

# **System Dynamics Model for Transportation Infrastructure Investment and Cultural Heritage Tourism Development: A Case Study of Xidi and Hongcun Historical Villages**

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## **Abstract**

A system dynamics model is proposed to analyze the impacts of transportation infrastructure investment on the tourism development of Xidi and Hongcun World Heritage Villages in southern Anhui province, China. It is shown that both the short and long term impacts of transportation infrastructure investment on tourism development could be well predicted by the model. To achieve maximum tourism revenue, both villages attempt to take an aggressive strategy to continuously increase transportation infrastructure investment and exploit all available land. According to the scenarios results from the simulation, several other development strategies are proposed as well as the prediction of the perspective of the two villages 20 years later: with all available land being exploited, the sites are still full of tourists that are comprised mainly of mass tourists.

## **Keywords**

Transport infrastructure investment, cultural heritage, tourism development, system dynamics.

## **1 Introduction**

As tourism has been developing rapidly in China since 2000, competition of infrastructure investment is becoming one of the most important sections for attractions all over the nation, especially transportation infrastructure investment. The fast increase of tourists always comes with the transportation infrastructure indicates that transportation has strong impacts on shaping the development process of the competition of tourism destinations.

A range of studies have been done in the field of tourism competition, within which

marketing is one of the most popular topics, such as market segmentation, market strategy and market choice (Zhang, Zhang, and Wang 2007; Sun and Feng 2003; Li and Sun 2002; Zhang, Zhang, and Liu 2005). Although it is acknowledged that transportation is the link between tourists' origin point and destination regions, the impacts of transportation infrastructure investment have not been investigated in detail. The role of transportation in tourism has also involved in topics of tourist management, such as behaviors of local government, local organization and management skills in destinations (Xu 2003; Yang et al. 2008; Garrod and Fyall 2000). The importance of transportation as a factor in tourism management has also been widely recognized by many researchers, mainly discussing the roles and effects in general. Besides, transportation has also been mentioned in some other research, such as information asymmetry of tourism market (Chen 2000), economic cooperation of adjoining destination regions (Liu, Zhang, and Gu 2005), etc. All the studies above give some valuable qualitative understandings to the roles and effects of transportation from different angles, which consist the foundation of some hypotheses mentioned later in this paper.

It is clear that transportation infrastructure is one of the key issues addressed for successful tourism; and the conceptualization of tourism transportation, especially the relationship between transportation infrastructure and destination development, has been illustrated in a number of studies (Khadaroo and Seetanah 2007, 2008; Prideaux 2000). Beginning with the comprehensive concentration on tourism sustainability, the sustainable problems brought by tourism transportation - for examples, the pollution caused by transportation (Dickinson and Robbins 2008) and tourism transportation externality cost on inequality (Hall 1999) - have already been considered by some researchers. The impacts of transportation on tourism development are considered in some research to some extent, mostly in the sight of the effects of accessibility and mobility (Israeli and Mansfeld 2003; Gronau and Kagermeier 2007; Schiefelbusch et al. 2007). Besides, integrated strategy plan is made for the management and planning of local government, without detailed analysis on the specific relationship between transportation infrastructure and tourism development.

This paper intends to investigate the relationship between transportation infrastructure investment and tourism development of two competitive historical villages through system dynamic simulation. The field work was carried out in 2008 and 2009 when the authors were asked to carry out a strategic plan for the villages. Different scenarios were simulated to work out suitable infrastructure investment strategies for the two villages.

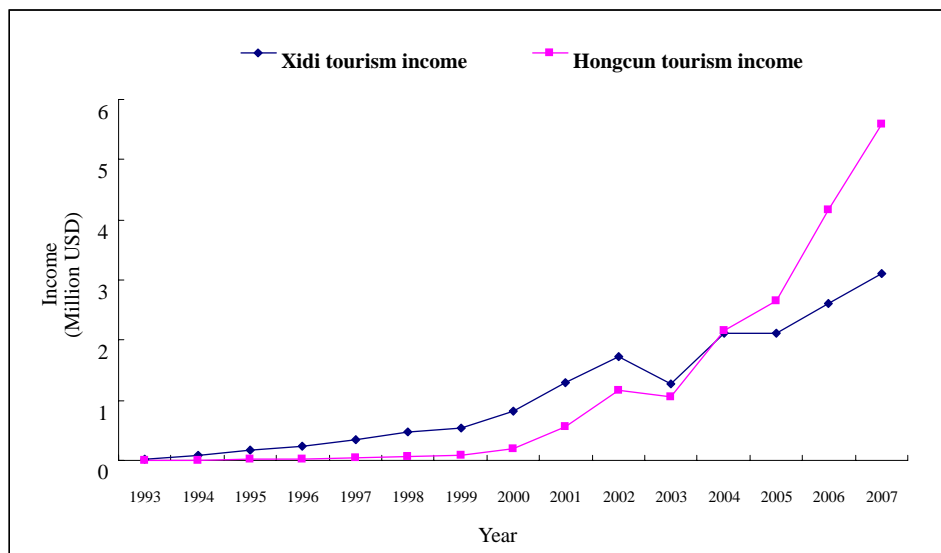
## **2 Tourism of Xidi and Hongcun Historical Villages in Southern Anhui**

Xidi and Hongcun are two exquisite historical villages in southern Anhui province (Wan'nan) which were listed as World Heritage Sites by UNESCO in 2000. The two historical villages preserve to a remarkable extent the appearance of non-urban

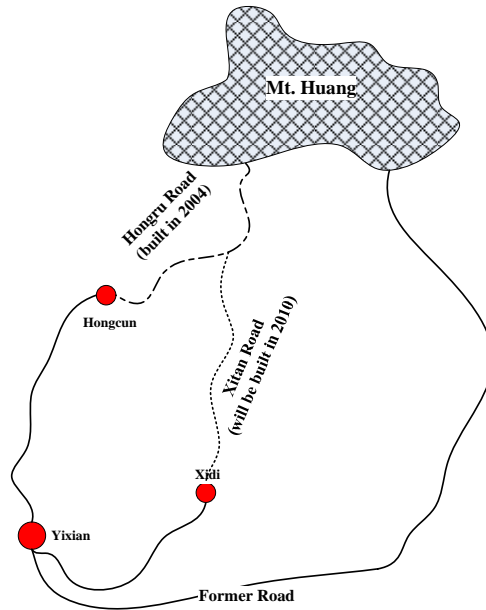
settlements of a type that largely disappeared or was transformed during the last century, whilst Xidi Village is entitled the “Ming and Qing Dynasty Local Residence Museum” and Hongcun Village obtains the reputation of “a village in the beautiful Chinese picture”.

The two villages were just like most of the villages in Wan’nan before 2000: dominated agriculture, bad infrastructure, and low GDP. The official approval from UNESCO gave the two villages a great opportunity to develop tourism (Lu, Zhang, and Su 2009); which replaced agriculture as the dominated industry in 2001, only one year after they became World Heritage Sites (Chan, Lu, and Ling 2003).

The major market of the two villages is the tourists from adjoining interest Mt. Huang, which is one of the most famous natural attractions in China. The competing situation of Xidi and Hongcun is considered to be very special as it is hard to find another similar case in China with so close location and similar landscape, and the room to improve their scenery is limited because of the strict protection law of the World Cultural Heritage (Lu et al. 2005). Therefore, the scenery of the two villages is considered unchanged in the long term. As there was only one way from Mt. Huang to the county town before 2003 and Xidi is 3 km nearer to the county town (Cheng and Wang 2008), it was considered that Xidi had location advantage in transportation over Hongcun; that is, Xidi was more accessible than Hongcun to the tourists from Mt. Huang. As a result, Xidi obtained more revenue from tourism than Hongcun at the beginning, even though two sceneries are almost the same (see Fig. 1 and Fig. 2).



**Fig. 1 Comparison of tourism income between Xidi and Hongcun  
(Data Resource: Economics Report of Yixian County (1993-2007))**



**Fig. 2 Transportation infrastructure of the case**

The open of Hong-Ru Road in late 2003 has significantly changed the competing situation. Hongcun has built up a direct link to Mt. Huang, which makes Hongcun more accessible to their major market - tourists from Mt. Huang as shown in Fig. 2, and the tourism revenue of Hongcun exceeded Xidi in 2004. More transportation infrastructure, especially new roads and parking facilities, are continuously built up to satisfy the increasing tourists, which results in an increase of revenue gap year after year as shown in Fig. 1. The case of Xidi and Hongcun is a good example to demonstrate the impact of transportation infrastructure on tourism development. A system dynamics model is proposed to analyze the relationship in detail in the next section.

### **3 The Model Development**

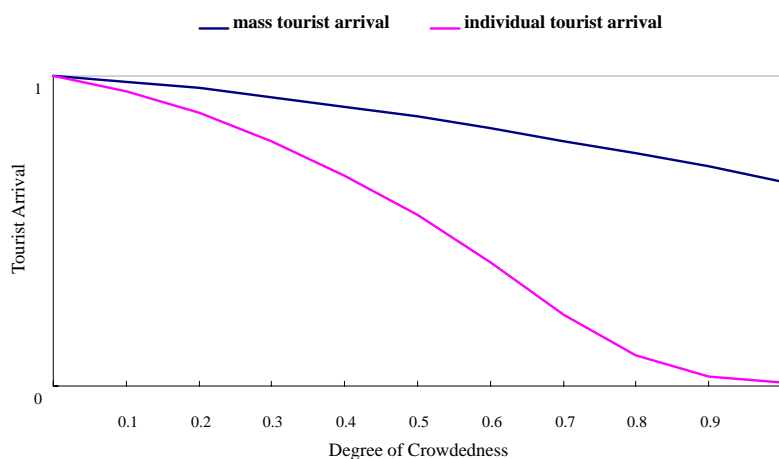
#### **3.1 Conceptualization of the model**

The first assumption for the model is that the tourism market of Xidi and Hongcun is a seller's market, i.e., the number of potential tourists is much larger than tourism capacity (Sun and Feng 2003; Li and Sun 2002). The assumption is based on that the tourism resource is rare in China comparing with the large number of potential tourists. Secondly, the sceneries of the two villages are identical and do not change during the simulation. Thirdly, the effects of transportation infrastructure investment are completely represented by accessibility, and the details of transportation infrastructure are neglected.

The model includes two sectors to describe the competitive situation of Xidi and Hongcun tourism market: the first sector describes the stimulating effects of transportation infrastructure investment on the number of tourists of a single village and the second sector describes the interaction of the two villages in the decision process of

transportation infrastructure investments.

The first sector explains the mechanism how transportation infrastructure investment affects the development of tourism. The tourists are classified into two categories, mass tourists and individual tourists according to the behavior characteristics they show in Xidi and Hongcun. The visits of mass tourists largely are arranged by tourism agencies which care more about the monetary and time cost on their way to the destination. High accessibility represents low monetary and time cost on the road, so travel agencies can provide better service and add more visit sites to satisfy mass tourists, as they are more particular to accommodation and dining service than cultural appreciation and are more likely to visit several sites in short time. On the contrary, individual tourists are assumed to have particular preference on the place not only full of cultural resources but also quiet and un-crowded, so that the inconvenience of transportation has minor impact on the visits and the tourists who like to stay for a longer time. The individual tourists are more sensitive to crowd and less sensitive to accessibility than mass tourists are, as shown in Fig. 3. The fast growth of mass tourists would drive away individual tourists as mass tourists always bring with crowd which is hard for individual tourists to tolerate (Su et al. 2005; Lu et al. 2004).

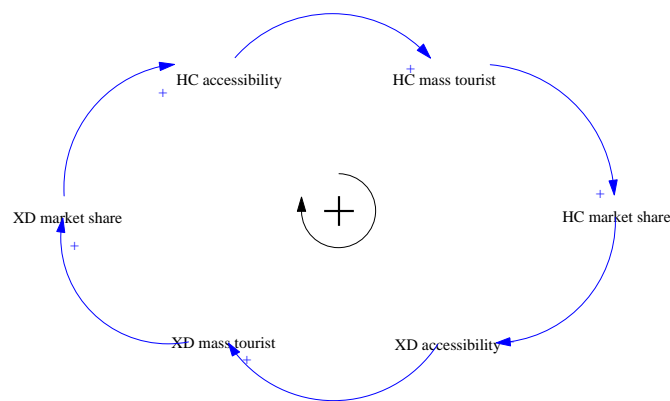


**Fig. 3 Comparison of the crowd effects of mass and individual tourist arrival**

The local people, usually the local government, have the right to decide the amount of investment spent on transportation infrastructure in order to reach a certain level of accessibility. Meanwhile, the level of accessibility and the number of potential mass tourists together decide how many mass tourists would arrive to visit the two villages. The increase of revenue from tourism is the most important thing concerned by local people according to the survey, they intend to improve transportation infrastructure to attract more mass tourists. The growth of mass tourists leads to crowd in the site, which not only drives away individual tourists but also affects the arrival of mass tourists. Therefore, the growth of tourism heavily depends on the level of accessibility. Due to

the limited available land in total, the tourism capacity of the sites cannot be increased when all available land have been exploited and there will not be any way to reduce crowd even the local people are still continue increasing accessibility,.

The second sector reflects major interaction of the two villages with the examination of the impact of transportation facility. Xidi and Hongcun have to decide the level of accessibility according to the last year's market share every year: the leader of market share chooses a lower growth of rate while the follower chooses a faster rate to catch up with the leader, as shown in Fig. 4. The change rates are decided by the gap of the market share between the two villages. The time delay is implemented to reflect the process of the ambition and effectiveness of the villagers and their government.



**Fig. 4 Major feedback of the first sector**

### 3.2 Dynamic hypothesis

The dynamic behavior of the accessibility-tourist interaction is dominated by the feedback loop structure, which controls change in the system. As external and internal conditions vary, the contribution of each feedback loop may change. Hence, an integrated analysis of complex feedback relationships is helpful for a better understanding of the accessibility-tourist dynamics.

There are three negative feedbacks in the first sector, as shown in Fig. 5. The increase of accessibility leads to the increase of mass tourist arrival, forcing the degree of crowd on site to rise up, which decreases both mass and individual tourist arrival in the next step. The small effect of accessibility on individual tourist arrival is neglected in the model. As individual tourists are more sensitive to the crowdedness, they may decrease faster than mass tourists. But these effects will be delayed to reflect as it needs some time for tourists to recognize. The available land around the site is exploited to increase the tourist available land – tourist capacity, and to decrease the degree of crowdedness. As long as the degree decreases, the demand of tourist land investment falls. Likewise, it needs time to adjust the tourist land investment. The growth of the number of mass tourist will raise the market share of the village, and the market share will affect the action of increasing accessibility in the next step.

The simulation step is set to one day. The crowdedness is measured by the tourist arrival per hour and the tourist length of stay on site (usually several hours); tourist arrival per day is calculated by the number of tourist arrival per year, with the consideration of tourist travel seasonal changes. The degree of crowdedness is measured by the ratio of tourists on site to tourist capacity. The number of tourists on site changes every hour, it depends on the number of arrived tourists hourly and their stay period. Suppose that tourist arrival complies with normal distribution, tourist departure is the same curve but right shift for the length of stay. Therefore, the maximum number of tourist on site is represented by the shaded area in Fig. 6. The ratio that the shaded area divided by the whole area of the normal distribution curve is the conversion factor in the model. As the total tourists arrival per day is known, the maximum number of tourists on site could be calculated by the total arrival multiplies the conversion factor. The conversion factor is different from mass tourists to individual tourists as the length of stay is not the same.

The second model has one positive feedback. The increase of Hongcun's accessibility will raise the number of mass tourists in Hongcun and promote the market share of Hongcun; while Xidi has to increase its accessibility more and more, if it wants to attract more mass tourists and keep their market share, as shown in Fig. 4.

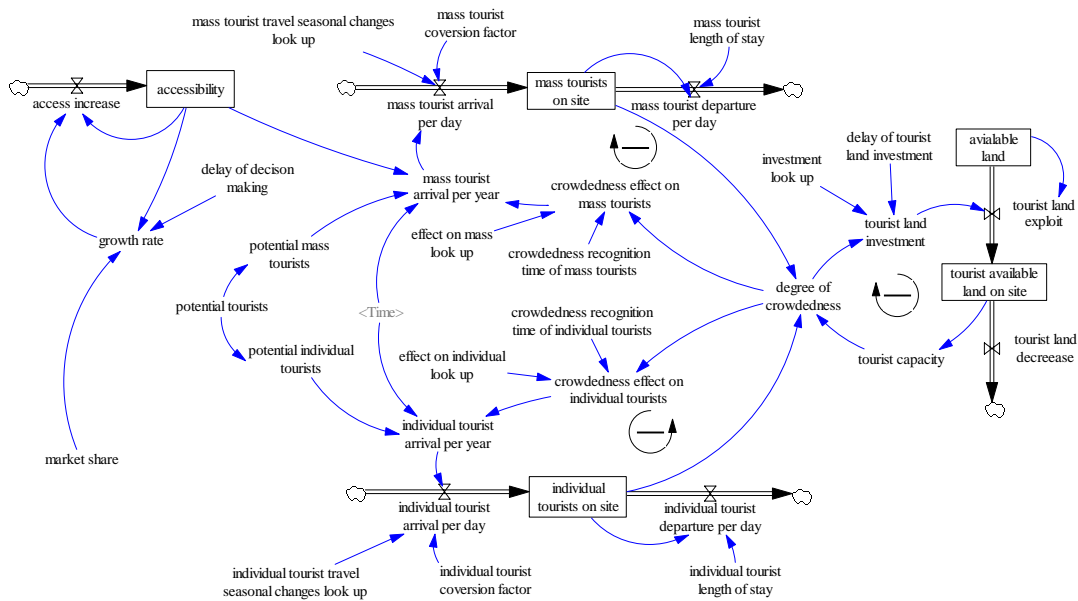
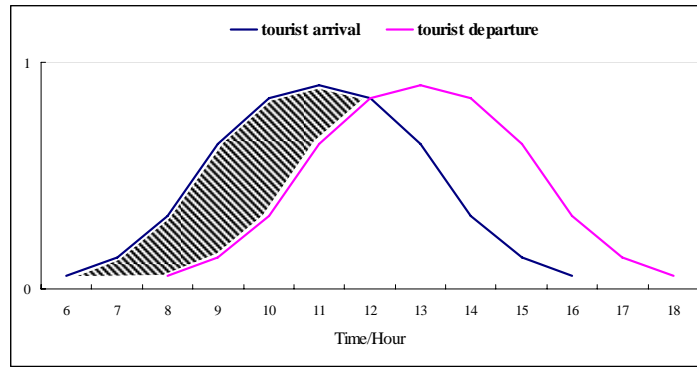


Fig. 5 Major feedbacks of the second sector



**Fig. 6 The sketch map of tourist arrival and departure**

### 3.3 Major stocks and behavior variables

There are five major stocks in the model, namely accessibility, mass tourists on site, individual tourists on site, available land, and tourist available land on site. Accessibility is controlled by its growth rate, which is controlled by market share and the time delay of decision making process. Both mass and individual tourists on site are controlled by tourist arrival and tourist departure, while tourist arrival is mainly controlled by accessibility and crowdedness. Available land is the land resource that has not been developed for tourism yet but is available. Hence, tourist land development will reduce this resource and it is hard to increase it. Tourist available land on site is controlled by tourist land development and tourist land decrease, but how much available land to be utilized to tourism available land is determined by the increase of crowdedness. Tourist available land on site will stop increasing when available land is all used for tourism.

The growth of accessibility is actually the increase of external transportation infrastructure, such as new roads, parking space or the improvement of road quality, public transport service, etc. Accessibility is the proportion of actual tourists and potential tourists, with a value between 0 and 1. Zero means no potential tourists could arrive at the site, one means the external transportation could provide all the potential tourists with satisfied service so that they are all willing to visit the attraction. But there is the likelihood that the value of accessibility may be above one. As the value of potential tourists is fixed in the model, the growth of potential tourists caused by the improvement of external transportation cannot be reflected directly. Therefore, if the value of accessibility is above one, that implies the number of potential tourists increases. Moreover, because the external land resource is also limited, the growth rate of accessibility will go down as the value of accessibility increases.

It should be emphasized that the effects of crowdedness are very important in the model as crowdedness affects the arrival of mass tourists and individual tourists, which has been mentioned at the beginning of this section. Moreover, crowdedness also affects the tourist land investment; that is, the higher the degree of crowdedness, the higher the tourist land investment as long as the available land is sufficient.

### 3.4 Model implementation and calibration

After the construction of the model structure, the equations and parameters are



defined. Parameters are selected or estimated from statistical or historical data, then tested in the model, and adjusted until the model exhibits realistic outputs according to the reference behavior and historical data.

Taking 2001 as the baseline year, the SD model of accessibility and tourist is developed for this Xidi-Hongcun case. The major data are derived from field work done in Xidi and Hongcun, July- September, 2008. Other data are gained from various sources, including some historical data from local government, some investigation results done by other researchers, etc.

#### 4 Model Verification

The base run is from 2001 to 2007. The observed results and stimulating results of the number of tourists per year are shown in Fig. 7 and Fig. 8. The root-mean-square percent errors (RMSPE) of Xidi and Hongcun are 0.1237 and 0.1462 respectively, which are below 0.15, indicating that the model replicates historical data well. The abnormal years 2003 and 2004 are due to the impact of SARS, and repressed tourism is not considered in this model.

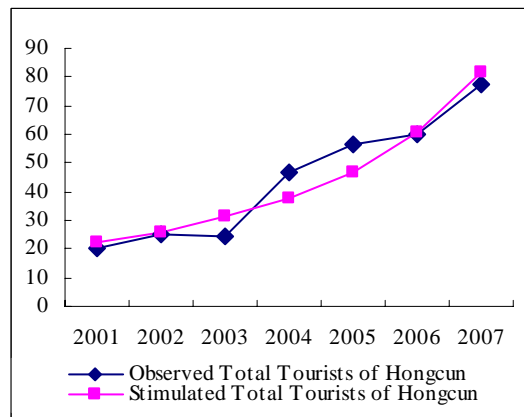
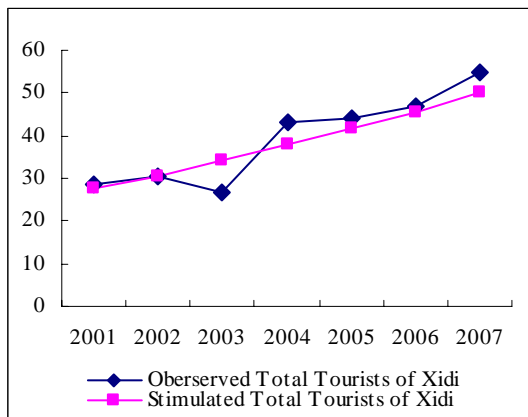


Fig. 7 Contrast of observed and stimulated XD tourist

Fig.8 Contrast of observed and stimulated HC tourist

(All the data observed are from Economic Report of Yixian County (2001-2007))

Both simulation and observed results demonstrate the different attitudes of the two villages towards transportation infrastructure investment, i.e. Xidi chose a more conservative attitude to increase external transportation infrastructure than Hongcun did, as discussed before. Fig. 9 gives a comparison of the accessibility of Xidi and Hongcun. Hongcun has showed an aggressive ambition with a new Hong-Ru Road in 2004 since the UNESCO approval, resulting in an increase of market share every year, which is complied with the historical data. Now Xidi is planning to build a new road to Mt. Huang directly, called Xitan Road in 2010 (see Fig. 2), as the reaction towards the quick fall of Xidi's market share.

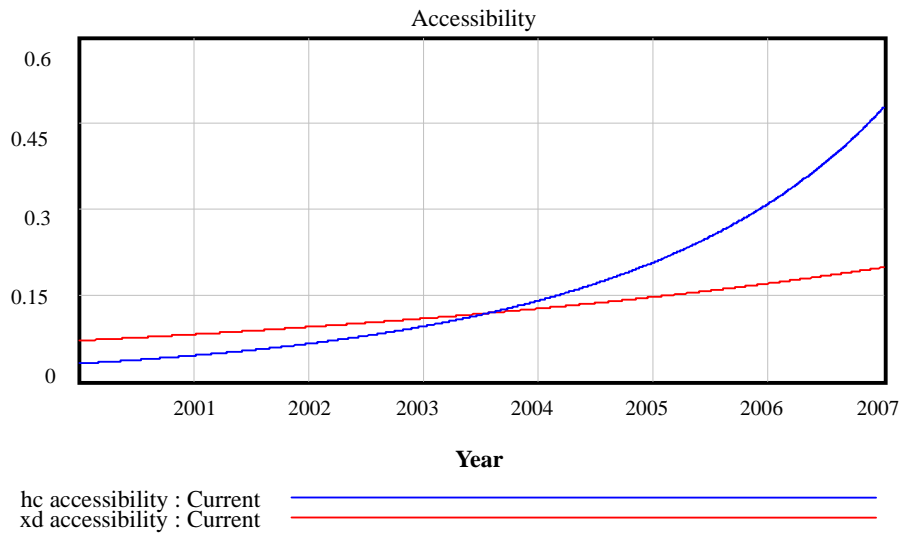


Fig. 9 Stimulated result of hc and xd accessibility

The tourist capacity, determined by tourist available land<sup>(Shang et al. 2009)</sup>, is also an important variable to reflect the validity of the model. The comparison of observed data and stimulated results are given in Fig. 10 and Fig. 11.

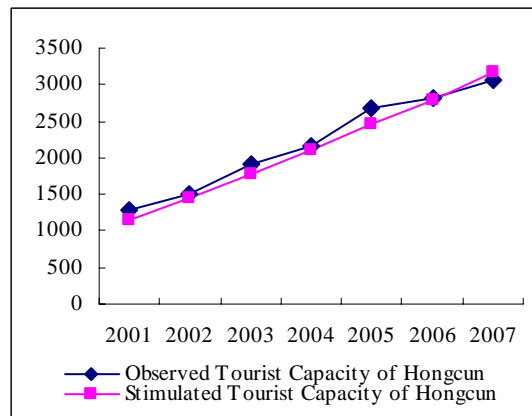
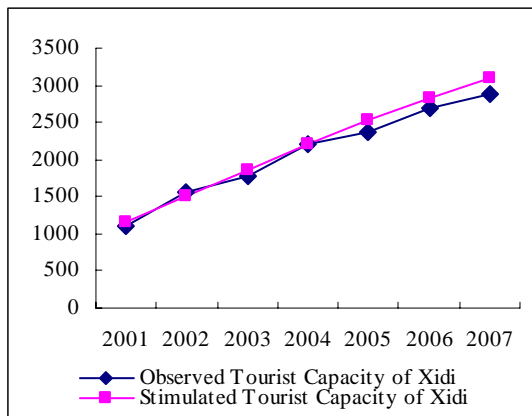


Fig. 10 Contrast of observed and stimulated XD capacity

Fig. 11 Contrast of observed and stimulated HC capacity

(All the Observed data are from Economic Report of Yixian County (2001-2007))

The RMS percent errors of tourist capacity are all below 0.1, with Xidi of 0.0571 and Hongcun of 0.0618, indicating that the behavior of the model replicates historical data very well.

Historical data demonstrate that both Xidi and Hongcun realize the negative effects of crowdedness. As a result, both villages never stop the efforts to increase tourist capacity. Compared with 2001, tourist capacity of each village was doubled in 2007.

## 5 Scenario Analysis

### 5.1 Scenario 1: turning point

Stimulation time is from 2008 to 2019. As a follower, Xidi wants to keep pace with Hongcun on the number of tourists. In this scenario, some important parameters are set as below:

- Time delay of increasing accessibility of Xidi and Hongcun is 730 days.
- Time delay of increasing tourist available land of Xidi and Hongcun is 365 days.
- Recognition time to crowdedness is 180 days for mass tourists and 30 days for individual tourists, no difference to the two villages.
- The number of potential tourists is 2 million for both of the two villages.
- The initial proportion of mass tourists and individual tourists is 9:1.
- Available land in 2008 is 1,364 (converted to capacity) for Xidi and 2,312 for Hongcun.
- There are two categories of growth rate: fast rate and slow rate. When market share is above 50%, the slow rate is chosen. When it is below 0.5, the fast rate is chosen.

The stimulated result of Hongcun's market share is shown as below (all the market share figures are represented by Hongcun's market share in this paper, the value of Xidi's market share is the one subtracts Hongcun's):

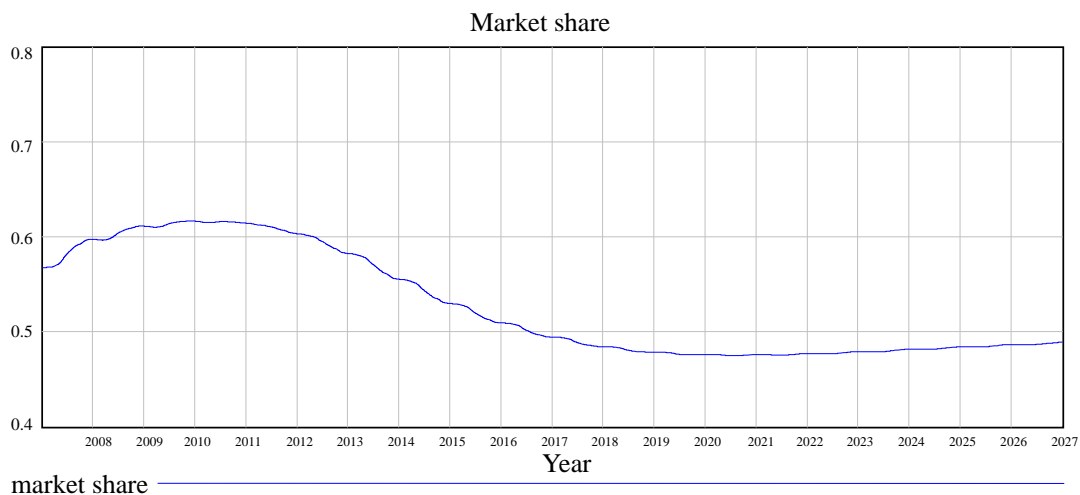


Fig. 12 Stimulated data of Hongcun's market share in scenario one

As Fig.12 shows, Hongcun's market share first rise to above 0.6, then it falls as Xidi choose a faster growth rate to increase its accessibility. Then Hongcun's market rate goes down to 0.5 in 2016. When the market share reaches 0.5, Hongcun will choose a faster growth rate and Xidi slower its growth rate. As the value of accessibility is already very high, the increase of accessibility is much difficult than before, no matter at

fast or slow pattern of growth rate. So Hongcun will take a longer time to retake the market share. The stimulated numbers of total tourists are as below:

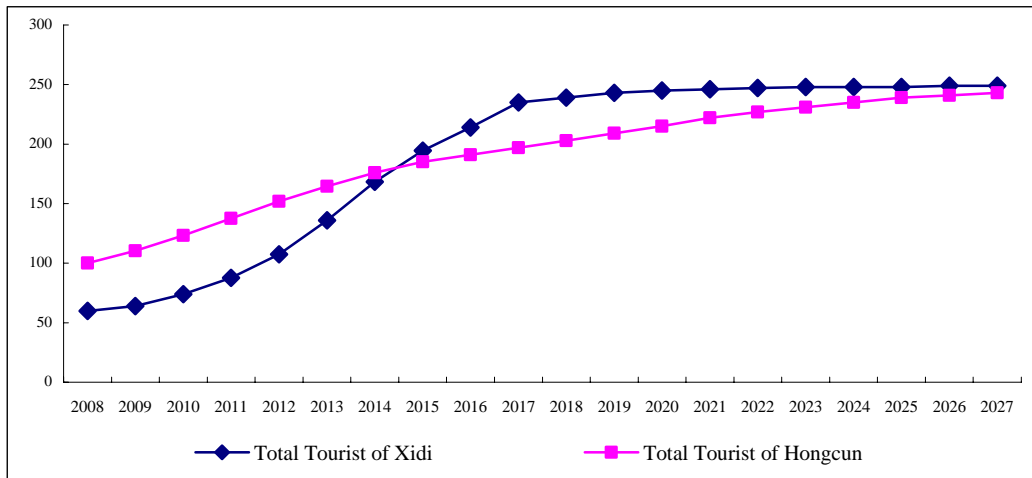


Fig. 13 Stimulated results of total tourists in scenario one

Because accessibility determines the number of mass tourists, which is the major part of total tourists, the trend of accessibility curve could represent the trend of tourist curve. In scenario one, the accessibility curves of the two villages are shown in Fig. 14:

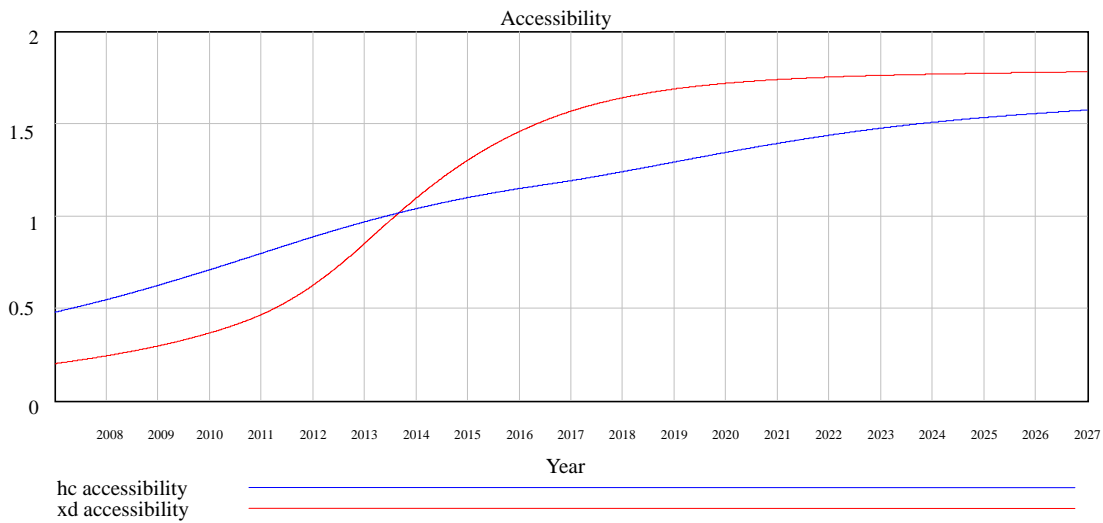


Fig. 14 Stimulated results of accessibility in scenario one

As it is indicated in Fig.12, Hongcun chooses the slow pattern of growth rate until 2016, then it changes the pattern to fast because its market share goes down to 0.5. The value of Hongcun’s accessibility is about 1.3 in 2017, which is pretty high. Therefore, the increase of accessibility is much more difficult than before, that’s why there is not a sudden change in the curve.

Xidi chooses the fast pattern of growth rate until 2016. The slop of the curve first increases and than falls, the turning point (the point with highest slop) is when the value

of accessibility reaches one. As it was said, it's much harder to increase accessibility when its value is above one. Xidi changes the pattern of growth rate in 2017 because its market share rises up to 0.5. As Fig. 14 shows, the value of accessibility almost stops increasing after 2017.

One of the commonplaces in accessibility curve is that the value of accessibility reaches one in 2013 for both the two villages. Thus, 2013 is the watershed for the two villages. The major effort of increasing accessibility before 2013 is more investment in transportation infrastructure to enhance the service capability of transportation infrastructure. However, the major effort after 2013 is to increase the number of potential tourists. There are a lot of methods to increase potential tourists, while the "transportation" method is one of the effective ones. Although there may be no more land to build infrastructure, it still has room to improve the quality of transportation service and the effectiveness of transportation facility to attract more tourists. Therefore, with the form of elevating service quality, the value of accessibility could be raised even if all the land has been exploited.

Except for the external land, the tourist available land on site is another factor that should be paid more attention to. The stimulated results of tourist available land (all the value of land size has converted into capacity in this paper) are shown in Fig. 15. The maximum capacity of Hongcun is about 1,000 more than Xidi due to their geographical characteristics; the available land of Hongcun runs out in 2012 and that of Xidi runs out in 2011, the tourist available land cannot be increased any more after that. However, the number of tourists will continuously increase for a long time, the crowdedness will become a long term issue.

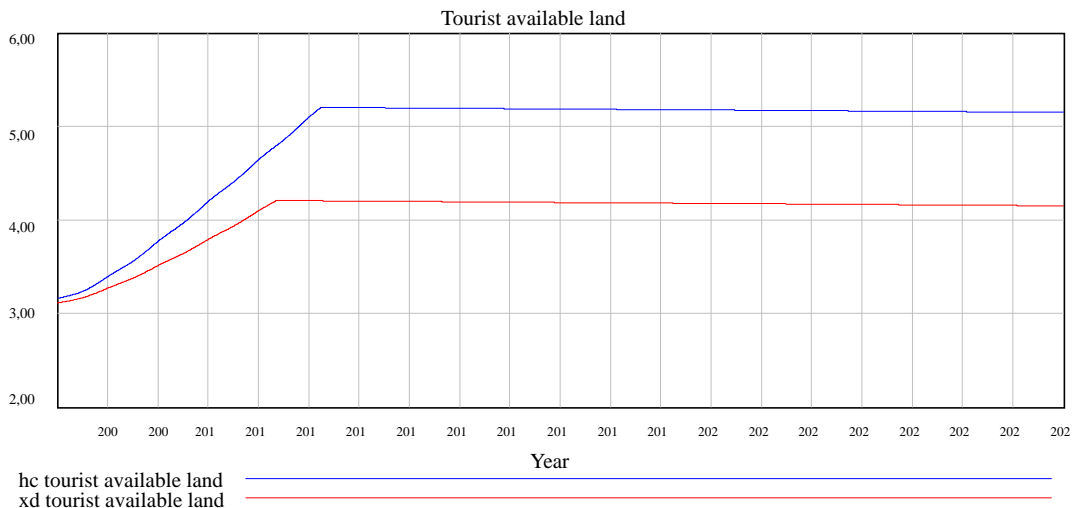


Fig. 15 Stimulated results of tourist available land in scenario one

As individual tourists are more sensitive to crowdedness, the trend of individual tourist curve is important to understand the effects of crowdedness. As shown in Fig. 16, both of the two villages are facing the loss of individual tourists. The short-term change of the number of individual tourists is not obvious, but the number of individual tourists

falls apparently when the available land begins to reach its limit. The number of individual tourists will drop and remain in a lower level in the long term when the negative effects of crowdedness have been reflected thoroughly and the total number of tourists stays stable. The number of individual tourists arriving in Xidi is more than those in Hongcun in the beginning, that is because the high growth of accessibility in Hongcun has brought more mass tourists and driven away more individual tourists. However, since Xidi wants to catch up with Hongcun on market share, it tries to attract more mass tourists and the crowdedness will get worse. The number of individual tourists drops quickly in Xidi and even lower than that in Hongcun after 2013. When the number of total tourists per year keeps stable, Xidi's individual tourists per year will be lower than Hongcun's due to its lower tourist available land.

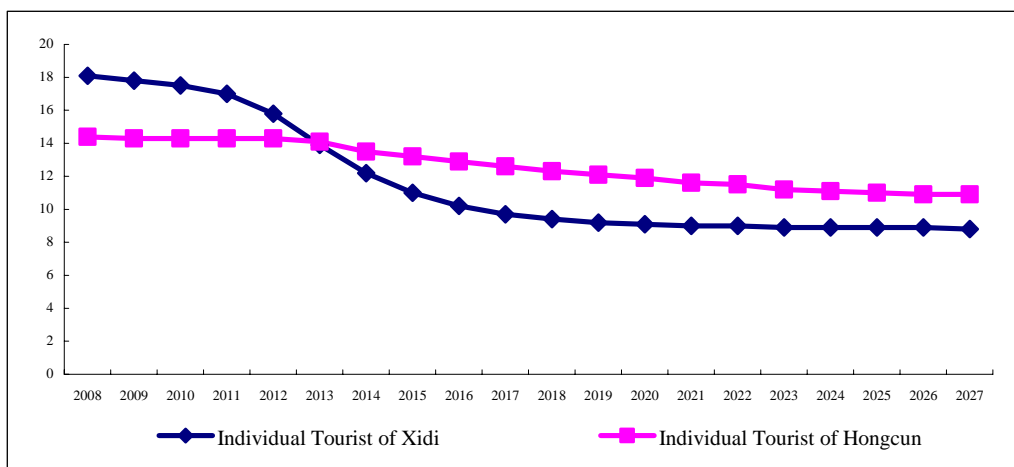


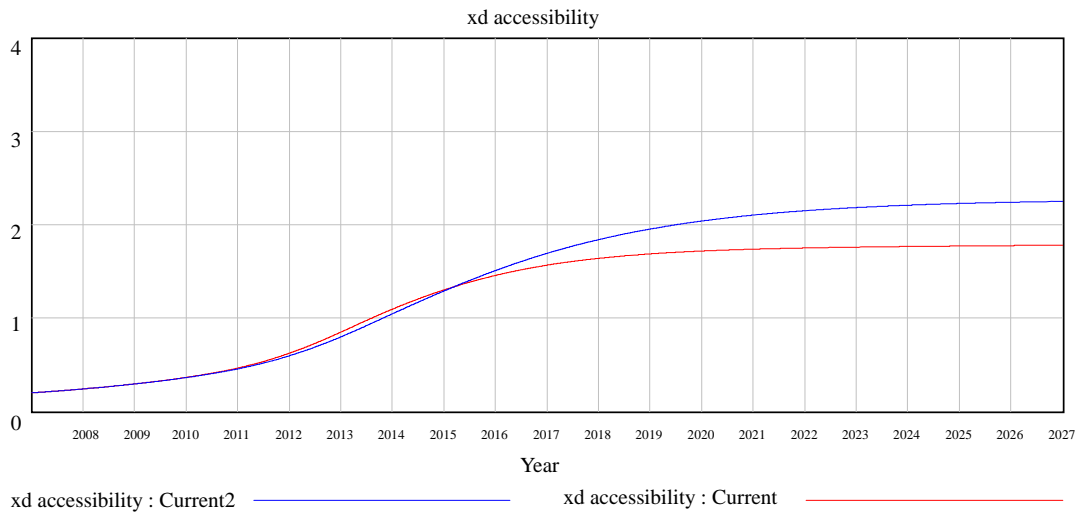
Fig. 16 Stimulated results of individual tourists in scenario one

Since the scenery cannot be changed, the competition between Xidi and Hongcun is actually the competition of their land investment. On one hand, local government pours much budget into transportation infrastructure to attract more mass tourists, which is accomplished by exploiting the land outside the generalized area of site. On the other hand, it exploits inside land to be tourism land in order to retain individual tourists. When all the lands are run out, it is very hard to attract more mass tourists and reduce the crowdedness. That is the phenomenon of some early-developed attractions in China, which have much larger size than before, but are still full of tourists.

## 5.2 Scenario 2: sensitivity analysis of the turning point

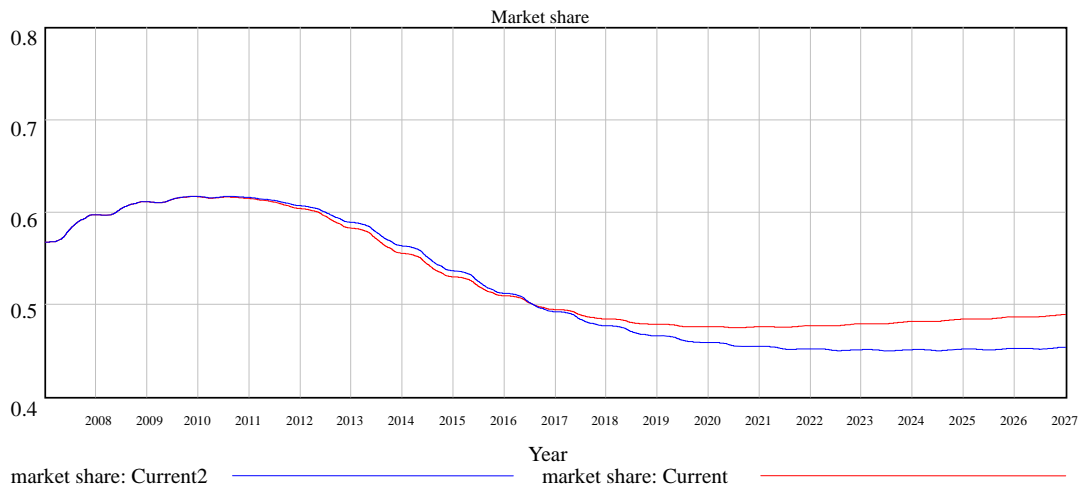
Among all the parameters mentioned in Scenario 1, the time delay in increasing accessibility and the time delay in increasing tourist land are the parameters that reflect the behavior characteristics of the two villages. The responding speed of local government towards the change of market share is reflected by time delay in increasing accessibility. The decision making process to increase accessibility is the major reflection of ambition and effectiveness of the local government. In scenario 2, the time delay in increasing accessibility for Xidi is changed to 3 years, which is one year more

than scenario 1.



**Fig. 17 Comparison of Xidi’s accessibility in scenario one and two**

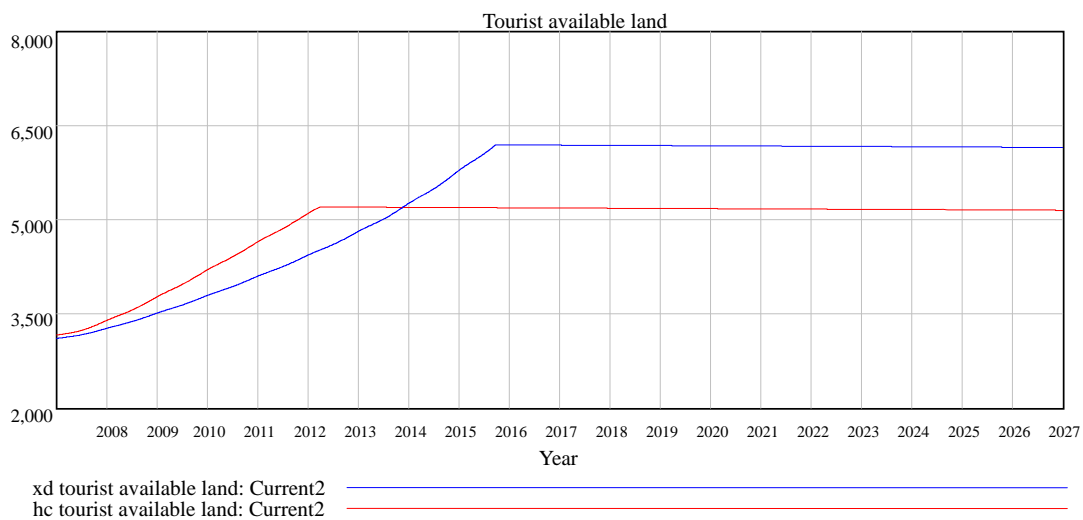
As shown in Fig. 17, the turning point (with highest slop) of accessibility curve appears one year later than that in scenario 1, while the final value of Xidi’s accessibility is larger than scenario 1. However, the turning point of market share (the point where market share equals to 0.5) remains unchanged as shown in Fig. 18. Also the final market share is lower than scenario 1 because the final value of Xidi’s accessibility is larger. The increase of Xidi’s market share illustrates that Xidi gains more competing power by decision delay in increasing accessibility. The reason is that the delay will make Xidi to choose fast growth rate longer than scenario 1 so that the accessibility will be increased more than scenario 1.



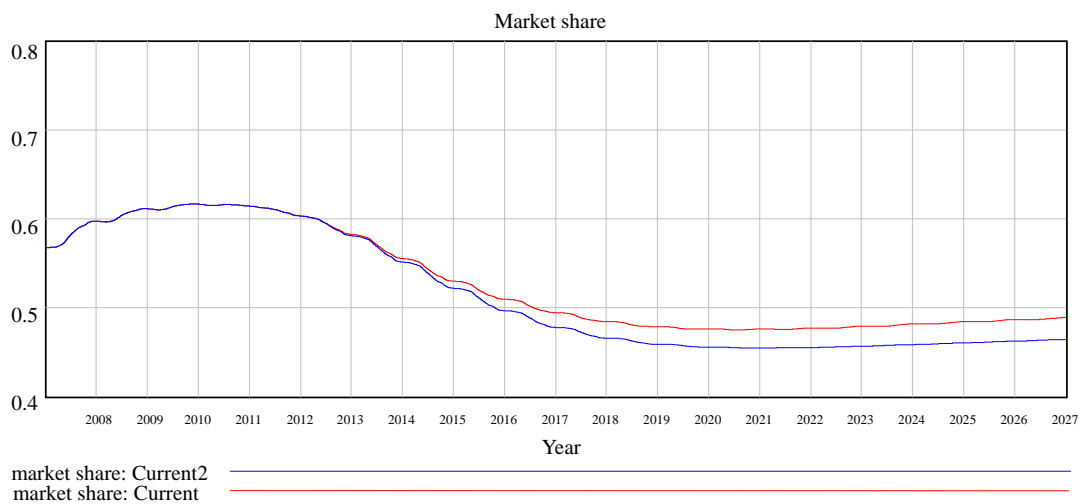
**Fig. 18 Comparison of Hongcun’s market share in scenario 1 and 2**

The time delay in increasing tourist land is important to reduce crowdedness; however it is not so crucial in comparing with the total available land, as available land

will run out due to the high development speed. The total available land has more significant impact on the simulation results. Suppose that Xidi suddenly finds more available land that equals to the capacity of 2,000 tourists; that is, the maximum capacity of Xidi is 1,000 more than that of Hongcun now. Fig. 19 and 20 give the simulation results under this assumption. The turning point appears about one year earlier than scenario 1 (see Fig. 20) because Xidi could continue reducing crowdedness by exploiting available land until 2016 so that the negative effects of crowdedness are smaller than scenario 1, and fewer tourists will lose due to crowdedness. The final market share of Hongcun is lower than scenario 1, indicating that the increase of available land would raise the competition of Xidi and help it hold its market share.



**Fig. 19 Stimulated results of tourism available land in scenario two**



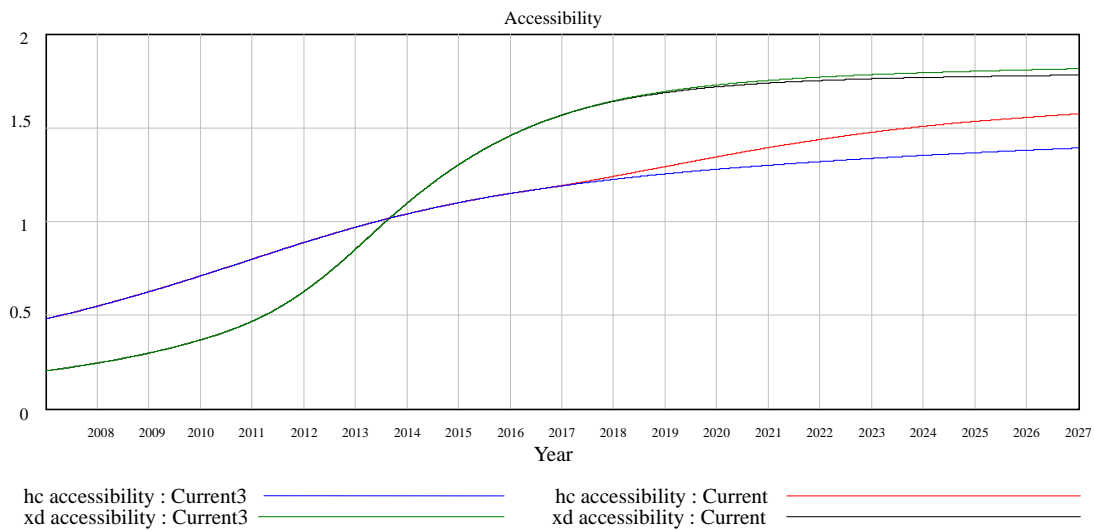
**Fig. 20 Stimulated results of market share in scenario two**

### 5.3 Scenario 3: relationship between Xidi and Hongcun

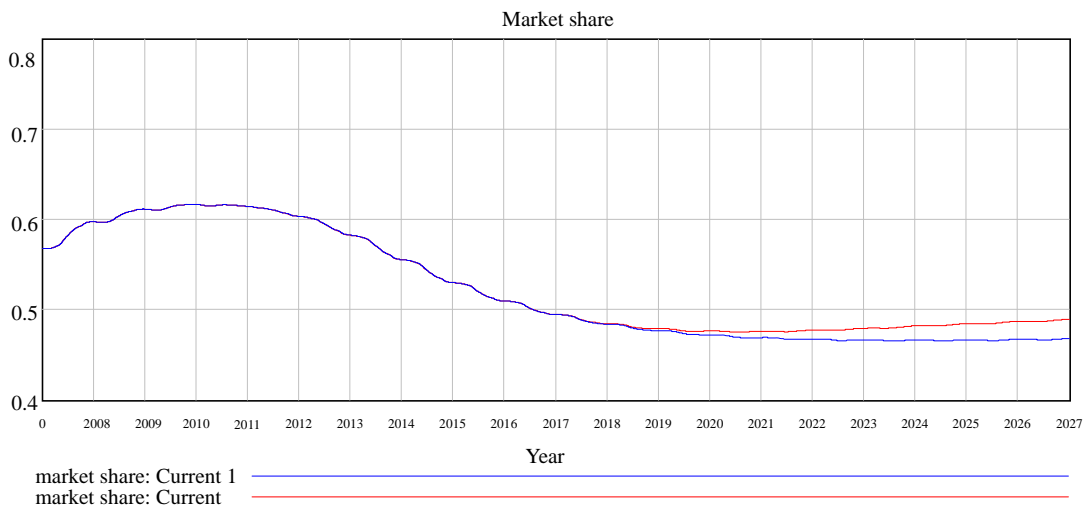
The market share target in scenario 1 is comparatively an aggressive one since both villages have targeted on a market share of 50%, which means no village wants to be



left behind. Now let us change the characteristics of the two local governments: Hongcun dislikes trying to make progress while Xidi is full of ambition and very aggressive. This is done by setting the baseline of Xidi and Hongcun to 0.6 and 0.4 respectively, i.e., Xidi will not change the fast grow rate of accessibility until its market share is above 0.6 while Hongcun will not change the slow grow rate of accessibility until its market share is below 0.4. Fig. 21 shows the stimulated results of accessibility, the curve of Xidi rises slightly while the curve of Hongcun drops dramatically, reflecting that Xidi is more aggressive than before while Hongcun is on the contrary. Fig. 22 shows that the market share of Hongcun continues to drop till the end of the stimulated time, without any sign of turning back. This is a ‘life and death’ competition to Xidi and Hongcun: no village should be tender to the other in order to get more market share and more tourism revenue.



**Fig. 21 Stimulated results of accessibility in scenario three and scenario one**



**Fig. 22 Stimulated results of market share in scenario three and scenario one**

## 5.4 Scenario analysis

### (1) Suggestions for local competition

The revenue from tourism is the major concern by the local government and local people at the moment. As discussed before, Xidi and Hongcun used to be very poor in the county and tourism is the most hopeful way to develop their local economy and get external incomes. Due to the similarity of sceneries and close location, each village takes the other one as threat to its own development. This is a 'life and death' competition to both of the two villages. The best strategies for both villages are as follows:

- Firstly, increase accessibility as much as possible. Do not slow down the growth rate of accessibility, try the best to keep it grow in a fast speed. Higher level of accessibility means higher increase of mass tourists – the major part of tourists. As the tourism market in China is a seller's market, there is no need to worry about losing tourists. Therefore, attract as many tourists as you can.
- Secondly, expand tourism site as large as possible. If tourists arrive too many, the negative effects of crowdedness will finally harm the tourist arrival. Therefore, the size of tourism site should be increased to reduce crowdedness. More lands and local people should be involved into tourism to maintain the smooth operation of the site.
- Thirdly, try to be as aggressive as possible. Do not be tender to the competitor, set a high market target.

If both of the two villages react according to the suggestions above, the final ending is evident: all the available lands are exploited to transportation infrastructure and tourism land; the final market share is determined by the level of transportation infrastructure and the size of site; the tourism sites are overloaded, with more mass tourists and less individual tourists.

### (2) Tourism development vs. site protection

The scenery of two historical villages is the dominant factor to attract tourists. Under the strict protection law, it may be assumed that the scenery – especially the buildings – will certainly be protected well in the long term. But the core attraction of a cultural heritage is not only its architecture, but also its people and its traditional customs. The rapid increase of tourists will bring lots of incomes with no doubt, but it will also lead to the over-commercialization problem and the villages will lose its local people quickly (Xu 2005; Zhang and Bao 2009). Once the local people leave their hometown, they bring away with their traditional culture. That is a huge damage to these cultural heritages, forcing them to become an architecture museum in the end.

The reasons why local people leave are diverse. Some people become rich resulted from tourism, they move to cities to live another style of life. Some cannot find a job in tourism market because of lack of skills, therefore then they go to other places to earn

their living. But there is a common cause – huge number of tourists flowing into the sites. The investment of transportation infrastructure is one of the most efficient ways to attract tourists, and in this case perhaps the only way. However, the fast growth of accessibility brought by transportation infrastructure investment will certainly bring significant changes to the cultural heritage and its local people. Due to this effect, the actual methods to reach local optimum may not be the same as the suggestions above. How to gain more tourism incomes and at the same time keep its local people and particular culture is a question that all local governments of cultural heritages should think about.

### (3) Tourist behavior

The tourists in the model in this paper are typical Chinese tourists: who are not so sensitive to crowdedness compared with tourists from some developed country, low proportion of culture fans, not so sensitive to the quality of tourism service. It might be true for major Chinese tourists at this time, but it will not sustain in the future. There is the likelihood that they will be more sensitive to crowdedness and the drop of tourism service because of the enhancement of living standards, and this will result in an increase of the number of individual tourists. As the expansion of sites will certainly drop down, the increase of crowdedness is unavoidable. Therefore the final results of the stimulation may be changed by the change of tourist behavior. One of the possible trends is that the number of tourists may fall in the end, not stay stable as the scenario analysis shows.

## 6 Conclusion

The tourism development of Xidi and Hongcun demonstrates the importance of transportation infrastructure in a competitive market. The short term effect of transportation infrastructure investment is significant due to the low level of infrastructure in the two villages. In the case of tourism competition, both of the two cultural heritages tend to continue increasing their accessibility to retain their market share. They are likely to continue expanding the size of sites to reduce crowdedness. It's a 'life and death' competition, the actions will not stop until all the lands are run out and the quality of service cannot be enhanced any more. Regarding to the result of the scenario analysis, these cultural sites will be much bigger and more crowded in 2027, but have lower proportion of individual tourists.

There are also some important factors without consideration in this model, such as the loss of local people caused by increasing accessibility, the possible change of tourist behaviors, etc. These factors will definitely change the final results of stimulation and should be studied further.

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