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Do plans contain urban sprawl? A comparison of Beijing and Taipei

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A B S T R A C T

The setting of urban construction boundaries (UCBs) through the imposition of master plans (MPs) is commonly practiced in China and Taiwan. However, the effectiveness of UCBs in containing urban sprawl has been challenged. In this paper, from a property rights perspective, we first explain, theoretically and conceptually, why UCBs in general could cause urban sprawl, rather than stop it. Using the case of Beijing and Taipei in particular, we further examine the effectiveness of the UCBs policy and conclude, as predicted by our analysis, that the urban sprawl in Beijing during the two planning periods from 1983 to 2005 took place mostly outside the UCBs. In contrast to Beijing, the UCBs in Taipei, a counter example for our hypothesis, from 1958 to 1991 were quite effective in containing urban sprawl. The different results between Beijing and Taipei, we argue, lie in the effectiveness of regulations setting. In Taipei, the regulations were effective in restricting developers from searching for land outside the UCBs, but no such evidence was found in Beijing. We argue, therefore, that a successful land control measure, such as UCBs, should take into account developers' behavioral reaction to plans and regulations in order to stop effectively urban sprawl.

Introduction

The comprehensive planning approach to managing urban growth as manifested by limiting cities in compact forms is being widely applied. For example, in the United States, the "growth management" policy and "smart growth" concept were developed primarily to curb widespread urban sprawl (Barnett, 2007; Bengston, Fletcher, & Nelson, 2004; DeGrove & Miness, 1992; Nelson & Duncan, 1995; Porter, 1986; Porter, Dunphy, & Salvesen, 2002; Stein, 1993; Szold & Carbonell, 2002; Urban Land Institute, 1998). Among different approaches to managing urban growth, urban containment policy, widely adopted in the United States, has been extensively introduced to many countries (Bengston & Youn, 2006; Couch & Karecha, 2006; Millward, 2006). Urban containment policies basically have three major forms: urban growth boundaries (UGBs), urban service boundaries (USBs), and greenbelts (Pendall, Martin, & Fulton, 2002). UGB is probably the best known among these urban containment boundaries. In fact, UGBs were not implemented in China and Taiwan, but the land control mechanism in China closest to the idea of UGBs is urban construction boundaries (UCBs), and the boundaries between urbanized land area and non-urbanized land area in Taiwan are also quite close to the concept of UGBs. In both cases, we use the term "urban construction boundaries", or UCBs, in China and Taiwan as the land control mechanism in the present paper.

The formulation of the Master Plan (MP) in Taiwan has been considered as the imagination of the city's future development and management of urban growth. According to the Urban Plan Act enacted by the Ministry of the Interior, cities in Taiwan can be divided into urbanized land areas, such as residential, commercial, industrial, public facilities, as well as non-urbanized land area, such as agricultural area, protected areas and non-urban land. Theoretically, urbanized land areas are surrounded by UGBs, as the containment of urban development in reality, although the UGBs are not required to be clearly delineated on a MP map. We name these boundaries as UCBs for comparison purposes.

In China, there is also a tradition of managing urban growth pattern through land use regulation tools. A city master plan has traditionally been a crucial type of spatial plan to both envision city development perspective in the future and implement land use control over a specific time period, typically 20 years. According to

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the Code for Classification of Urban Land Use and Planning Standards of Development Land (GBJ137-90) promulgated by the Ministry of Construction, all land in the MP area is classified into ten categories, among which nine categories belong to urban construction area (Ministry of Construction, 1990). The UCBs, encompassing all these nine categories of land use, have been applied for a long time as the basis to issue land development permit. The containment function of UCBs were further consolidated by the new Code for Classification of Urban Land Use and Planning Standards of Development Land (GB 50137-2011, Ministry of Housing and Urban-Rural Development, 2011), which specified that all land is classified into construction and non-construction uses. Although the UCBs were never explicitly marked in the land use maps of a MP, they have functioned as special and important boundaries to distinguish urban land from rural area. The UCBs in Taiwan and China have thus some similarities, so it would be interesting to compare the effectiveness of the UCBs of land control mechanism in containing urban sprawl in the two regions.

In the past, due to the limitation by map preservation, research on UCBs are subject to some restrictions; however, in recent years, remote sensing technology advances and local government devotes large resources to creating topographic maps, causing more research to apply the related technology to study urban land use changes (Hathout, 2002; Herold et al., 2003; Huang, Wang, & Budd, 2009; Masek, Lindsy, & Goward, 2000). However, since the periods of research in previous studies had little correspondence with the MP periods, the influence of the MP policies on land use change remained unclear. As a result, little research has been developed yet to examine the effectiveness of the UCBs over several consecutive and intact MP periods and explain why.

Focusing on the UGBs function as containing urban growth, Gennaio, Hersperger, and Burgi (2009) recently selected a Switzerland city as the case of examination of their effectiveness. Summed up the change from building density, the UGBs would limit improper urban expansion, but some literature argued the UGBs implemented to contain urban sprawl was not effective than those not implemented (Cox, 2001; Jun, 2004; Richardson & Gordon, 2001). Instead of assuming perfect rationality of local governments and developers (Knaap et al., 1998), we intend to look at in greater depth based on the assumption of bounded rationality to explain analytically the micro, dynamic adjustment among developers, local governments, and landowners due to the setting of UCBs and show how land use plans as manifested by UCBs affect land development behavior individually and thus urban development collectively in order to provide useful recommendations as to how such plans should be made in Beijing and Taipei in light of planning effectiveness for urban development.

In the next section, we will provide a property rights approach to exploring micro, dynamic adjustment of developers, local governments, and landowners due to the setting of UCBs, and proceed to derive a testable hypothesis explaining whether UCBs fail in Beijing and Taipei in containing urban sprawl. Theoretical explanations and empirical examinations of the hypothesis and predictions depicted in Section 2 are provided in Sections 3 and 4, respectively. Possible explanations are discussed in Section 5. We conclude in Section 6.

Land development: a property rights account

Cities are the outcome of individual spatial decisions that interact with each other. To understand how cities evolve, it is fundamental to understand the land development behavior of individual agents and how they interact. The analytic method for exploring empirically and theoretically land development activities and their interaction are depicted in this section.

The usual difficulties in modeling the land development process are that the process involves so many participants with conflicting perspectives, and that it is almost impossible to characterize the behavior of the participants in a common framework. For example, the process can be described in terms of decision sequences, focusing on how decisions are made in the process, or a production-based approach, which emphasizes how the final products are established (Gore & Nicholson, 1991). Given the idiosyncratic characteristics of the land development process depicted in different descriptive models, we argue that two elements pervade in any type of land development process, namely, information and property rights.

The land development process is usually divided into four phases: acquisition, approval, construction, and letting. In the first phase, the developer must locate a parcel of land that might yield profits from the project. Once the land is secured, the process enters into the second phase, in which the developer must apply for the necessary permits. Construction commences in the third phase. In the fourth phase, the final output after construction is then sold or leased in the market in order to yield profits for the developer. As argued by Schaeffer and Hopkins (1987), in each phase, planning yielding information is conducted with respect to environments, values, and related decisions. Plans are made and revised as sets of related, contingent decisions based upon the information gathered. As a result, the land development process is a sequential decision making problem, the decisions made in each phase being contingent on those to be made in the future. To clarify the roles that information and property rights play in the land development process, we focus in this section on the first phase: land acquisition. The interpretation of the behavior in other phases can be made similarly.

Property rights play an important role in the land development process so it is useful first to define property rights. Property rights are the power to consume, obtain income from, and alienate the assets over which the owners have the authority to do so (Barzel, 1991). Thus, the property rights over a parcel of land are the power to use the land to make a profit through cultivating, improving, or exchanging it. According to Barzel, in reality, property rights are impossible to delineate completely in any exchange. Thus, transaction costs arise due to incomplete information about attributes of assets. For example, in making investment decisions developers usually acquire information about the locational advantages of parcels of land with a certain amount of cost. This implies that some of the attributes of exchanged goods, unknown to either party involved in the exchange, are left in the public domain, and the exchanging parties are motivated to capture these attributes during the exchange.

This is particularly true in land transaction, regardless of the types of land tenure. More specifically, the property rights of a parcel of land can be divided into fixed, legal right and variable, economic right. Whereas the fixed, legal right is that legally protected by the government, such as documented ownership of the land, variable, economic right includes the attributes of the land affecting its valuation, such as its accessibility to transportation network. Because the fixed, legal property rights usually incur the fixed cost of land acquisition as indicated by land price, we argue that it is the variable, economic property rights that fundamentally affect how and why developers proceed in the land development process. If the economic property rights are not taken into account in the land development process, the developer would be indifferent between two parcels of land with the same amount of fixed, legal costs but different attributes. However, this is obviously not the case in reality, regardless of the types of land tenure.

Consider a developer in the first phase of land acquisition, looking for an appropriate parcel of land for a certain type of development. The attributes of each parcel of land vary depending

on its location, land price, geological conditions, access to public facilities and infrastructure, the socioeconomic conditions of the surrounding environment, landscape, amenities, and environmental considerations. No two parcels of land are identical, and methods used to measure these attributes are expensive and often imperfect in their results. As a result, complete information about land attributes is prohibitive in cost to obtain, which results in positive transaction costs. Put differently, both the exchanging parties will invest resources to measure the attributes of the land before deciding whether to proceed in the exchange. After the transaction costs expenditures, the developer and the owner of the land each will only obtain a certain amount of the information about these attributes, albeit incomplete. The information is incomplete for both parties because information is asymmetric or at least different due to the prohibitive cost of the complete measurement of all attributes of a parcel.

As a result, some attributes are thus unspecified and left in the public domain. For example, the owner might conceal a criminal problem in the community where the land is located, while a developer might be secretly informed of a public transit facility that would be constructed near the property, thereby increasing the value of the land. In deciding which parcel of land to acquire for development, we argue that the developer will secure the land from which he or she can maximize the value of property rights by capturing that left in the public domain.

Before realizing the exchange, the developer and the owner invest resources to gather information about the attributes of the land to reduce uncertainties/risks. This investment is the major source of transaction cost. Thus, planning as information gathering occurs during each transaction. It is worth noting what information the exchanging parties should gather and how he or she should proceed in information gathering. According to Friend and Hickling (1987), Hopkins (1981), and Schaeffer and Hopkins (1987), the developer is faced with four types of uncertainties: uncertainty about the environment, uncertainty about values, uncertainty about related decisions, and uncertainty about the search for alternatives. In the land development context, before land acquisition, the developer is uncertain about whether the investment would yield net gains. These gains are dependent on the trends of the surrounding environment of the land, government policies concerning future community development, related development decisions of other developers and the government, and possible final outputs of built form. All these types of information influence the profit-yielding attributes of the land under consideration.

As argued earlier, the complete measurement of the attributes of the land is prohibitively expensive since the measurement process incurs cost. Therefore, uncertainties cannot be eliminated completely, and the planning, i.e. information gathering, that occurs requires investment of resources. Planning produces additional information for the developer and landowner whose value is the discrepancy between the expected values of outcomes with and without that information. As a result, whether the developer should plan depends on whether the increase in the value of the information produced by planning exceeds the cost of conducting planning. In the land acquisition case, if planning with respect to the attributes of land at different locations results in an increase in the expected value of property rights captured from the public domain, which in turn exceeds the cost of conducting the planning, then planning is worthwhile and should be conducted by the land developer.

In deciding whether the developer should plan, the information with respect to the four types of uncertainty gathered through planning must be specified a priori. That is, the developer must determine beforehand what information to gather. It has been proven analytically that the information must be payoff relevant and sufficiently accurate; that is information affecting expected gains in making decisions (Lai, 2002). The proof was based on the notion of optimal information structures that would yield the highest expected utility given a best action. These conditions provide a useful guideline for information gathering in reality. In the land development context, the developer should acquire the information that is related to the value of the property rights captured in the land exchange, and that accurately measures the attributes of the land and predicts possible consequences resulting from the exchange.

In short, the seemingly idiosyncratic process of land development can indeed be described as a sequence of property rights-capturing activities. By completing the contractual exchange, the developer captures the property rights in terms of land attributes that is not fully delineated and left in the public domain. The transaction costs incurred in the exchange result mainly from information gathering or planning concerning the measurement of these attributes to reduce uncertainties. Since that measurement is costly, not all planning activities yield benefits; benefits are dependent on whether the value of the information gathered exceeds the cost of conducting planning. Since uncertainties cannot be eliminated completely, it follows that some property rights are always left in the public domain and the capturing of such right will always occur in any land development process, regardless of how much is invested in planning.

Effects of UCBs on land development

As a concrete example of how the property rights approach to land development can be used to interpret developers' behavior in response to the setting of UCBs, consider a city with a growing amount of developable land that is subject to the setting of UCBs. Suppose initially that all developable land is legally permissible and that the land prices are determined through the market mechanism. In this hypothetical example, imposing UCBs would limit all land developed within these boundaries. How would the developer react to such a land control policy?

Referring to Fig. 1, the initial demand and supply curves for land are shown as D and S. Viewing land as an intermediate, not the final, good of the land development process, the developer is on the demand side and the landowner is on the supply side. The market clearing price for land is P^* with the associated amount of land exchanged as Q^*. Assume a new land control policy of UCBs is imposed inelastic with respect to price that limits all land developed within Qc below the equilibrium amount Q^*, indirectly imposing a price limit of land set at Pc. The unit price of land

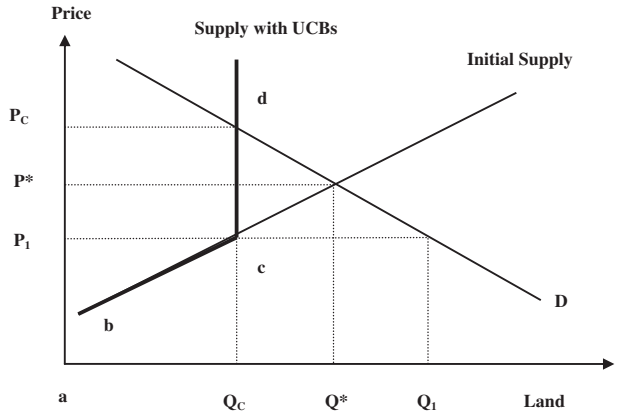

Fig. 1. Effects of UCBs as developable land control.

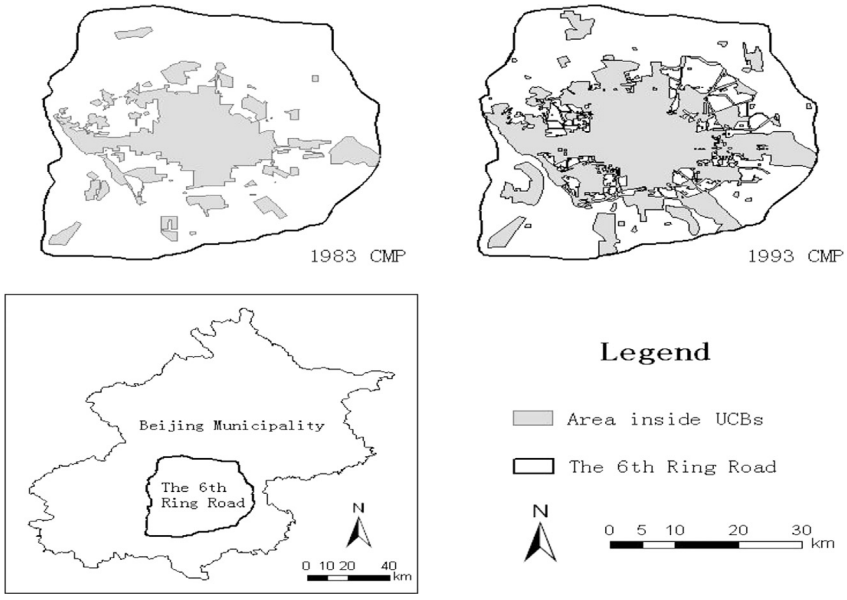

Fig. 2. UCB maps in the 1983 MP and in the 1993.

demanded shifts from P^* up to Pc, while the unit price of land supplied shifts from P^* down to P_1, and the market clearing price would be at Pc. However, the landowner is willing to sell at P_1 with the developer to secure the land at Pc, and there would be a price discrepancy of Pc−P_1 in the marketplace. The difference (▱ bcdP_C) in the amount between Pc × Qc, the amount the developer actually pays for the total amount of transacted land, and ▱ abcQ_C, the amount the landowner is willing to sell the transacted land, is dissipated in the public domain without identified recipients, but captured by the landowner through the market mechanism. *The implication is that the developer would be willing to risk violation of the UCBs to pay that amount in order to acquire additional land outside the UCBs at lower cost.* As argued by Barzel, the rationing of any type for a good with a limited supply, for example, by waiting or queuing, is not caused by a "shortage" of the supply of the particular good as traditionally conceived by economists. Instead, the shortage of the particular good in the market is a result of the consumers' maximization principle of capturing dissipated property rights. The same argument was applied to gas station owners' reactions toward the oil crises during the 1970s. Other behavioral predictions can be derived in response to the land control policy similar to the above analysis using the property rights approach.

On the other hand, as argued by Mohamed (2006), imposing the UCBs on a city reduces the risk of land development faced by developers, which in turn triggers off the frog-leap type of development pattern. "This raises an interesting question: do local governments unwittingly promote sprawl when they introduce policies to make the development process more predictable? *The answer appears to be tentatively yes.*" (Italics ours) (Mohamed, 2006: 34). Finally, plans do not necessarily reduce uncertainty though they definitely help cope with it and developers seeking the greenfield sites for development outside the UCBs might face a lower degree of uncertainty and smaller transaction costs than infill and redevelopment inside these UCBs. Therefore, we argue that plans, such as UCBs, might encourage use of exurban sites for development rather than discouraging it. With the three effects of the imposition of UCBs discussed in this section: increase of land prices, encouragement of use of exurban sites due to developers' behavior, and increase in uncertainty due to plans, we suspect that imposing UCBs in Beijing and Taipei would cause unwittingly urban sprawl rather than containing it, a hypothesis we test empirically in next section.

Empirical examination

Beijing and Taipei are selected for the empirical examination of the hypothesis depicted earlier because both are capital cities in China and Taiwan, respectively. In Beijing, as shown in Fig. 2, there have been altogether three versions of MPs since the 1980s: the Beijing MP (1981–2000) was put forward in 1982 and approved in 1983; the Beijing MP (1991–2010) was put forward in 1992 and approved in 1993; the Beijing MP (2004–2020) was put forward in 2005 and approved in the same year (Beijing Municipal Institute of City Planning and Design, 1982, 1992, 2005). Consequently, the Beijing MP (1981–2000) actually functioned from 1983 to 1993, the Beijing MP (1991–2010) from 1993 to 2005, while the Beijing MP (2004–2020) from 2005 to the present. The three Beijing MPs are denoted as the 1983 MP, the 1993 MP, and the 2005 MP, respectively. Moreover, the actual implementing period of the 1983 MP is denoted as "the first planning period," and that of the 1993 MP as "the second planning period." In addition, Beijing is characterized by a ring-concentric growth pattern, including six ring roads and over ten radiant roads. The 6th ring road is selected in this section as the study area due to the following two reasons. First, the 6th ring road is the outmost ring road of Beijing and is easy to identify. Second, the area inside the ring road is large enough to encompass the central city of Beijing and much of its surrounding open space for the estimation of urban growth intensities. For a detailed account of the analysis, the reader is encouraged to consult the work by Han, Lai, Dang, Tan, and Wu (2009).

A comparison of the areas between the UCBs and the 6th ring road across the two planning periods already shows that much development has taken place outside the UCBs during the first planning period. To examine the effectiveness of the UCBs, it is crucial to distinguish the land uses they allow and encourage from those they prohibit and discourage. Consequently, the land use within the 6th ring road was classified into urbanized land areas and open space in this section. The urbanized land is defined as all types of developed land, including urban and rural built-up areas and urban green space, such as developed parks, golf courts, and other urban green space for recreation. At the same time, open

space is defined as land for agricultural use (according to its broad definition in China), including farmland, woodland, pastureland and orchards. The estimation of these areas is conducted using the Landsat images.

Taipei was selected as the study area due to the following two reasons. First, from the degree of analyzed timeframe for credibility, Taipei is one of the earliest cities that implemented an urban plan in Taiwan. Second, for credible data, Taipei's map data compared to other cities were relatively complete, especially topographic maps. Theoretically, the whole Taipei metropolitan area should be studied, but because of limited time and ease of data acquisition, the administrative district of Xinyi District was selected in this section as the study area also due to the following two reasons (see Fig. 3). First, in Xinyi District, there were both urbanized and non-urbanized land areas. Second, from the establishment of Taipei city until now, Xinyi District was incorporated from other counties, so we expected urban sprawl would be quite significant there.

In Taipei and Xinyi District, as shown in Fig. 3, the first major plan had been released since 1956, involving adjustment of the major plan in roughly two stages. The first stage from 1956 to the Protected Areas Plan was put forward in 1979, denoted as 'the first planning period' (MP1) and the second stage was from 1979 to 1991, denoted as 'the second planning period' (MP2). The analysis ended in 1991 because the map data were only available until 1991 in Taipei. This would not affect the results of the analysis because the study spanned a significant length of planning period of Taipei, from 1956 to 1991. To examine the effectiveness of the UCBs, it was crucial to distinguish the land uses allowed and encouraged from those prohibited and discouraged. Consequently, the land use within Xinyi District was classified into urbanized land area and non-urbanized land area. The urbanized land area included all developable land, such as commercial, residential, industrial areas and related public facilities such as parks, green spaces, squares, etc. On the other hand, non-urbanized land areas were referred to as the protected and agricultural areas. The estimation of these areas was conducted using the topographic map data. Taipei City Government owned the topographic maps data, including the 1958 analog topographic maps and digital topographic maps of 1969, 1980 and 1991, the two periods, MP1 and MP2, were divided into four stages and denoted as MP1 (1958), MP1 (1969), MP2 (1980), and MP2 (1991).

The present research examines the effectiveness of UCBs basically by comparing developments outside with those inside the boundaries. Three presumptions are identified to assess the effectiveness of the UCBs. The first presumption is that less urbanization should occur outside the UCBs than inside if the UCBs are effective to contain urban sprawl. The second is that the total possible increase in urbanized land area should be less than or equal to the existing open space within the UCBs at the beginning of each planning period in order to achieve effective urban containment, meaning that the area of land consumed should be no more than supplied. The third is that the urban growth immediately outside the UCBs should be avoided if the UCBs are

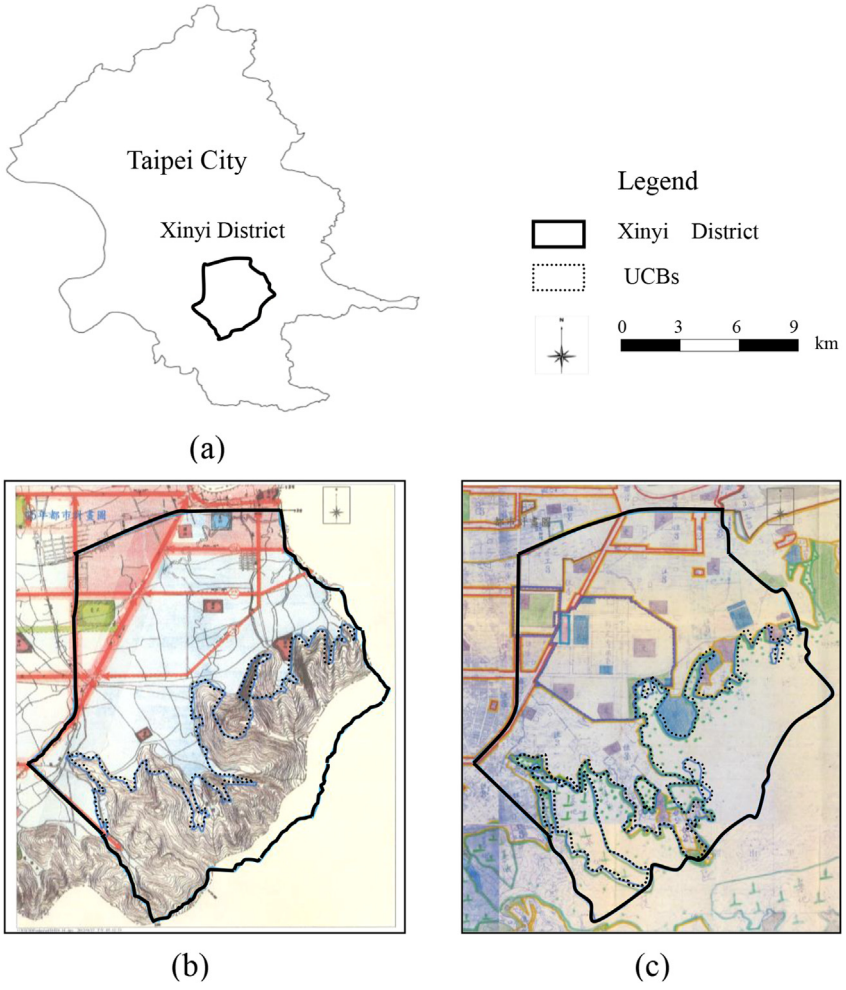

Fig. 3. Master Plan Maps in Xinyi District, Taipei (a) location of Xinyi District (b)1956 (c)1979.

effective to contain urban sprawl, as that growth would significantly undermine the urban containment objective by encouraging urban sprawl.

According to these presumptions, three quantitative indicators are defined for the assessment of the UCBs, i.e., boundary containment ratio (BCR), boundary sufficiency ratio (BSR), and boundary adjacent development ratio (BADR), as follows:

$$\mathrm{BCR} = A_2/A_1, \quad (1)$$

$$\mathrm{BSR} = (A_1 + A_2)/A_3, \quad (2)$$

$$\mathrm{BADR} = L_1/L_2, \quad (3)$$

where A_1 and A_2 are areas of urbanized land increase (open space consumption) inside and outside the UCBs during the planning period, respectively; A_3 is the area of open space inside the UCBs at the beginning of the planning period; L_1 and L_2 are lengths of the UCBs with and without new land development immediately outside, respectively. Fig. 4 illustrates conceptually all types of areas and boundaries defined in Eqs. (1)–(3).

According to the presumptions, we expect that a high value of BCR indicates a large share of urban growth outside the UCBs, that a high value of BSR indicates an insufficient size of the UCBs, and that a high value of BADR indicates a high proportion of urban growth occurring immediately outside the UCBs.

Results from Beijing

In the following analyzes, we measured land areas in terms of km^2 and lengths of UCBs in terms of km. During the first planning period (1983–1993), the urbanized land area inside the UCBs increased from 333.3 km^2 in 1983 to 474.6 km^2 in 1993 (Table 1). At the same time, the urbanized land area between the UCBs and the 6th ring road increased from 76.3 km^2 in 1983 to 239.2 km^2 in 1993. As a result, during the first planning period, the urbanized land area increased by 141.4 km^2 inside the UCBs, consisting of 46.5% of the total urbanized land growth in the 6th ring road; while it increased by 162.8 km^2 between the UCBs and the 6th ring road, consisting of 53.5% of the total urbanized land growth in the 6th ring road. Urban sprawl in Beijing was found to have occurred immediately outside the UCBs. At the beginning of the first planning period, 22.0% or 134 km of all UCBs had already been adjacent to the existing land development outside them. During the first planning period, 28.2% or 172 km of all the UCBs had new land development immediately outside them. By the end of the first planning period, only 49.8% or 304 km of the UCBs did not have any land development immediately outside the UCBs (see Figs. 5 and 6).

The growth pattern during the second planning period shows similar results. During the second planning period, the urbanized land area inside the UCBs increased from 619.1 km^2 in 1993 to 807.1 km^2 in 2005 (Table 2). At the same time, the urbanized land area between the UCBs and the 6th ring road increased from 94.2 km^2 in 1993 to 336.3 in 2005. During the second planning period, the urbanized land area increased by 188.0 km^2 inside the UCBs, consisting of 43.7% of the total urbanized land growth in the 6th ring road; while it increased by 242.1 km^2 between the UCBs and the 6th ring road, consisting of 56.3% of the total urbanized land growth in the 6th ring road. Urban sprawl was also found to have occurred immediately outside the UCBs. At the beginning of the second planning period, 41.9% or 518 km of all UCBs had already been adjacent to the existing land development outside them. During the second planning period, 25.3% or 313 km of all the UCBs had new land development immediately outside them. By the end of the second planning period, only 32.7% or 404 km of the UCBs did not have any land development immediately outside the UCBs (see Figs. 7 and 8)

Table 1
Land area change inside and outside the UCBs in the first planning period 1983–1993 (km^2).

Item	Urbanized land area		Open space		Urbanized land area change	Open space change
	1983	1993	1983	1993	1983–1993	1983–1993
Inside UCBs	333.3	474.6	215.7	74.4	141.4	−141.4
Outside UCBs	76.3	239.2	1680.7	1517.8	162.8	−162.8

By calculating BCRs, BSRs, and BADRs in the two planning periods, respectively, a comparison was made to analyze the implementation effectiveness of the UCBs in the Beijing MPs from early 1980s to mid 2000s (see Table 3). The results are summarized as follows:

1) The BCR was 1.15 in the first planning period and 1.05 in the second planning period. It indicates that the urban growth outside the UCBs had a larger share of the total growth than that inside the UCBs in both planning periods.
2) The BSR was 1.41 in the first planning period and 1.50 in the second planning period. Both are greater than 1. It suggests that the UCBs were not planned encompassing areas large enough to accommodate all new urbanization if measured by the actual development density in both planning periods.
3) The BADR was 0.57 in the first planning period and 0.77 in the second planning period. The high values of BADR suggest that a large amount of urban growth had occurred immediately outside the UCBs.

In short, the UCBs in Beijing failed to contain urban sprawl in that much development took place outside the MPs of Beijing during the two planning periods, confirming our hypothesis.

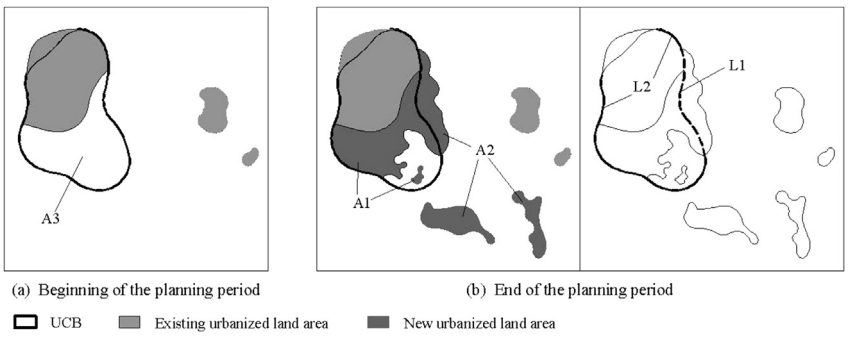

Fig. 4. Illustration of the areas and boundaries of analysis.

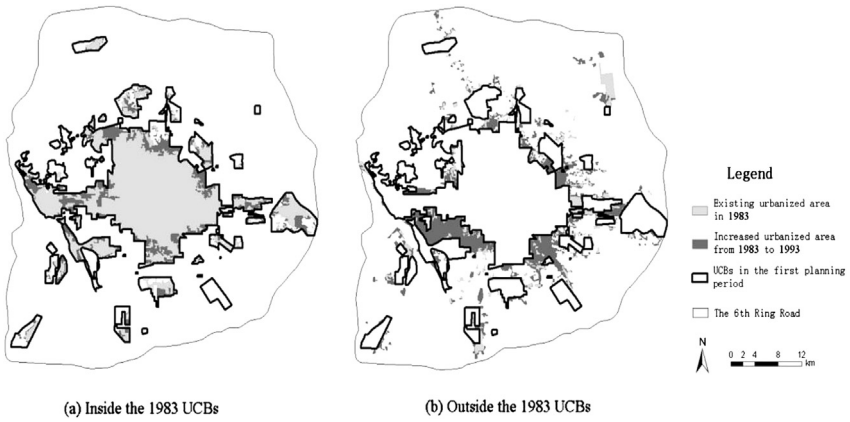

Fig. 5. Urbanized land area change during the first planning period.

Results from Taipei

The total area of Xinyi District is about 11.23 km^2. In the 1956 plan, the urbanized land inside the UCBs was about 6.80 km^2, of which developable land was about 3.483 km^2, and the non-urbanized land outside the UCBs was about 4.43 km^2, of which developable land was about 1.469 km^2; In the 1979 plan, the urbanized land inside the UCBs extended to 7.68 km^2, of which developable land was about 3.933 km^2, the non-urbanized land outside the UCBs reduced to 3.55 km^2, of which developable land was about 0.589 km^2. In the developable land, the public facilities were designated by the public sector, and developers were not expected to obtain development benefits through changes of zone in public facilities. Therefore, public facilities were excluded within the UCBs. On the other hand, developable land outside the UCBs were referred to as the net area delineated by the Building Technical Regulations. In Taiwan, an average slop gradient of more than 30% of the hillside land was restricted for development. The results of the analysis for the two planning periods and four stages are shown in Figs. 9 and 10, as well as Tables 4 and 5, respectively.

In the two stages in the first planning period, MP1 (1958) and MP1 (1969), the developed land inside the UCBs increased from 0.61 km^2 to 1.22 km^2, accounting for 35% of the developable land inside the UCBs. At the same time, the developed land outside the UCBs increased from 0.038 km^2 to 0.051 km^2, accounting for 3.5% of the developable land outside the UCBs. In the second planning period, MP2 (1980) and MP2 (1991), the developed land inside the UCBs increased from 2.25 km^2 to 2.57 km^2, accounting for 65.3% of the developable land inside the UCBs. At the same time, the developed land outside the UCBs increased from 0.109 km^2 to 0.16 km^2, accounting for 27.1% of the developable land outside the UCBs (see Tables 4 and 5).

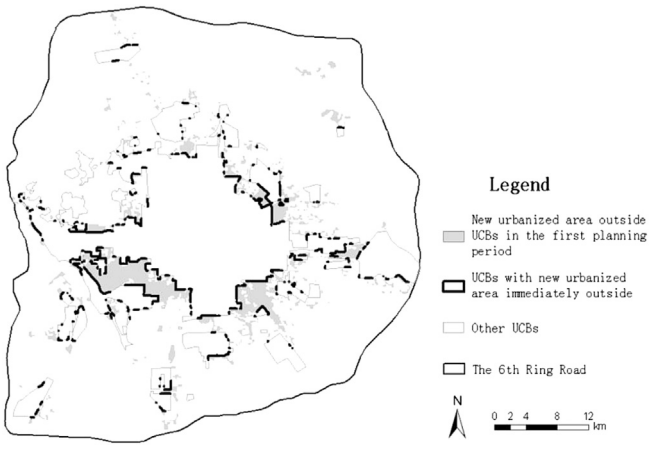

Fig. 6. UGBs with urbanized land growth immediately outside during the first planning period.

At the beginning of the first planning period, 12.6% or 1.782 km of the UCBs had already been adjacent to the existing land development outside them. During the first planning period, only 1.5% or 0.216 km of all the UCBs had new land development immediately outside them. By the end of the first planning period, 85.9% or 12.768 km did not have any land development immediately outside the UCBs (see Fig. 9). At the beginning of the second planning period, 17% or 4.070 km of the UCBs had already been adjacent to the existing land development outside them. During the second planning period, only 8.7% or 2.097 km of all the UCBs had new land development immediately outside them. By the end of the second planning period, 74.3% or 17.808 km did not have any land development immediately outside the UCBs (see Fig. 10).

By calculating BCRs, BSRs, and BADRs in the two planning periods, respectively, a comparison was made to analyze the implementation effectiveness of the UCBs in Taipei from early 1958 to 1991 (see Table 6). The results are summarized as follows:

1) The BCR was 0.02 in the first planning period and 0.16 in the second planning period. It indicates that the urban growth outside the UCBs did not have a large share of the total growth than that inside the UCBs in both planning periods.
2) The BSR was 0.21 in the first planning period and 0.22 in the second planning period. Both were less than one. It suggests that the UCBs were planned large enough to accommodate all new urbanization if measured by the actual development density in both planning periods.
3) The BADR was 0.14 in the first planning period and 0.26 in the second planning period. The lower values of BADR suggest that a small amount of urban growth had occurred immediately outside the UCBs, though it is increasing.

Table 2
Land area change inside and outside the UCBs in the second planning period 1993–2005 (km^2).

Item	Urbanized land area		Open space		Urbanized land area change	Open space change
	1993	2005	1993	2005	1993–2005	1993–2005
Inside UCB	619.1	807.1	315.9	127.8	188.0	−188.0
Outside UCBs	94.2	336.3	1276.8	1034.7	242.1	−242.1

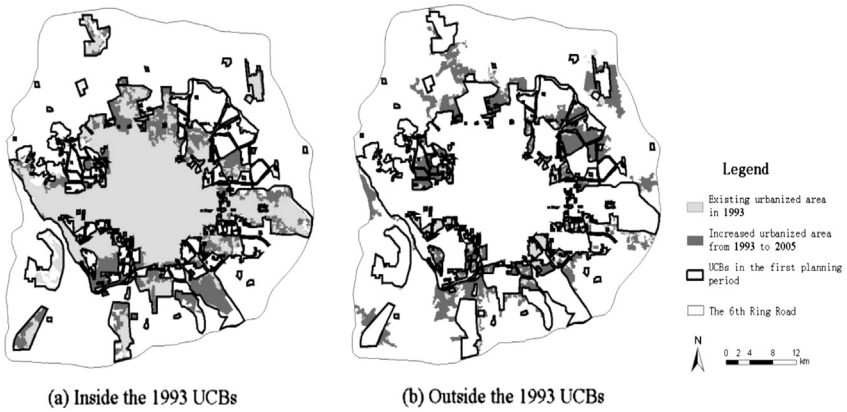

Fig. 7. Urbanized land area change during the second planning period.

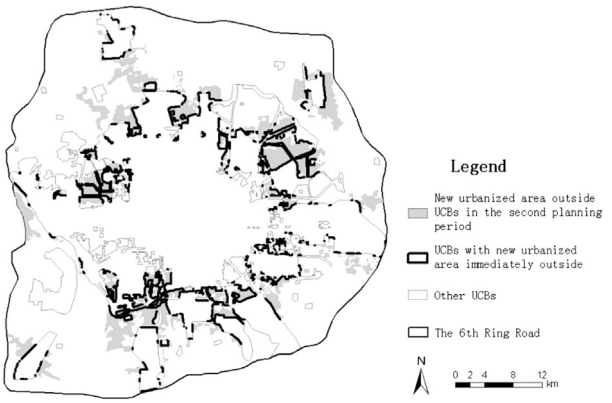

Fig. 8. UCBs with urbanized land growth immediately outside during the second planning period.

Table 3
Comparison of the implementation of UCBs in the two planning periods (Beijing).

The first planning period			The second planning period		
BCR	BSR	BADR	BCR	BSR	BADR
1.15	1.41	0.57	1.05	1.50	0.77

In contrast to Beijing, the UCBs in Taipei were quite effective in containing urban sprawl, a counter example for our hypothesis.

Discussion

In Beijing it can be concluded that the urban sprawl during the two planning periods from 1983 to 2005 took place mostly and increasingly outside the UCBs, in particular in the land which was immediately adjacent to existing development, a result predicted by our analysis depicted in Section 3. On the other hand, according to the empirical examination shown above, we have insufficient evidence to confirm that in Taipei, urban sprawl occurred in the first and second planning periods mostly outside the UCBs. The different results between Beijing and Taipei, we wonder, might lie in the effect that the plans made and regulations set in the two cases worked respectively. In the case of Beijing, the results of the analysis were based on the conformance of urban construction with plans, whereas in the case of Taipei, the results were focused on the conformance of construction with regulations. We argue therefore that in Taipei, the effects of regulations were more significant than plans in restricting the developers from looking for land outside the UCBs for development. In other words, both plans in Beijing and regulations in Taipei affected the developers' behaviors, but through different means. Plans affect these behaviors through information, whereas regulations through setting rights in development (Hopkins, 2001).

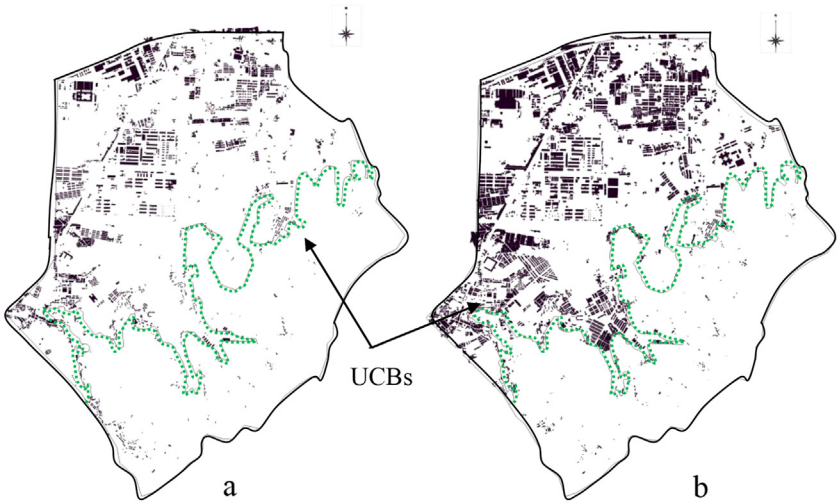

Fig. 9. Developed land during the first planning period (a)MP1(1958) (b)MP1(1969).

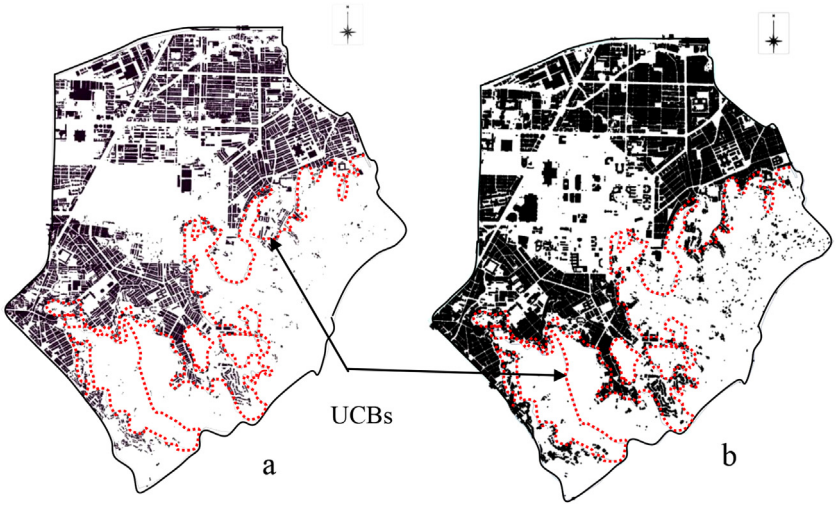

Fig. 10. Developed land during the second planning period (a) MP2 (1980) (b) MP2 (1991).

In addition, we conducted an experiment on developers' attitudes toward land development inside and outside UCBs through prospect theory (Kahneman & Tversky, 1979). Preliminary findings showed that the setting of UCBs made a proportion of developers search for land outside the UCBs for development in order to capture property rights left in the public domain, as predicted by in Section 3. In addition, the forces of pulling development inside the UCBs because of loss aversion and those of pushing development outside the UCBs because of risk seeking both reinforce the validity of our hypothesis.

From the analysis shown in Taipei, BSR was 0.21 in the first planning period, implying that the land for development inside the UCBs was still enough, but the area inside the UCBs was still expanding for about 0.88 km^2 in the second planning period. This shows an interesting phenomenon: the developers might capture dissipated property rights not only outside the UCBs but also potentially through the UCBs adjustment by expanding the developable land for more property rights. For example, in 1973, Taipei City Government made the Yi Cui Hills plan, and approximately 0.186 km^2 of protected areas were changed to residential areas. The reason was: "The geographical barriers … Taipei southeast hilly ground, …, beautiful environment, fresh air, …, to solve the problem of life" (Department of Urban Development, 1973). In the second planning period, the Government made the Protected Areas Plan through a comprehensive review, about 4.666 km^2 being changed to residential use, of which about 0.0426 km^2 were in Xinyi District. In assessing the plan (Department of Urban Development, 1979), we did not find these reasons persuasive. The cases above imply that the developers captured additional property rights by adjusting and expanding the UCBs for development.

The results of Taipei indicated that each indicator still showed a gradual growth trend during each planning period. For example, the indicators of BADR were 0.14 and 0.26 during the first and second planning periods, respectively. Does it imply that the UCBs were effective only during the period of 1958–1991, but would become uncontrollable in the future? It seems that the plans made in the second planning period were not fully realized yet to accommodate the speed of the development outside the UCBs. This also implies that the plans contemplated through the traditional, hierarchical, and rational planning process may not take into account developers' behavior appropriately, resulting in plans that generate unanticipated consequences. In addition, one might argue that the contrasting results between Beijing and Taipei found in this research are mainly caused by the significant population growth of Beijing after the economic reforms commencing in 1978. A closer examination showed that Taipei even experienced a relatively higher rate of population growth than Beijing during the planning periods. For example, in Beijing the population in 1983 was about 5,570,000 and 12,861,000 in 2005 with a growth rate of 131%. As for Taipei, the population in 1951 was 562,261 and 2,719,659 in 1990 with a growth rate of 384%. Therefore, our findings in the comparison would hold given the differential population growth rates of the two cities and the fact that Taipei is much smaller than Beijing in size.

A limitation of the empirical examination of Taipei is, like Beijing, that theoretically the whole Taipei metropolitan area should be studied. It is not clear whether the empirical results from such a large scale study would be the same as those in Xinyi District, which begs backing from future research. And what would developers' attitude be toward UCBs for capturing additional property rights? Would their attitude differentiate before and after implementing the UCBs? This would prompt more rigorous experiments in the future.

Conclusions

From a property rights perspective, we first explained, theoretically and conceptually, why UCBs in general could cause urban

Table 4
Land area change inside and outside the UCBs in the first planning period 1958–1969 (km^2).

Item	Developed land area		Undeveloped land area		Developed land area change	Undeveloped land area change
	1958	1969	1958	1969	1958–1969	1958–1969
Inside UCB	0.61	1.22	2.87	2.26	0.61	−0.61
Outside UCBs	0.04	0.05	1.43	1.42	0.01	−0.01

Table 5
Land area change inside and outside the UCBs in the second planning period 1980–1990 (km^2).

Item	Developed land area		Undeveloped land area		Developed land area change	Undeveloped land area change
	1980	1991	1980	1991	198–1991	1980–1991
Inside UCB	2.25	2.57	1.68	1.36	0.32	−0.32
Outside UCBs	0.11	0.16	0.48	0.43	0.05	−0.05

Table 6
Comparison of the implementation of UCBs in the two planning periods (Taipei).

The first planning period			The second planning period		
BCR	BSR	BADR	BCR	BSR	BADR
0.02	0.21	0.14	0.16	0.22	0.26

sprawl, rather than stop it. Secondly, we proposed three assumptions and corresponding quantitative indices to evaluate empirically the effectiveness of the UCBs policies in Beijing and Taipei to test the hypothesis derived from the theoretical explanation. As predicted by our analysis, the urban sprawl in Beijing during the two planning periods from 1983 to 2005 took place mostly outside the UCBs, but the counter-example of Taipei showed no significant urban sprawl during the two planning periods from 1958 to 1991. The different results between Beijing and Taipei, we argue, lie in the effectiveness of regulations setting. In Taipei, the regulations were effective in restricting developers from searching land outside the UCBs, but no such evidence was found in Beijing. We argue, therefore, that a successful land control measure, such as UCBs, should take into account the developers' behavioral reaction to plans and regulations in order to stop effectively urban sprawl. The immediate policy implications are twofold. In order to stop urban sprawl, at least in China, more stringent regulations and permit systems must be set to prevent land development from taking place outside UCBs. On the other hand, local governments should levy taxes on landowners or even developers for land and housing transactions to present windfalls due to inflations of land and housing prices caused by the delineation of UCBs. As argued in Section 3, these windfalls are roughly the property rights dissipated in the public domain during the land and housing transactions and belong to neither the landowners nor the developers. Of course, how these policies should be designed and implemented effectively begs careful, future research.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.habitatint.2013.11.001.

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