same compensation - Figure 4.

<table>
<thead>
<tr>
<th>Owner</th>
<th>Work cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
</tr>
</tbody>
</table>

| Figure 4 – Renewal of X St. – Final situation |

What if all owners act like this – to wait? The truth is that no one would rehabilitate their property because every single owner would be waiting for other to have initiative. This statement proves the statement from Nash Equilibrium – there is no natural incentive to rehabilitate. It is now proved that there has to be an external factor to influence rehabilitation. In fact, the first owner to rehabilitate, in a current market situation is always the most prejudiced.

Now, according to theoretical model, we could state that if, in Nash equilibrium, X rehabilitates, Y would be impelled to rehabilitate too. This does not happen. The thing is Nash Equilibrium works as if players had to make their decision at the same time without knowing each other’s decisions. On the other hand, in the theoretical model, there’s a timeline. So, theoretical model and Nash equilibrium do not contradict. They complement. Nash equilibrium comes to prove that the incentive in rehabilitation only occurs after other decides to rehabilitate.

The effect of externalities on the investment on rehabilitation game

Until now, the values and hypothesis studied involved several situations that embrace primarily private externalities and overlook many variables on the development of an urban rehabilitation project. To those private externalities are added the public ones that influence directly or indirectly the private externalities. Truth is rehabilitation does not only involve the book value of the properties. All externalities involved add or take value to that property. $V_{p_{ind}}$ value represents precisely that fact.

So, Building 1 for example will value more than expect. By all means, externalities have an effect in all buildings and influence the prices from the beginning of the design so they cannot be forgotten.

4. Case Study

This chapter summarizes the study made. So, it answers the question: is the profit in a rehabilitation process different considering a rehabilitated area? We already attend this question on the theoretical model but now we prove it through collaboration with companies in the sector. After gathering data from a total of 39 blighted buildings, the area surrounding then was divided by categories according to the area status of conservation. Three criteria were used:
Conservation status of buildings – good, medium or bad; Rehabilitated area – when there is presence of rehabilitated buildings nearby (yes or no); Localization – according to various factors, the area is considered Good, Medium or Bad. Now, having the area characteristics we gather data from the companies, namely the book value, areas and acquisition costs.

Companies say that rehabilitation costs in Lisbon round about 530 m² + IVA. In this approximation we are considering values related to housing rehabilitation because the data base only considers this kind of rehabilitation. The IVA was despised because it is the same for all situations and as we are comparing, it would not add nothing new to that comparison. Through the product between work cost and total area of each building we reach the value invested in rehabilitation approximately.

To understand the profit it is important to have the property sales value to which we have no direct access. The properties are not for sale yet or there is no information available. For this value a relation with a similar building in the same situation and for sale is going to be made based on the areas of the two. This relation is:

\[ \frac{V_{vs}}{A_s} \times A_e = V_{ve} \]  

(1)

Where: \( V_{vs} \), Sales value of similar building; \( V_{ve} \), Sales value of studied building; \( A_s \), Area of similar building; \( A_e \), Area of studied building.

On the demand for similar properties, the advanced search tool of various companies in real estate acting in Lisbon was used. With this value it is possible to obtain the relation between invested and earned, relating it then with the status of the area and evaluate the success or failure of the business. The profit of the transaction is obtained by:

\[ V_p - V_a - C + V_v = L \]  

(2)

Where: \( V_p \), Book value; \( V_a \), acquisition value; \( C \), work cost; \( V_v \), sales value; \( L \), profit.

So, analyzing the results is possible to understand that profit is always bigger every time the area is rehabilitated with some exceptions that can be justified by the high amount of work costs exceeding the average values adopted.

Interesting to notice that by calculating the percentage of profit over costs (acquisition value plus work cost) the percentage is well above 100%, percentage that decreases as we descend to areas classified as bad in Location criteria which indicates that the location of a building as influence on his transaction profits. This percentage is in fact what matters to investors.

5. Conclusions

In an environment increasingly marked by dilapidated buildings, all the efforts that have been developed in Lisbon have indeed been successful in improving buildings but there is still a quite high work load ahead so more than talk about rehabilitation and promote projects we need to change mindsets - alert the population to this reality so that they do the maintenance of their properties without profit as the main concern. But for this, we need to encourage urban renewal
and therefore at an early stage this incentive goes through entice owners and investors to the benefits that it can bring in terms of investment so than later it can become a multidisciplinary reality happening in a natural form. The identification of externalities works as the first phase for investors / owners realize that to rehabilitate a building does have consequences and most of them positive.

In this context, this paper had as main objectives to understand to what extent and how rehabilitation is important for urban environments mostly at the private level to initiate a process of awareness mentioned before. The adequacy of game theory was a novelty because as mathematical tool allowed the development of a robust argument for the fact that rehabilitation does not happen by itself. The intention was to, in order to prove that there is no incentive to rehabilitate, notice if there is any difference in investing in a rehabilitated area or not and how much translates this investment.

**Key findings**

In this document, the main conclusion is that there is no natural incentive for rehabilitation unless it is developed through a deliberate action to do so. This aspect is demonstrated by the Nash Equilibrium of the Game Theory.

Thus, since there is no natural incentive to rehabilitate, will it be develop after a few buildings in the area are rehabilitated? In answer to this question can be said that there is this incentive from the moment that other rehabilitates and this is a fact regardless of the number of rehabilitated homes in the area. What the case study has proved is that this incentive is greater the more properties are rehabilitated, which is why many owners even though others take the initiative, are always waiting for the right time to invest.

Simply put, there is no incentive to start rehabilitation but it appears from the moment that exogenous incentives force or pressure for rehabilitation to take place. From there, it is greater as more buildings are rehabilitated. However, this brings a currency reverse: it can cause the process to stop by itself as owners in the greed of getting higher profit expect others to invest in order to invest too. That is, if all investors/owners start thinking this way the rehabilitation process is stuck. Consequently it is necessary that stimuli are developed for the process to take place and to continue to develop.

The advantages of this study relate to the use of strong arguments based on a mathematical theory that alone brings them credibility in the importance of an external source of stimulation in rehabilitation. This source can come from a philanthropist investor but in normal situations must come from mainly the governing bodies.

Despite its limitations, including the fact that is a study based on average costs and therefore error-prone and non-consideration of all the externalities that appear on the market this unspoken failure the same as the conclusions presented here can be designed in more situations specific because they are science-based arguments.
Future suggestions

From all these conclusions we can state that the consideration of externalities cannot be neglected either by the government or by the investors/owners. They dictate the success of a project both in private terms, more related to investors/owners or public speaking, more related to the government agencies that regulate urban planning section in the cities, although this last statement has an obvious and indirect impact on investments.

It will be also interesting, the future development of a complementary study, involving all kinds of externalities including the effects of public externalities applying them Game Theory, which turns out to be a very solid argument among rehabilitation ins and outs.

So it is necessary to continue with the work that has been done in the city of Lisbon in order to move consciences and improve access, services, trade, housing and renting and all sectors that relate directly or indirectly to the rehabilitation. Therefore, the construction of a matrix in which all the social, environmental and economic externalities are identified and quantified can be useful in order to understand the amount of public subsidy that may be invested in mitigating or exacerbating the effects of externalities within the border of economically viable.

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