A Game Theory Approach to The Preference of The Street Development in Semarang Chinatown

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Abstract. The Chinatown of Semarang consists of many historical streets along with their heritage temples where a few informal social and physical urban developments occurred in those streets. This calls for a systematic urban redevelopment decision-making process. Using spatial data to demonstrate the current and future situations of street development, this paper aims at investigating the best scenario to develop Semarang Chinatown and also the advantages as well as the limitations of game theoretical models for the development of Semarang Chinatown. Therefore, we have developed game model based on Nash game theory, in which a certain action results in a certain payoff, for the case study. Our study demonstrates that game theory can provide key strategic decision of Chinatown development by showing the different payoffs of choosing main streets that are more urgent to be developed and selecting the equilibrium in which involved important stakeholders best interests. We also found limitations on using game theory in our case study especially regarding the assumption of preferred historical streets in the area.

Keywords: Game theory, conservation, Semarang Chinatown, decision-making, area development

1. Introduction

Chinatown of Semarang has been famously reviewed in many scientific articles particularly in the area of architecture and heritage [1–5]. The fact that many buildings in this area are still the same as the way it was since the Dutch colony calls for the government to state this area as heritage area. Although many buildings have shown some quality degradation, the law of heritage buildings protection also making it difficult to revitalize the traditional buildings. Apart of that, there are many temples that still exist in the area. On the other hand, The modernization of the city threatens the local culture of the Chinatown itself. The newer architectural style started to replace the traditional architectural style [3]. Local people were left with choices either to modernize the old buildings or to leave the old buildings as it is due to the restriction of heritage law.

The history of Semarang Chinatown goes back to 1740 when it was a seaport with multi nations visitors, including Chinese ethnic. Around the same time, the Dutch colonial government gave order to put the Chinese society in a certain region in Semarang, nowadays called Semarang Chinese, in order to ease the supervision process. Consists of many small streets, at the beginning, most alley buildings belonged to the Chinese residents. Bigger street such as, Gang Warung, Gang Pinggir and Gang Besar, were developed into commercial district while smaller street like Gang Tengah, Gang Cilik and Gang Gambiran can we identify some traditional Chinese residential buildings. However, this paper will focus only the streets that are developed for commercial purposes. There are two most important streets in Semarang Chinatown from economic perspective; they are Gang Pinggir and Gang Warung. Many activities occur during the day and night as shown on Error! Reference source not found. and Error!
Gang Warung is famous with its night market that happened on Friday evening, Saturday evening and Sunday evening. During this time the street was closed for the culinary market purposes, therefore this street became inaccessible for any vehicles. During the day everyday and weekdays evening, this street is accessible by vehicle and some stores also open during the day. Error! Reference source not found. showed the different activities and crowd it causes at noon and evening during the night market.

On the other hand, Gang Pinggir is one of the main vehicular street in Semarang Chinatown that lays for X km. Although as not as crowded as Gang Warung night activities, this street activities are relatively more active during the day and the whole weeks. Businesses such as jewellery store, bank, hotel, restaurant etc. exist along the streets. This street is also longer than Gang Warung.

![Figure 1 Activities in Gang Warung during the day (left) and during the night (right) (Author's documentation)](image1)

![Figure 2 Activities in Gang pinggir during the day (left) and during the night (right) (Author's documentation)](image2)

Although both streets considered the busiest street in the area, the activities occurring in either of them showed different results whether in economics aspects or spatial and architectural aspects. This paper is aiming to use game theory model to present the payoff and explore the main cause why different activities can happen in different way. The game model of the two important economic streets of Chinatown. We also give the system equilibriums under the non-cooperative conditions to compare results whether the streets will be developed or take the over spill and if any of them rejected the development plan, so as to propose a reasonable result.

2. Data and Methods

2.1. Why game theory
Although game theory has been applied in many field of research, there are only a few applications found in urban development practice. Game theory applications in urban development mostly focus on negotiations between players or stakeholders involved in the game. Game theory was used to model negotiation in forming public partnerships for brownfield redevelopment [6,7], negotiation processes
with respect to value capturing in land and property development [8,9], pricing strategies with respect to land use [10], negotiation between the tenant and the landlord with respect to lease contract [11] and also borough development was modelled using game theory [12].

In general, games can be represented in strategic or extensive form. According to the decision making process of the players, simultaneous games (where the players can either act simultaneously) can be represented using strategic form using a payoff matrix, while sequential games (players act in sequential movement during the games) can be represented in extensive form with a game tree. While in the application, game can be classified in to cooperative and non-cooperative game. Cooperative game is where players agreed to cooperate in order to achieve the best outcome out of their interest. While non-cooperative game usually deals when there are conflicts occur when the interests of players opposed each other.

In a game, players are the decision makers. When a player knows exactly where he stands in the game or he knows exactly the other players strategy in the game, then we speak of perfect information. If the player does not know where he is in the tree but he still can estimate the probability of the payoff then we speak of imperfect information. In this situation, he does not know the previous moves made by other player. In this paper, we assume that the players are the two streets that will possibly be developed and both cannot predict the other’s move. Therefore, this game is in the state of imperfect information.

In a game there is a strategy which is defined as a contingent plan of action [8]. In the field of strategic management, a strategy contains long-term goals and objectives, as well as a plan how to attain them [13]. For each strategy taken, there is an outcome for it and the value of the outcome is defined as payoff. In essence of game theory is that each players determine what strategies, but the results depends on the selection of the strategy, in order to pursue their own interest. Therefore we can speak of maximizing each player’s payoff by solving the game using Nash equilibrium.

2.2 Developing Game Model

Began with literature review on the current situation in Semarang Chinatown as presented on Section 1, the map of Chinatown building mass and streets developed with GIS, in order to map and point out the accessibility and spatial quality of the streets in Chinatown. The next step is to develop the game model using matrix payoff to present payoff if the strategy taken in this case, which are developing the bigger streets in Semarang Chinatown. This paper will only cover Gang Warung and Gang Pinggir where current informal development (in the form of night market) occurred in one of them and influencing the others. Therefore, game theory is suitable to elaborately present the effect of certain strategy in terms of payoff to ease the decision-making process.

Game model used in this paper is non-zero sum non-cooperative game under imperfect information. Since this game model is a non-zero sum game, the payoffs can be represented on positive number, instead of using payoff like -1 for loss and +1 for winning. There are three aspects to be considered in calculating the payoff: spatial quality, financial aspects and architectural value. The calculation and the weighted score of the payoff are presented on Appendix 1. The given payoffs were gathered based on field observation and several literature sources. This given payoff is however required feedback from expert, which are still inadequately available. Since this paper only presented the game model to present the development scenarios, such feedback will be required for further study and for bigger scope.

3. Result and Description

Looking at the present condition, both Gang Pinggir and Gang Warung are the main urban catalyst acting as the business district in Semarang Chinatown that present activities during the day and night. Although Gang Warung night activities during the weekend yield more revenue for the locals, Gang Pinggir yield activities every evening even though the crowd is not as much as Gang Warung However, the effect of weekend crowd in Gang Warung is traffic jam in some part of the streets across it, such as: Jalan Beteng, Jalan Pedamaran and Gang Pinggir as well. Gang Pinggir on the other hand, unlike Gang Warung, it is the main access to many smaller streets, which mostly are residential area, in Chinatown, as Figure 3 suggested. Developing Gang Pinggir will result in bigger visitor of the temples along the way. Therefore, the development of Gang Pinggir will increase awareness in heritage but will cause worse traffic than
the existing traffic caused by Gang Warung due to its main function as the main street in Chinatown.

Figure 3 Building Mass on Semarang Chinatown

Furthermore, both streets have unique typical row shophouse buildings that can be seen in many Chinatown in Asia. Figure 3 suggested that both streets have very dense buildings along its main streets. Cities like Singapore, Kuala Lumpur and Malacca also have similar style of row buildings which consists of shops on the ground floor and living space on the top floor. These buildings remains in Gang Warung since the building tenants still use them to do their business while the living function is less likely functioning. The situation at the moment is that the locals transformed the street into Semawis Night Market every weekend evening to gain more revenue. Although economically positive, the market cause degradation in spatial quality as it cause disorder in parking space and traffic. Although, the night activities in Gang Warung do not affect much the architectural façade of the buildings, what happened in Gang Pinggir is otherwise. As the main business street in Chinatown, there are many businesses in Gang Pinggir that changes the façade and the layout of the traditional shop house buildings. Even though the activities in Gang Pinggir cause less traffic disorder, the architectural changes are inevitable. In other words, improving the Gang Warung will yield more revenue but causing traffic jam in some part of Gang Pinggir but improving Gang Pinggir will create more traffic that might cause Gang Warung to be transformed into an accessible parking area.

Considering the condition above, we determined the higher score weight on financial aspects with 40% and spatial quality and architectural value were equal on 30%. Thus, we presented the outcome on the certain strategy in terms of payoffs.
Table 1 Matrix Payoffs

| Development of Gang Warung | No development of Gang Pinggir |
|---------------------------|-------------------------------|
| Development of Gang Pinggir | -2,-2                         |
| No development of Gang Pinggir | 8,4                           |
| No development of Gang Warung | 3,3                           |
| Development of Gang Warung | -1,-1                         |

Table 1 demonstrated the simple model for two-person game where either streets can be developed and accepting growth, or not be developed and refusing the growth. The simple two-person non-zero-sum game shows equilibria when both parties disagree to the same plan, neither both agreeing to accept growth nor both refusing. The payoff matrix suggested the development of one street at the cost of other would bring better stability for the area, being the result of rational solutions from the basic game. In this case, the option to develop Gang Warung and preserve Gang Pinggir is a more adequate option due to the effect on Gang Pinggir spatial quality. When both streets agreeing to accept of refuse the development, the results will not beneficial to many parties’ interest because some strategies planned on one street would influence other streets in terms on those aforementioned aspects. Therefore, a matrix payoff was developed to see the possible outcomes for every strategy. The considerations on how the payoffs were determined were presented on Appendix 1. This model can be used for more than one strategy also and played with many players. In the case of many players, an extensive game tree would be a more suitable option.

On the other hand, further validation involving stakeholders such as locals, municipalities and experts are required when one want to ensure the results of such game model since there are many more aspects to consider besides economic, spatial and architectural factors. However, this game only focuses on presenting the possible game model to present some of the examples of conflict and negotiation in spatial planning.

4. Conclusion

This paper investigates the possibility of smoothing decision making process with game theoretical model. The non-cooperative game between strategies of developing on which Chinatown business streets are discussed. Research suggested that focus on the development on one of the streets yield a higher positive result than forcing on developing both streets and none of them, the optimal effect achieved by Gang Warung development rather than Gang Pinggir. Despite of only showing the preliminary game model, the results of this paper, which is the design of the game model for street preference development in Semarang Chinatown, encouraged to conduct further research using experimental game theory to ensure the validity and reliability using respondents or preferably experts feedback of the proposed game model since the current condition presented in this paper were gathered from field experience and literature source.

5. References

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Appendix A. The outcomes and payoffs of street development in Semarang Chinatown

| Development of Gang Warung | Development of Gang Pinggir | No development of Gang Pinggir |
|---------------------------|----------------------------|-------------------------------|
| + High Revenue for gang pinggir and gang warung but will result in competition (10,10) | - Very poor spatial quality, causing traffic jam and terrible accessibility (-10,-10) | - Optimal spatial quality for gang warung due to ease of access on the west and east point of the street. On the other hand causing traffic jam and parking area in other streets including gang pinggir. (10,-10) |
| - Deterioration of architectural aspects on traditional building (-10,-10) | - High revenue for gang warung with additional revenue for gang pinggir (20,10) | - The activities on gang warung cause the change of building facade and some buildings lose its traditional mark. While gang pinggir has less traditional buildings than gang warung but the buddhist temple remain preserved. (-10,10) |
| No development of Gang Warung | + The revenue in gang warung will remain the same while gang pinggir will double its revenue if there is a night market as well (0,20) | - No additional revenue is made and less will people will come (-10,-10), may lead to abandonship and may affect the spatial quality |
| - Gang warung spatial quality will remain the same, however it will be a challenge for gang pinggir accessibility since the gang warung itself is a main access to enter chinatown. Therefore, it will deteriorate the spatial quality (0,-10) | - Promoting Buddhist temple in gang pinggir, though the current situation in gang pinggir has no more traditional buildings while the traditional buildings facade in gang warung are preserved, (10,-10) | + The spatial quality will not change (0,0) |
| + Preserve the traditional architectural value in both streets (10,10) | - | |

- Deterioration of architectural aspects on traditional building (-10,-10)