

1 **What if Beijing had enforced the 1st or 2nd greenbelt? --- Analyses**
2 **from an economic perspective**

3 **Abstract**

4 Many fast growing cities have designated greenbelts but have failed to maintain them. This is
5 often attributed to weak planning regulations, but there is little understanding of the underlying
6 impacts of greenbelts on the interactions among land use control, transport supply and economic
7 activities. This paper presents a counterfactual analytical model to examine the greenbelts'
8 impacts on consumers' utility, producers' productivity, and their locational choices. The model
9 establishes historic-what-if scenarios and compares what historically happened with what could
10 have happened under alternative levels of greenbelt interventions. The model is applied to
11 Beijing, which intended to establish two greenbelts in 1994, but large parts of the greenbelts
12 have disappeared under fast urban expansion. The model compares the economic impacts of the
13 greenbelts as they stood with hypothetical fully-enforced greenbelts and no-greenbelt scenarios
14 from 1990 to 2010. The modelling results show that the two greenbelts, if fully enforced, would
15 have decreased consumer surplus by \$202 million in Beijing in 2010. To fulfil the policy aim of
16 decentralisation, transport improvements between the city and new towns are crucial. For a more
17 effective implementation of greenbelts in the future, development constraints could be carefully
18 removed from non-ecologically sensitive sites which are served with good transport conditions.

19 **Key words**

20 Greenbelt; greenbelt evolution; policy review; counterfactual planning; land use and transport
21 interaction; spatial equilibrium

22 1. Introduction

23 Greenbelts are a key instrument for safeguarding the environment, providing open space and
24 containing excessive urban expansion in a large number of cities, such as London (Amati, 2008),
25 Vienna (Amati, 2008), Melbourne (Buxton & Goodman, 2003), Hong Kong (Tang, Wong, &
26 Lee, 2007), Seoul (Kim & Kim, 2008), and Ontario (Carter-whitney & Esakin, 2010) among
27 others. Cities in emerging economies, for example, Beijing, Bangalore and Sao Paulo, also
28 intended to establish greenbelts for their environmental benefits and aesthetic value (Adkin,
29 2009; Han & Long, 2010).

30 However, it is common to see greenbelt plans falter in fast expanding cities. For example, the
31 planned greenbelt disappeared under urban expansion in Tokyo after the Second World War
32 (Okata & Murayama, 2011). In Beijing, proposed greenbelt plans were largely ignored and large
33 parts of the planned greenbelt areas were built upon (Han & Long, 2010; Wang, 2015). A similar
34 situation happened to Bangalore's greenbelt plan (Adkin, 2009). Weak planning regulation and
35 governance are often criticised for causing such a policy deficiency (Amati, 2005; Han & Long,
36 2010; Yokohari, Takeuchi, Watanabe, & Yokota, 2000). However, there is a lack of research and
37 a gap in understanding the underlying economic impacts of greenbelts on local businesses and
38 residents in fast growing cities.

39 Beijing is a typical example of a fast growing city that intended to establish greenbelts for
40 protecting the environment and providing open space for residents (Beijing Municipal
41 Government, 1994, 2003). The idea of using green spaces to separate built-up areas, stop urban
42 expansion and decentralise population was proposed in multiple versions of Beijing Master Plans

43 (Master Plans of 1958, 1982, 1991, 2004-2020, 2016-2035). The First Greenbelt (GB1) was
44 introduced in 1994 to support the decentralisation policy proposed in the Beijing Master Plan of
45 1991, with a designation of 240 km² of green areas around the fourth ring-road preserved as a
46 greenbelt. Nine settlements beyond GB1 were designated for absorbing population overspills
47 from the city centre. The Second Greenbelt (GB2) was introduced in 2003 to support the
48 decentralisation and environmental policy in the Beijing Master Plan of 2004-2020, with a
49 further designation of 1650 km² of green areas between the fifth and sixth ring-roads. Eleven
50 new towns were designated to support the population decentralisation of Beijing.

51 Studies have shown that Beijing's greenbelt policies increased tree canopy cover (J. Yang &
52 Zhou, 2007), encouraged tree planting on village brownfield land (Tan, 2008), preserved the
53 continuity of large pieces of greenspace (Gan, 2012), and safeguarded water bodies and forests
54 (Han & Long, 2010). Although the environmental benefits of greenbelts are well-known by the
55 public, planners were frustrated by the fact that the designated greenbelt land was encroached
56 upon by new development arising from the fast urban expansion since the 2000s. In fact, data
57 show that the percentage of greenfield land remaining from the proposed First Greenbelt is less
58 than 11% (Wang, 2015). For the Second Greenbelt, although the percentage of built-up area in
59 GB2 was planned to be under 32%, it increased from 35.7% to 40% from 2003 to 2006 (Zhang,
60 2007). Weak planning regulation is one reason that caused this setback (Han & Long, 2010; X.
61 Yang, 2008), but there is little research investigating the underlying economic impacts that may
62 have hindered the greenbelt policy's implementation in Beijing. In this research, we investigate
63 the evolution of Beijing's greenbelts from an economic perspective to explain why some
64 greenbelts were hard to maintain.

65 We examine the impacts of greenbelts on consumers and businesses through establishing
66 historic-what-if scenarios under alternative greenbelt interventions. This method “conjectures on
67 what might have happened in order to understand what did happen” (MacRaild & Black, 2007, p.
68 125). Such retrospective analyses will help to identify and explain the impacts of plans and
69 inform future decisions. This paper intends to answer the following questions: Why have
70 Beijing’s greenbelt policies encountered difficulties in implementation? What are the potential
71 economic costs and benefits of the proposed (but not fully accomplished) greenbelts on residents
72 and businesses? What can we learn from past experiences that can help to design more effective
73 greenbelts for the future?

74 The following sections of this paper are arranged as follows: section 2 offers a literature review
75 of existing models for assessing greenbelt impacts. It introduces the concept of a counterfactual
76 history and explains how to incorporate spatial equilibrium models in a historic counterfactual
77 framework. Section 3 presents the structure of the counterfactual model and components of the
78 spatial equilibrium model. Section 4 applies the model to Beijing under historic-what-if
79 scenarios. It compares the economic impacts of the remaining greenbelts as they stood in 2000
80 and 2010 with hypothetical fully-enforced greenbelts and no-greenbelt. The modelling results
81 show the impacts in terms of residents and business adaption to the greenbelt, rent, household
82 utility and productivity changes. Section 5 offers a discussion of the economic impacts of
83 Beijing’s greenbelts, the reason that the greenbelts were hard to maintain, and summarises the
84 strength and weaknesses of the model.

85 2. Literature review

86 Greenbelts have existed for many decades, which provides rich records for planners and policy
87 makers to measure the impacts of greenbelts on the urban economy. One of the existing
88 approaches to measure the impacts of a greenbelt is to carry out a before-after policy comparison
89 of a city over a time period (Amati & Yokohari, 2006; Lee, 1999; Long, Gu, & Han, 2012).
90 Nelson (1999) pointed out that the before-and-after temporal analysis was hindered by
91 insufficient controls and difficulties in obtaining panel data, which is particularly difficult for
92 fast-growing cities like Beijing.

93 As a paired set analytical method to temporal comparison, spatial comparison was also used to
94 measure the impacts of greenbelts. It compares roughly comparable cities/towns with and
95 without greenbelts at one time horizon (Nelson, 1999; Siedentop, Fina, & Krehl, 2016; Woo &
96 Guldmann, 2011). It is worth noting that these empirical comparisons cannot fully differentiate
97 which impacts are due to the greenbelt and which are due to other factors, for example market
98 incentives and institutional backgrounds.

99 We suggest that we can truly clarify real-world impacts of a given policy by evaluating an
100 alternative scenario that removes or strengthens that historical policy, while keeping other
101 conditions intact. This compares a city with itself at the same point in time, so that influences
102 from other background policies can be controlled. For example, what conditions would have
103 been in a greenbelt city in the absence of the greenbelt? Such questions can be answered through
104 scenario planning.

105 Scenario planning has been used to analyse the future outcomes of alternative planning policies,
106 including predicting the impacts of alternative greenbelt interventions (Anas & Liu, 2007; Anas
107 & Rhee, 2006; Jin & Echenique, 2012; Jun, 2011; Ma & Jin, 2014, 2016). The existing models
108 first predict a benchmark scenario that is what will happen in a future time horizon following the
109 current development trend. Then they predict alternative scenarios given different policy
110 variations. Finally, they compare the alternatives with the benchmark. Obviously, there are
111 background uncertainties involved when predicting the benchmark scenario, for example, the
112 assumptions regarding total population growth and an economy's size. The validity of the model
113 might be affected when comparing future alternatives with the benchmark due to such
114 uncertainties.

115 The difficulties in controlling background uncertainties could be overcome using counterfactual
116 history studies. The concept of counterfactual history was introduced in the 1960s. It attempts to
117 answer historic-what-if questions known as counterfactuals, for example, what the U.S. economy
118 would have been like in 1890 had there been no railroads (Fogel, 1964). Compared to the
119 existing scenario planning models, the historic counterfactual model has advantages. The
120 benchmark to compare with in such a model is what actually happened. It is therefore free of the
121 uncertainties in background development trend assumptions, and gives confidence in interpreting
122 modelling results.

123 Based on the historic counterfactual idea, Bae and Jun (2003) used a regression model to test
124 what would have happened if there had been no greenbelt in Seoul. The model predicted the
125 counterfactual population and employment numbers within and beyond the greenbelt. The
126 authors suggested that counterfactual planning had much broader implications, such as to

127 estimate how the spatial structure of a city would change if a transit rail system had never been
128 built, or how the allocation of land uses would change in the absence of zoning.

129 Inspired by the idea of counterfactual history, we build a general spatial equilibrium model and
130 put it into a recursive modelling framework as done by Jin, Echenique and Hagreaves (2013). In
131 this framework, the spatial equilibrium model explores the interactions amongst the labour
132 market, product market, and the housing and business floorspace market. The recursive structure
133 compares a city under different hypothetical policies to what actually happened over a historic
134 time period, so that the inertia of a certain policy from a previous modelling time horizon can be
135 passed onto the next horizon.

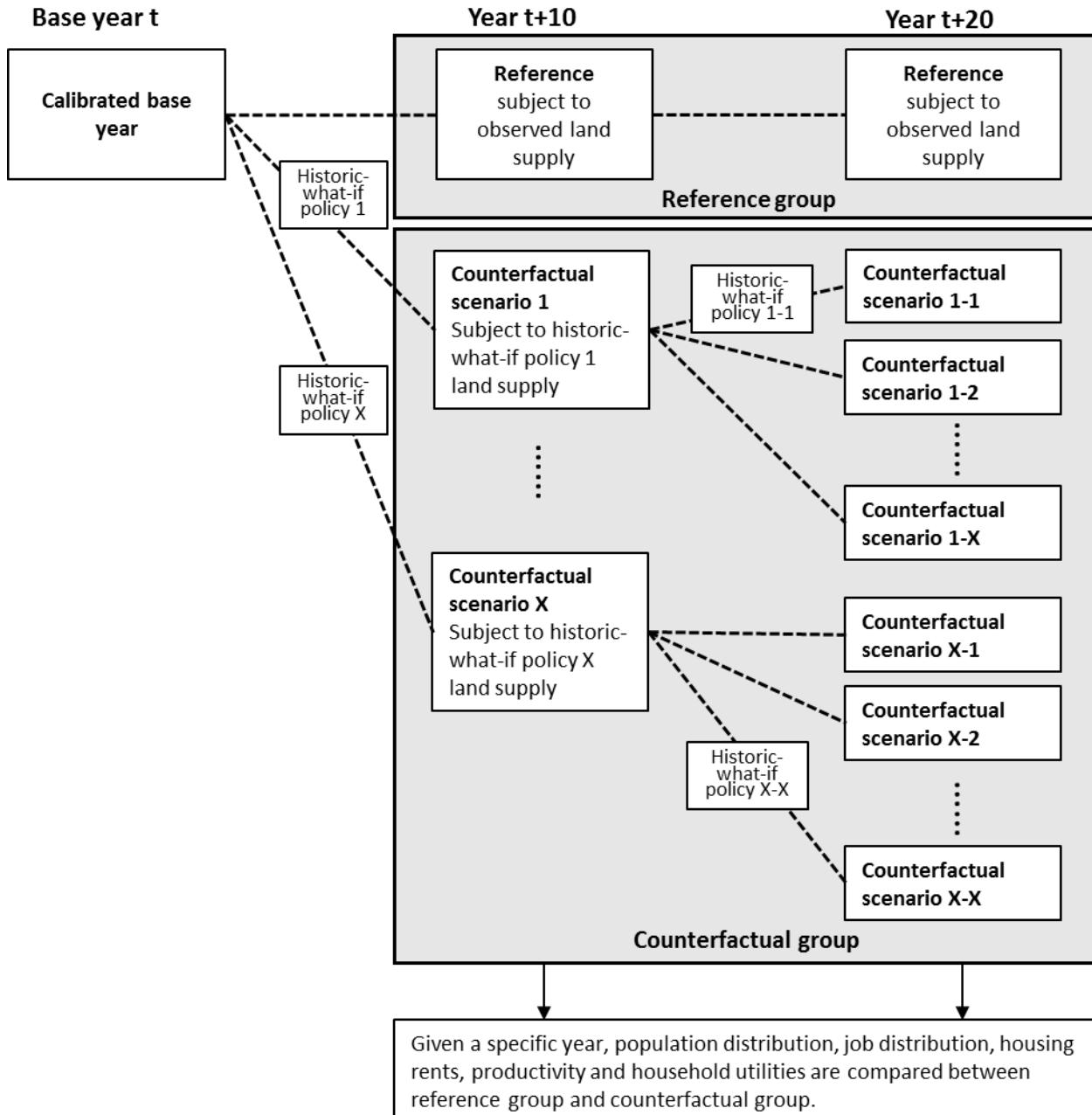
136 3. Methodology

137 In this section, we first explain the recursive counterfactual modelling structure, and then we
138 describe each component of the spatial equilibrium model. The recursive counterfactual structure
139 establishes a platform on which the historic spatial equilibrium conditions can be compared with
140 historic-what-if conditions. The spatial equilibrium model explores interactions between
141 producers, consumers and their locational choices, subject to floorspace supplies as a result of a
142 greenbelt constraint. The comparable measures from the modelling outputs are the number of
143 residents and jobs, rents, productivity and household utility in different areas of the city.

144 3.1. Recursive counterfactual modelling structure

145 The recursive counterfactual modelling structure includes two groups of spatial equilibrium
146 models (refer to Figure 1). The first is the reference group. This group consists of 3 cross-

147 sectional spatial equilibrium models that reproduce what happened in the past. The second is the
148 counterfactual group, which consists of spatial equilibrium models under historic-what-if
149 assumptions. The model starts from a calibrated base year t and runs to future year $t+20$, taking
150 information from both endogenous spatial equilibrium conditions from previous years and
151 exogenous policy inputs that are defined by the user.



152

153

Figure 1 Counterfactual modelling structure

154

155 3.2. Spatial equilibrium modelling components

156 Following the tradition of Anas and Liu (2007) and Jin, Echenique and Hargreaves (2013), the
157 spatial equilibrium model for producer and consumer behaviour follows a parsimonious design.
158 This allows the users of the model to understand and easily check the causal relationships
159 between producers, consumers and their locational choices. The spatial equilibrium model does
160 not currently include an explicit agency for developers or government, although these can be
161 added at a later date which will result in a more complex model to calibrate and use. Taxes are
162 not modelled explicitly; instead, the model assumes that the city balances its consumption with
163 its production, and any increase in the property sales/rental income is shared equally among all
164 households. The choice of this structure is to highlight the key interactions that are most relevant
165 to the broad thrust of urban development and its impacts on production and consumer welfare.

166 Spatially, the modelled area is divided into discrete but contiguous model zones. Spatial
167 activities can move within and between zones and the choice of location is modelled on a zonal
168 scale. Urban development is represented in terms of changes in the stock of housing and business
169 floorspace, all of which are inputs into the model periodically based on exogenous greenbelt
170 policy scenarios and endogenous economic performance.

171 **3.2.1. Consumers**

172 Following the random utility framework as put forward by McFadden (1974), an individual in
173 the population in socio-economic group f , living in zone i and working in zone j has a utility
174 function U_{fij} which can be written in the form:

$$U_{fij} = V_{fij} + e_{fij} \quad [\text{Equation 1}]$$

175 $V_{fij} \in (-\infty, +\infty)$ is non-stochastic and reflects the representative taste of the population, and
 176 $e_{fij} \in (-\infty, +\infty)$ is stochastic and reflects the idiosyncrasies of the population, which measures
 177 the unobserved utility variance among individuals. The non-stochastic observed utility V_{fij}
 178 consists of three parts: the quantity of retail goods and services a consumer buys, the quantity of
 179 floorspace he/she rents, and the time he/she contributes to leisure. The non-stochastic utility V_{fij}
 180 of an individual in socio-economic group f as a consumer, living in zone i , working in zone j and
 181 shopping in zone z is written as:

$$V_{fij} = \alpha_f \ln \left(\sum_r \left(\sum_z Z_{rzfij} \right)^{\eta_f} \right)^{\frac{1}{\eta_f}} + \beta_f \ln \left(\sum_h (b_{hfi})^{\sigma_f} \right)^{\frac{1}{\sigma_f}} + \gamma_f \ln l_{fij} \quad [\text{Equation 2}]$$

182 $\alpha_f > 0, \beta_f > 0, \gamma_f > 0$ are the shares of disposable income spent on the retail goods and service
 183 Z_{rzfij} , housing floorspace b_{hfi} , and annual leisure time l_{fij} respectively. Constant returns to
 184 scale is achieved by defining $\alpha_f + \beta_f + \gamma_f = 1$. From the consumer's side of the model, the
 185 subscripts r and h stand for the type of goods and services and the type of housing floorspace
 186 respectively. $\frac{1}{1-\eta_f} > 0$ and $\frac{1}{1-\sigma_f} > 0$ are respectively the elasticities of substitution between
 187 any two retail goods and any two types of housing.

188 **3.2.2. Producers**

189 The production function follows a hybrid Cobb-Douglas constant elasticity of substitution form.
 190 The output X_{rj} of a certain industrial type r (which produces type r goods and services) in a zone
 191 j is:

$$X_{rj} = E_{rj} K_r^{\nu_r} \left(\sum_f L_{rfj}^{\theta_r} \right)^{\frac{\delta_r}{\theta_r}} \left(\sum_k B_{rkj}^{\zeta_r} \right)^{\frac{\mu_r}{\zeta_r}} \prod_s (Y_{rsj})^{\gamma_{rs}} \quad [\text{Equation 3}]$$

192 In this hybrid Cobb-Douglas constant elasticity of substitution function, primary inputs are
 193 capital K_r , labour force L_{rfj} , business floorspace B_{rkj} and intermediate inputs Y_{rsj} . The
 194 subscripts f, k and s stand for the socio-economic level of a worker, the type of floorspace used
 195 for production, and the type of intermediate inputs respectively. $E_{rj} > 0$ is a scale parameter to
 196 convert production input into monetary terms. $E_{rj} = 1$ when production inputs are already
 197 counted in monetary terms. This production function is rendered constant returns to scale by
 198 setting $\nu_r + \delta_r + \mu_r + \sum_s \gamma_{rs} = 1$ ($\nu_r > 0, \delta_r > 0, \mu_r > 0, \gamma_{rs} > 0$). The elasticity of
 199 substitution between any two types of labour forces and building floorspace are $\frac{1}{1-\theta_r} > 0$ and
 200 $\frac{1}{1-\zeta_r} > 0$ respectively. At this initial stage of the model, two simplifications are applied to this
 201 production function. Firstly, the city is assumed to produce only one kind of conceptual
 202 composite goods and service. Secondly, only the labour and floorspace inputs are included for
 203 the model as done by Anas and Rhee (2006), because they are the most relevant inputs to affect
 204 the interactions between a producer's locational choice and the land use constraint from the
 205 greenbelt.

206 **3.2.3. Locational choice**

207 The locational utility v_{fij} for an individual in socio-economic group f living in zone i and
 208 working in zone j is specified as:

$$v_{fij} = V_{fij} - d_{fij} + E_{fij} \quad [\text{Equation 4}]$$

209

210 V_{fij} is the consumption utility specified in [Equation 2]. $d_{fij} = \phi_f c_{fij} + t_{ij} > 0$ is the travel
211 disutility. It is the cost of travel, including two parts: $c_{fij} > 0$ is the monetary travel cost from
212 zone i to j , converted by the marginal utility of money $\phi_f > 0$ into generalised travel time. $t_{ij} >$
213 0 is the travel time from zone i to j . $E_{fij} \in (-\infty, +\infty)$ is the residual attractiveness term which is
214 calibrated empirically in order to match the observed zonal numbers of residents and jobs. E_{fij}
215 represents the utilities that are not captured in the consumption utility V_{fij} . The amenity value of
216 the greenbelt is included in the residual attractiveness term E_{fij} .

217 To derive the probability of locational choice for a combined employment-residence decision, a
218 discrete choice model is adopted by specifying the distribution of the idiosyncratic utilities $e_{fij} \in$
219 $(-\infty, +\infty)$. Assuming e_{fij} follows a Gumbel distribution as specified in Anas and Liu (2007)
220 and Jin, Echenique and Hargreaves (2013), the probability of the combined locational choice can
221 be derived through a logit form. The probability P_{fij} for an individual in socio-economic level f ,
222 living in zone i and working in zone j is:

$$P_{fij} = \frac{S_i \exp(\lambda_f v_{fij})}{\sum_{mn} S_m \exp(\lambda_f v_{fmn})} \quad [\text{Equation 5}]$$

$$\sum_{ij} P_{fij} = 1$$

223 $S_i > 0$ is a size parameter that corrects for the bias introduced by the uneven sizes of zones in the
224 model. In this model, housing floorspace in each residential zone i is S_i . $\lambda_f > 0$ is the
225 concentration parameter for residential location choice. At one extreme, as $\lambda_f \rightarrow \infty$, taste of

226 idiosyncrasies vanish and all individuals choose their locations identically. At the other extreme,
227 as $\lambda_f \rightarrow 0$, all individuals choose randomly. The finite λ_f has empirical validity as it is
228 calibrated to match the observed commuting distance.

229 **3.2.4. Spatial equilibrium conditions**

230 Conditional on the travel disutility d_{fij} , the spatial equilibrium model requires the following
231 standard assumptions, subject to the zonal floorspace stock constraints for business floorspace
232 B_{rkj} and housing floorspace b_{hfi} , which are defined through the design of greenbelt policies; 1)
233 All consumers maximise utility subject to the housing floorspace, money and time constraints; 2)
234 All producers minimise cost subject to the input factors, which are the floorspace and labour
235 provision; 3) A zero profit condition is set for producers in an open competitive market which
236 means the price paid by the consumer equals the producer's cost. The market has zero excess
237 demand in the floorspace market, labour market and product market. In the labour market, total
238 working hours demanded equals total non-leisure hours minus travel time. In the product market,
239 total goods and services produced equals total goods and service consumed by consumers.

240 4. What if Beijing had enforced the 1st or 2nd greenbelt?

241 4.1. Model zones

242 The theoretical model is then applied to test historic-what-if scenarios in Beijing. Spatially, the
243 model divides Beijing into 130 zones according to the existing jiedao (subdistrict) boundaries
244 and transport links. Jiedaos in the city centre and far suburb are merged into larger zones because
245 the spatial variations within these zones are not the main focus in this paper. Greenbelt

246 constraints on urban development are represented in terms of changes in the stock of housing and
247 business floorspace in each zone. The 130 zones in Beijing Municipality are classified into seven
248 broad types in order to represent the impacts of the two greenbelts on different areas of the city.
249 We refer to previous studies by Ma and Jin (2014) to define these zone types (see Figure 2).

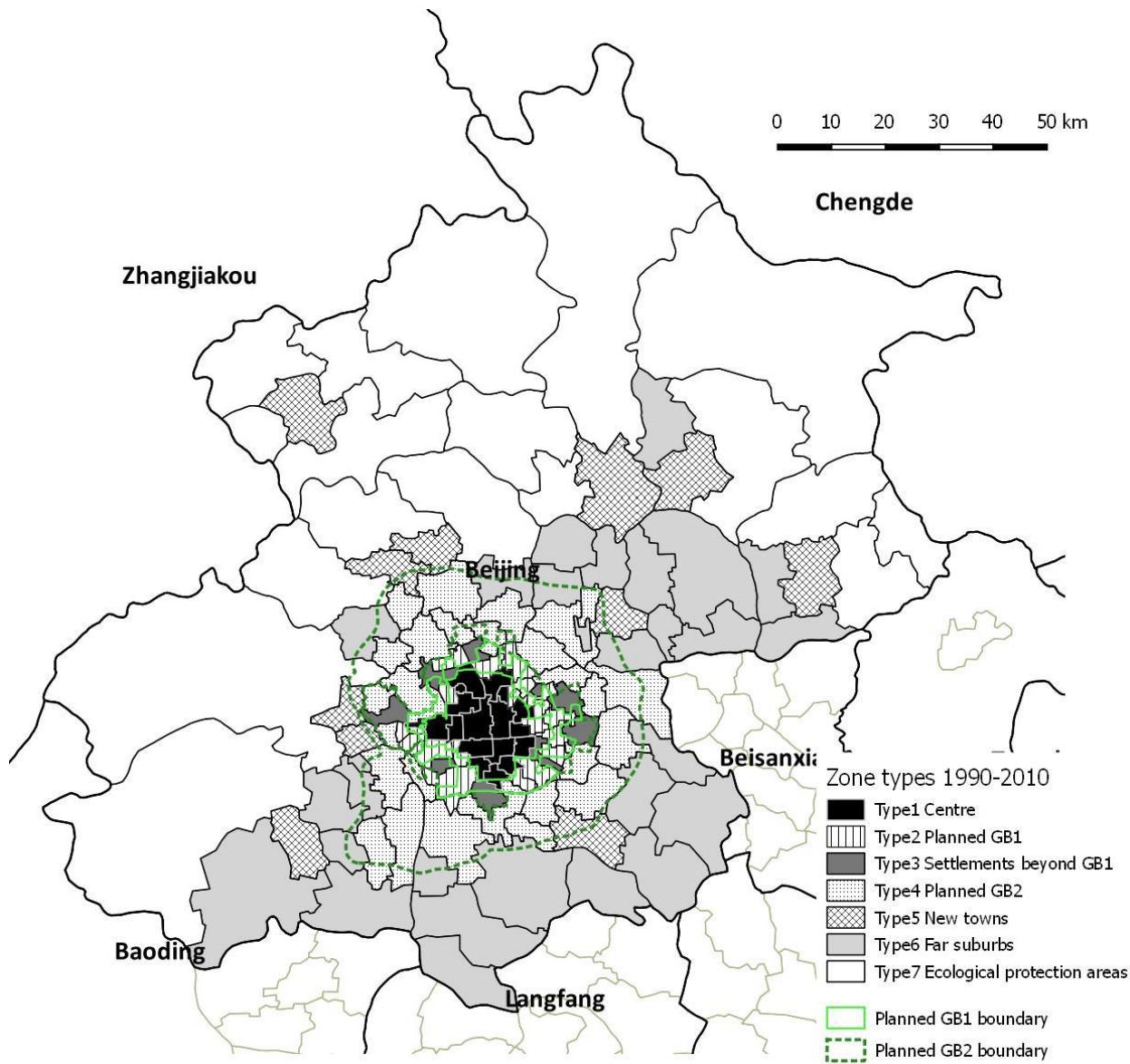


Figure 2 Zone categories in the Beijing Municipality in 1990

250
251

252

253 There are 20 zones categorised as GB1 and 23 zones as GB2. Boundaries do not fully comply
254 with the greenbelt policies, because zones are defined by transport networks and administrative
255 boundaries, not by greenbelt policy boundaries. However, this zoning is able to show the ring
256 shapes of the two greenbelts.

257 4.2.Counterfactual scenarios

258 Starting from a no-greenbelt base year 1990, the model runs through two decades till 2010. The
259 policy variations are solely the existence of the greenbelts. We push the variations to the extreme
260 by assuming the greenbelt as either fully enforced with no more excess building or that it never
261 existed. By comparing the historic pattern with fully-enforced greenbelt scenarios or no-
262 greenbelt scenarios, the counterfactual economic impacts of greenbelts or no-greenbelt can be
263 estimated.

264 From year 1990 to year 2000, GB1 is the policy variable. There are two scenarios which are
265 Scenario S1 - a stringent GB1, or Scenario N1 - no GB1. From year 2000 to year 2010, GB2 is
266 the policy variable. There are four scenarios stemming from the previous decade: Scenario S1-S2
267 is to implement a second stringent greenbelt in addition to the first one, so that the city will have
268 an expanded green system; Scenario S1-N2 is to keep the first stringent greenbelt, but no further
269 action of the second greenbelt will be put forward; Scenario N1-S2 is to implement a stringent
270 GB2 based on the condition that no GB1 has been designed; Scenario N1-N2 follows a no-
271 greenbelt policy. The “no greenbelt” scenarios do not mean that all of the greenbelt land would
272 be built upon. In such scenarios, development is allowed to happen in the two greenbelts
273 following market demand. The development can happen in the form of densification in existing

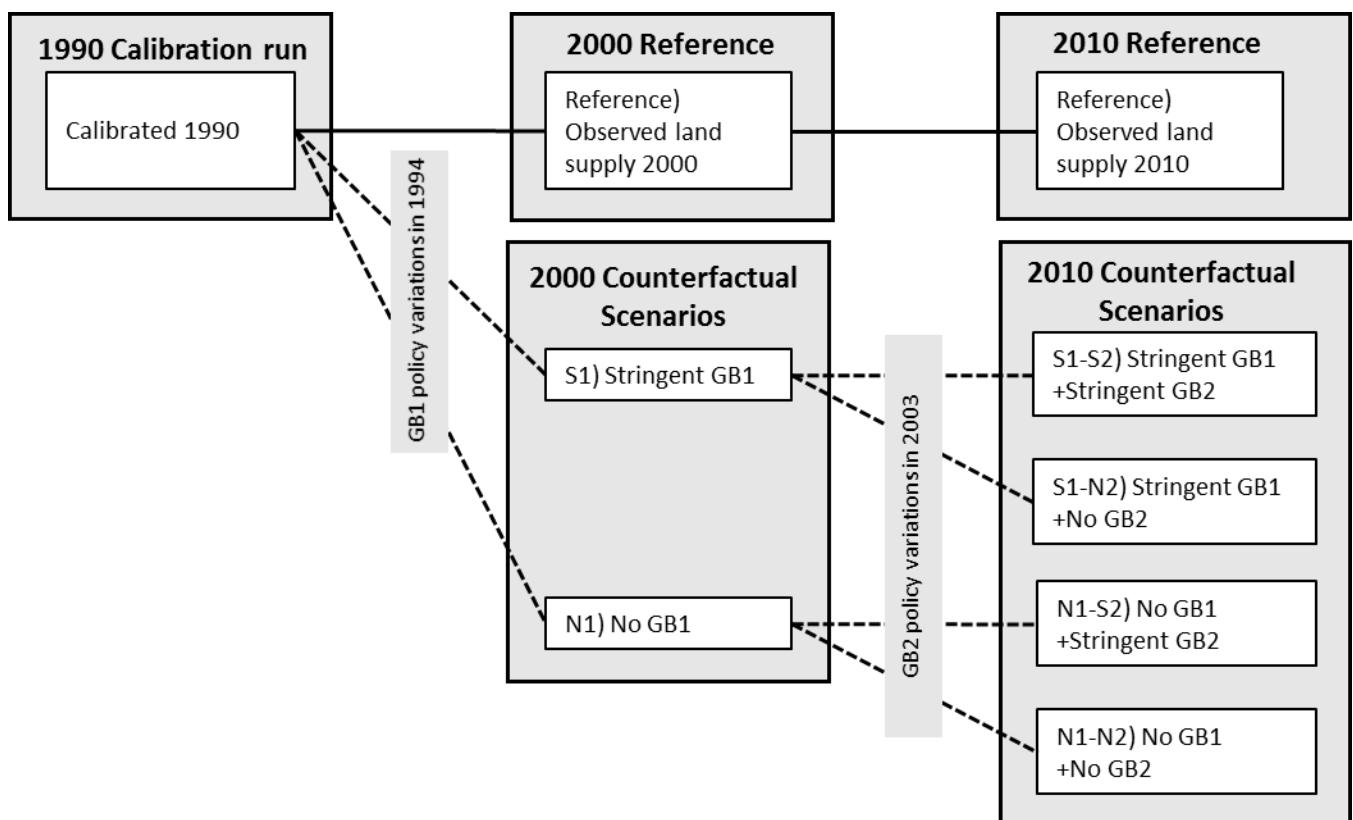
274 towns and villages, or it can be new construction in greenfield land. If the greenfield land is
 275 designated Basic Cultivated Land in Beijing, we assume a new piece of land in the far suburb
 276 with the same land area would be designated as new Basic Cultivate Land in order to conserve
 277 the total amount of Basic Cultivated Land in Beijing. Table 1 lists zone types and land use
 278 variations by scenario. Figure 3 summarises the order of scenario design.

279 Table 1 Zone types and land use variations by scenario

		Number of zones	Scenarios					
			Reference 2000, 2010	S1	N1	S1-S2	S1-N2	N1-S2
Type 1	17	The central city encircled by GB1						
Type 2	20	The planned GB1 area, land use varies according to scenario specifications.	<i>Observed land supply</i>	<i>Fully enforced GB1 control in 2000</i>	<i>No growth enforced GB1 control in 2000</i>	<i>Fully enforced GB1 control in 2010</i>	<i>No growth enforced GB1 control in 2010</i>	<i>No growth control in 2010</i>
Type 3	9	The settlements between the designated GB1 and GB2						
Type 4	23	The planned GB2 area, land use varies according to scenario specifications.	<i>Observed land supply control in 2000</i>	<i>No growth control in 2000</i>	<i>No growth enforced GB2 control in 2000</i>	<i>Fully growth enforced GB2 control in 2010</i>	<i>Fully growth enforced GB2 control in 2010</i>	<i>No growth control in 2010</i>
Type 5	16	The new towns beyond the designated GB2						
Type 6	27	The far suburb						
Type 7	18	The ecological protection area						

280 Apart from revealing the impacts of the existence of greenbelts, the reason for designing the four
 281 scenarios in such an order is to also measure the impacts of two variables associated with
 282 greenbelts: the locations and sizes of the greenbelts. Scenario S1-N2 represents the spatial
 283 structure of a narrow greenbelt implemented right next to the urban built-up area. Scenario N1-

284 S2 represents the spatial structure of a wide greenbelt implemented before the development
 285 actually reaches the urban fringe.
 286 The counterfactual scenarios will be compared with the reference scenarios, namely the 2000
 287 Reference and the 2010 Reference. The References take the observed supply of floorspace from
 288 1990 to 2010 as inputs, while the inputs for the counterfactual scenarios are predicted from the
 289 1990 model subject to the supply of greenbelt-specified floorspace.



290

291

Figure 3 Counterfactual scenarios

292

293 4.3.Scenario inputs

294 The scenarios in the same year have the same demographic settings: the same number of
295 households and jobs, the same family size and income. The model deals with the job-residence
296 location choices of employed residents. For non-employed residents, the model treats them as
297 dependents of employed residents and that they do not make a job-residence location choice.
298 Therefore, in Table 2 the total number of employed residents equals the total number of workers.
299 The total floorspace stocks across scenarios are the same. Differences are represented only in the
300 location of floorspace supply. The conserved total floorspace supplies make the comparisons for
301 rent among scenarios consistent.

302 Table 2 Inputs for year 1990, 2000 and 2010

Year	1990	2000	2010
Total employed residents (thousands)	6271	7116	11805
Total workers (thousands)	6271	7116	11805
Income per person per year (RMB)	3871	8641	22246
Household size (persons per household)	3.20	2.90	2.45
Total housing supply (m ²)	169,723,859	284,832,535	575,393,422
Total business floorspace supply (m ²)	125,420,000	142,331,749	236,824,134

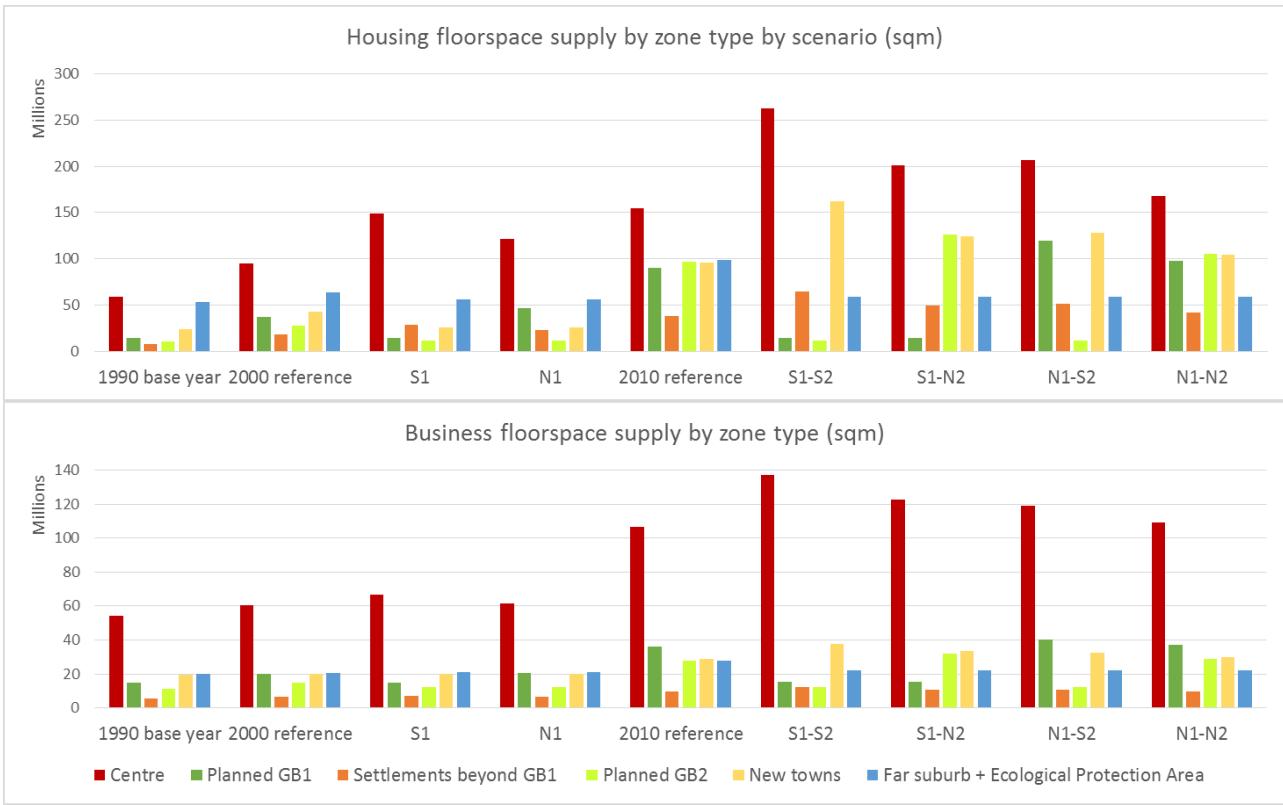
303 In terms of transport, it is assumed that transport conditions remain the same for the same year
304 across scenarios. This is to say that there is no planned transport improvement to support
305 decentralising population beyond the greenbelts. Such an assumption allows us to test if
306 greenbelt policies would work effectively without coordinating transport.

307 For each zone type in each scenario, we define a specific growth rate for business and housing
308 floorspace from base year 1990. For year 2000, Scenario S1 represents a stringent greenbelt plan
309 with intensively developed fringe settlements, which means only 2% growth is allowed in GB1

310 from 1990 to 2000 according to the First Greenbelt policy (Beijing Municipal Government,
311 1994). Scenario N1 represents a “no greenbelt” pattern, in which we deliberately eliminate the
312 growth control in the designated GB1 area. For the rural zones beyond GB1 in both scenarios, a
313 natural growth rate of 5% is applied.

314 Similarly, for year 2010, based on the floorspace supplies from the previous decade, a 2%
315 growth rate from the previous decade is used for the greenbelts in the stringent growth scenarios.
316 For the zones outside GB2, a natural growth rate of 5% is used. Natural growth means the
317 spontaneous expansion through extension of the existing buildings or infilling development in
318 built-up areas. In practice, the enforcement policies for GB1 and GB2 are different in many
319 ways. They have different regulatory approaches to creating greenspaces or preserving existing
320 greenspaces, for example, through reducing the footprint of old village sites or designating
321 statutory No-Construction Areas. However, the model deals with the total amount of floorspace
322 development as a result of enforcement policies, not the process of policy enforcement regarding
323 land area preservation.

324 For the zones which are not specified above, the floorspace increases proportionally according to
325 the stock sizes in the previous decade. In this way the total floorspace stocks are kept identical
326 across scenarios. This proportional distribution reflects development inertia, that is, development
327 is more likely to happen in places that are already partially built-up. Figure 4 reports floorspace
328 inputs.



329

330

331

Figure 4 Floorspace supply by zone type by scenario

332

4.4. Model runs and results

334 The model is calibrated using data from 1990. The main data inputs are estimated quantities of
 335 housing and business floorspace from the research done by Ma and Jin (2015) and the estimated
 336 average morning peak (6.30am-9.30am) travel times and costs by origin-destination zone pairs
 337 from the research done by Deng, Denman, Zachariadis, & Jin (2015). The modelled number of
 338 zonal employed residents and jobs are compared with the observed values to refine parameters
 339 by adjusting the zonal residual E_{fij} in [Equation 4]. After calibration, we input the parameters
 340 and zonal residual attractiveness of the calibrated 1990 model to reproduce the observed zonal

341 employed residents and jobs in 2000 and 2010 for validation purposes. We then use the
342 calibrated parameters and residual attractiveness terms in 1990 to predict the historic-what-if
343 scenarios in year 2000 and 2010. Price levels are all converted to 2010. The model will reveal
344 differences in spatial distributions of residents and jobs, the counterfactual rents, industry
345 productivities and household utilities across scenarios.

346 **4.4.1. Distribution of residents and jobs**

347 Figure 5 reports resident and job distributions across scenarios. We first examine what would
348 happen with a full-realisation of the designated greenbelts, namely comparing Scenario S1 to the
349 2000 Reference, and comparing Scenario S1-S2 to the 2010 Reference. A stringent enforcement
350 of GB1 in 2000 would engender further concentration of population and jobs in the city centre.
351 The establishment of GB2 in 2010 reinforces such effects, as more than 60% of the jobs and
352 residents remain in the city centre in Scenario S1-S2, and 2% more employed residents live
353 beyond GB2 compared to the 2010 Reference. In these alternative runs, transport conditions stay
354 the same as the two reference scenarios. As the greenbelts are not an option to live in, without
355 transport improvement people tend to move inward instead of outward and the city centre
356 becomes more compact.

357 Secondly, we analyse what would happen in the absence of greenbelts, namely comparing
358 Scenario N1 to the 2000 Reference, and comparing Scenario N1-N2 to the 2010 Reference. In
359 both the 2000 Reference and Scenario N1, GB1 contains about 20% of the total population and
360 jobs. In both the 2010 Reference and Scenario N1-N2, the two greenbelts together contain about
361 40% of the total population and jobs. The counterfactual simulations show that without
362 greenbelts, the distribution of employed residents and jobs are not dissimilar to what actually

363 happened. It suggests that the designation of greenbelts in Beijing hardly deterred development
364 during the modelling period 1990 to 2010.

365 The two hybrid scenarios (Scenario S1-N2 and Scenario N1-S2) in 2010 show that different sizes
366 and locations of greenbelts will trigger different spatial distributions of residents and jobs.
367 Scenario S1-N2 represents a smaller greenbelt which is close to the city centre. Consequently,
368 people tend to live beyond GB1, seeking lower rent and bigger properties. Scenario N1-S2
369 represents a wide greenbelt. Consequently, residents spread into GB1 in the near suburb but do
370 not go beyond GB2. It is worth noting that in either case, without improvements in
371 transportation, designated settlements beyond GB1 and new towns beyond GB2 would not
372 become major residence and employment centres.

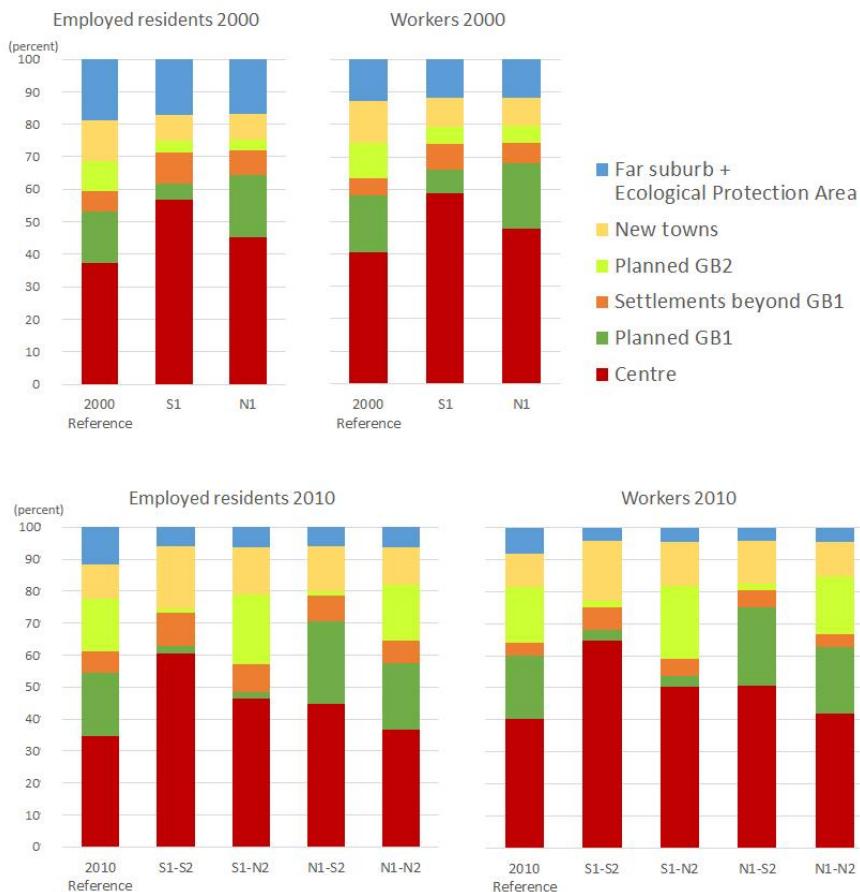


Figure 5 Comparisons among observed and modelled employed residents and workers in 2000 (top) and in 2010 (bottom)

4.4.2. Housing rent

378 Figure 6 shows the rent gradients in different scenarios in 2010. For the no-greenbelt scenario
 379 (Scenario N1-N2), rent levels reflect the direct market effects and drop from the centre to the
 380 suburb. Such a gradient is also observed in the 2010 Reference, which suggests that the
 381 remaining greenbelts did not significantly influence housing rents.

382 The decrease of housing rent in greenbelt areas can be found in the stringent greenbelt scenario,
 383 as well as the hybrid greenbelt scenarios. This can be explained by the modelling mechanism. In
 384 the model, housing rent is determined by housing floorspace supply as a result of the greenbelt

385 intervention and the numbers of residents as housing demand. Land use control has made the
386 greenbelt areas less attractive to urban economic activities, which in turn suppresses demand,
387 and rent decreases. Taking Scenario S1-S2 as an example, if GB1 was fully implemented, the
388 housing floorspace supply in GB1 would only be about 15 million m². Compared to the existing
389 90 million m² housing floorspace in 2010, housing supply in Scenario S1-S2 is 84% less.
390 Meanwhile, the model predicted a decline in the total number of residents in GB1 of 89%
391 compared to the observed number of residents (250 thousand versus 2.3 million). As a result, the
392 rent in GB1 becomes lower than the observed rent in the 2010 Reference, because housing
393 demand decreases more than housing supply.

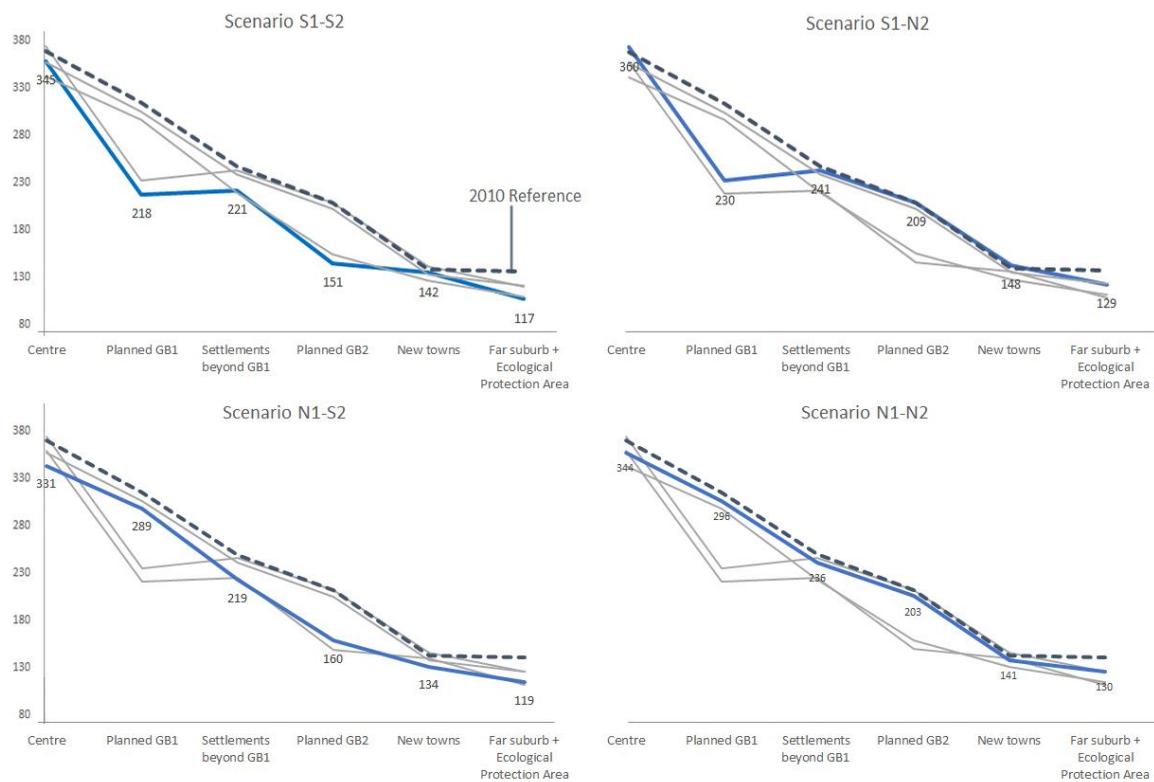
394 On the other hand, it is worth noting that greenbelt areas offer better environmental quality
395 which may attract more people. This amenity value of greenbelts is counted in the residual
396 attractiveness E_{fij} in [Equation 4]. This term is calibrated to match the spatial pattern in 1990
397 and kept constant to 2010. Therefore, any potential increase of amenity value from 1990 to 2010
398 may be underestimated and thus the magnitude of rent decrease in greenbelt zones may be
399 overestimated in 2010.

400 Regarding the city centre, if greenbelts were fully protected, as shown in Scenario S1-S2, more
401 people would live in the city centre. However, rents in our model are not pushed up substantially.
402 According to the same modelling mechanism explained above, this is because the increase of
403 housing supply in the city surpasses the increase of housing demand. The findings suggest that
404 under stringent greenbelt scenarios, counterfactual rents in the centre would stay stable,
405 conditional on the centre being included in the housing supply which would have been built on
406 the greenbelt land. However, in reality, such a floorspace increase is difficult to achieve in

407 Beijing's city centre. This implies that if greenbelts were fully protected and the expected
408 floorspace supply could not be fulfilled, rent in the centre might reach an even higher level.

409

Housing rent in 2010 by scenario by zone type (GBP/year/sqm)



410
411

412

413 4.4.3. Productivity

414 In the model, productivity is represented as the quantity of composite goods and services
415 produced. From the producer's side, it is defined by two factors: the inputs of workers and
416 business floorspace (refer to [Equation 3]). Total production across scenarios is listed in Table 3.
417 Production by zone type in 2010 is reported in Figure 7.

418

Table 3 Production quantities across scenarios

Scenarios	1990	2000 Scenarios			2010 Scenarios				
	Base	Ref	S1	N1	Ref	S1-S2	S1-N2	N1-S2	N1-N2
Total production (million units)	3985	4545	4521	4528	7419	7446	7377	7451	7407

419
420

Production in 2010 by scenario by zone type (million units)

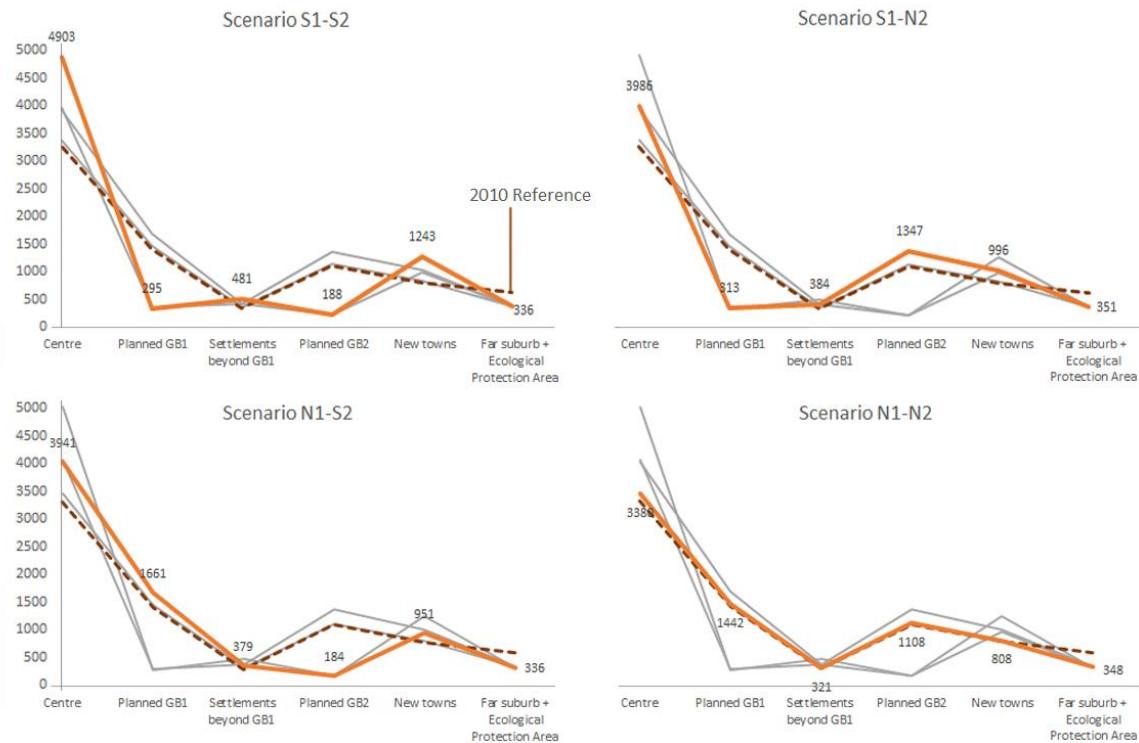


Figure 7 Production in 2010

421
422

423 In 2010, in terms of total production, Scenario S1-N2 has the lowest productivity, while Scenario
 424 N1-S2 has the highest productivity. Apart from Type 2 planned GB1 and Type 4 planned GB2
 425 zones, production elsewhere is of similar quantity. The difference is essentially a trade-off
 426 between the planned GB1 and GB2. Because planned GB1 zones are closer to the centre and
 427 have better transport accessibility, they attract more labour and floorspace inputs than planned
 428 GB2 zones. As a result, planned GB1 in Scenario N1-S2 is more productive than planned GB2 in
 429 Scenario S1-N2, even though it is much a smaller area.

430 **4.4.4. Utility level changes**

431 Household utility is an indicator to measure the overall economic well-being of the household
 432 (refer to [Equation 2] for the components of household utility). As shown in Table 4, the overall
 433 utility levels in reference scenarios increase from 1990 to 2010, because of increases in income.
 434 All of the alternative scenarios reduce utility levels compared to the 2000 Reference and 2010
 435 Reference.

436 Table 4 Utility levels across scenarios

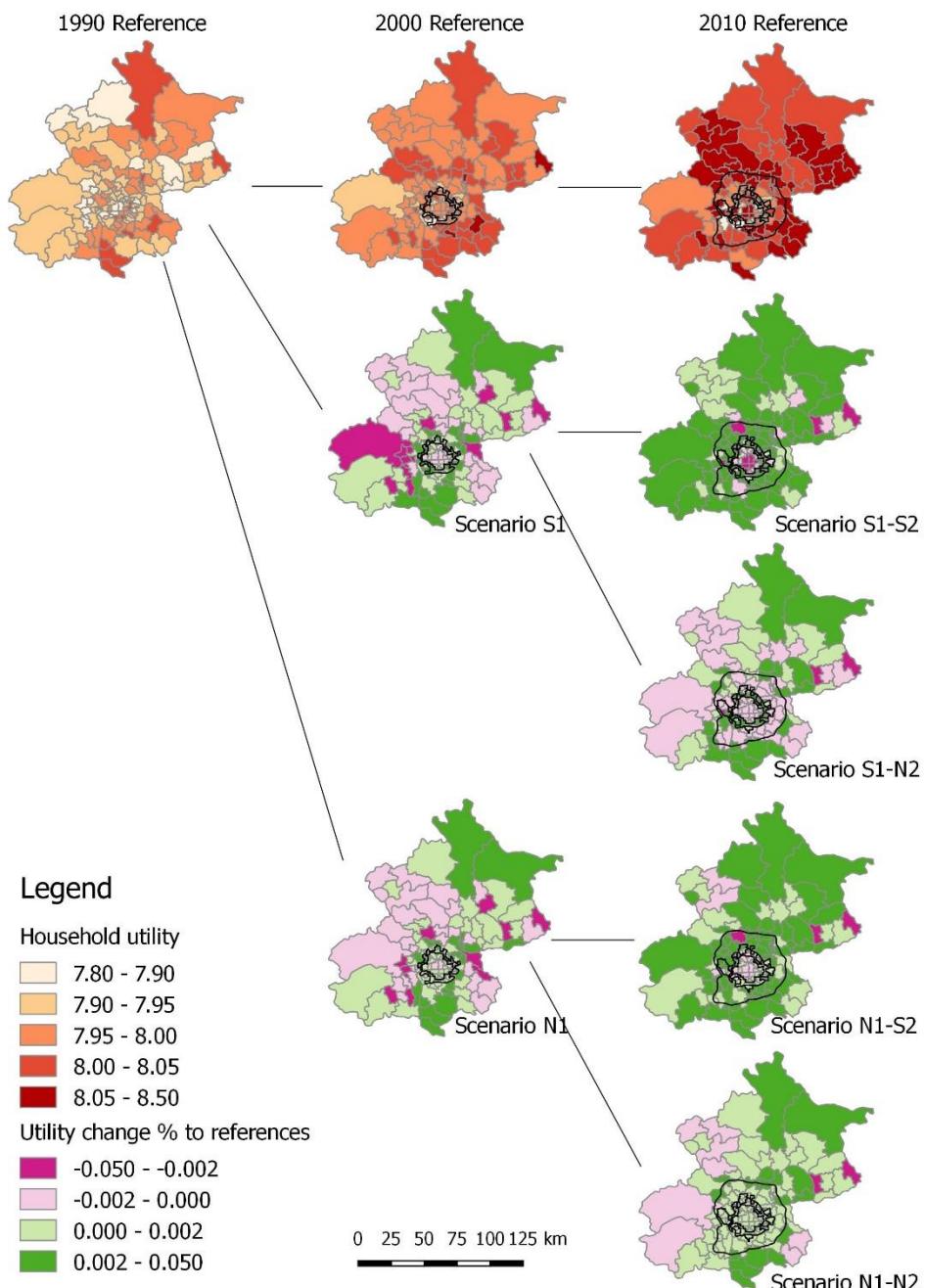
Scenarios	1990 Base	2000 Scenarios			2010 Scenarios				
		Ref	S1	N1	Ref	S1-S2	S1-N2	N1-S2	N1-N2
Average household utility	7.907	7.972	7.972	7.971	7.974	7.968	7.969	7.973	7.973
Consumer surplus as percentage of money income %, compared to References	-	-	-0.4%	-0.3%	-	-2.5%	-2.1%	-0.4%	-0.4%

437

438 Figure 8 presents utility levels spatially. In 2000, if a stringent GB1 is implemented (Scenario
 439 S1), utility in the city centre and new towns will drop while other zones will see a marginal
 440 increase. Households in GB1 will benefit due to lower rent. In 2010, if a stringent GB2 is added
 441 to the stringent GB1 (Scenario S1-S2), most suburban zones will see an increase in household
 442 utility. However, utility in the city centre, where 64% of households reside, decreases further. As
 443 the rent level in the city centre is relatively stable (see Figure 6), drops in utility are mainly
 444 because the labour supply is higher than production demands, so wages drop. If no GB2 is added
 445 to the stringent GB1 (Scenario S1-N2), the overall drop will be 2.1% for Beijing. The small and
 446 stringent GB1 appears to be uneconomic in both scenarios.

447 In 2000, if GB1 is removed (Scenario N1), the demand for housing in the city centre will be
448 relieved and the south of the city centre sees a small increase in utility. In 2010, if a stringent
449 GB2 was put forward without a previous GB1 intervention (Scenario N1-S2), apart from the
450 centre, most zones are better-off. Compared to the single existence of a small greenbelt (Scenario
451 S1-N2), a large one seems to be more appropriate. This is because GB2 does not increase rent in
452 the main city as much as GB1 does and because releasing the constraint from GB1 will increase
453 productivity for the whole city. The last scenario, Scenario N1-N2, is a free-market scenario and
454 causes an overall increase within the GB2 outer boundary. However overall utility is still slightly
455 lower than 2010 Reference.

456



457
458

Figure 8 Household utility among scenarios

459

460 Overall consumer surplus, ΔC , as a household well-being measure, is defined as the change in
461 average household utility divided by the average marginal utility of money (Jin, Y., Echenique,
462 M., & Hargreaves, A. J. 2013).

$$\Delta C = \frac{(\bar{U}_{Alternative} - \bar{U}_{Reference})}{\frac{1}{2} \left(\frac{1}{\bar{\Omega}_{Alternative}} + \frac{1}{\bar{\Omega}_{Reference}} \right)}$$

[Equation 6]

463 $\bar{U}_{Reference}$ and $\bar{U}_{Alternative}$ are the average household utilities; $\bar{\Omega}_{Reference}$ and $\bar{\Omega}_{Alternative}$ are
464 the average household incomes for the reference and alternative scenarios, respectively. Using
465 Equation 6, we convert the utility change into consumer surplus at 2010 price level. The decrease
466 of consumer surplus in Scenario S1-S2 is the largest. With two fully-enforced stringent
467 greenbelts in 2010, consumer surplus would drop by \$202 million per year for the city. Better
468 options would be Scenario N1-N2, which is the free market scenario, and Scenario N1-S2 which
469 is the wide greenbelt scenario. Compared to the Reference 2010, both scenarios would still drop
470 consumer surplus by \$31 million for Beijing. Although the decreases in consumer surplus are
471 similar in the two scenarios, compared to Scenario N1-N2, Scenario N1-S2 preserves more
472 greenfield land for Beijing. If transport conditions from the centre to new towns are improved in
473 Scenario N1-S2, the overcrowding issue in the city centre might be resolved. In that case, we
474 would need to test the potential of a wide greenbelt in improving the overall utility level given
475 different transport inputs into the model.

476 5. Discussions and conclusions

477 5.1.Policy implications

478 Firstly, the modelling results show that if there had been fully-enforced greenbelts, economic
479 well-being would decrease. This indicates that the planned greenbelts would bring some negative
480 economic impacts to the city, including decreasing productivity, decreasing household utility,
481 and concentrating residents in the expensive city centre. The effects of increasing population and
482 employment density in the city centre were also found in research done by Bae and Jun (2003)
483 and other studies. For example, Hall (1974) and Evans and Hartwich (2006) found that London's
484 greenbelt increased population density in the main city which pushed housing prices up.

485 The reasons for the concentration in the city centre in Beijing are 1) there is no transport
486 improvement from the centre to the suburb, 2) in the model, we did not limit floorspace
487 development in the centre, so more business and residents are attracted to locate there, and 3)
488 amenity values of greenbelts stayed constant from 1990 to 2010. As the city centre became more
489 crowded, the model did not assume that greenbelt areas became more attractive due to the
490 amenities it generated, so it did not encourage residents to move to the suburban area. The fully-
491 enforced greenbelt plans assumed that housing and business floorspace would need to increase
492 by 50% in the city centre to accommodate the increasing demands from households and business
493 activities. This is very hard for the already overcrowded centre in Beijing. On the other hand, we
494 would like to point out that a full-realisation of greenbelts would provide environmental benefits,
495 but this model currently does not compare overall benefits to costs. Instead, the findings indicate
496 that the potential negative economic impacts from the planned greenbelts may have hindered the

497 policy's implementation. An integrated assessment from both environmental and economic
498 perspectives is recommended in future policy design.

499 Secondly, the modelling results show that if there had been no greenbelts, the spatial distribution
500 of residents, jobs, rents and productivity would not change too much from what it was in 2010.
501 This indicates that the implemented greenbelts did not perform effectively in urban containment.
502 No-greenbelt scenarios reduce the floorspace demand in the main city and utility levels see a
503 small increase in 2010. However, the overall consumer surplus for the whole municipality will
504 still decrease by 0.4% in 2010. The spatial distribution of economic activities will be more
505 dispersed and more greenbelt land will be developed.

506 In terms of size, Scenario S1-N2 shows that a small and narrow greenbelt does not fulfil the aim
507 of urban containment, as people can easily cross it and build beyond the small greenbelt.
508 Scenario N1-S2 shows that a large and wide greenbelt performs better in containing population
509 and jobs within the designated greenbelt boundary. This finding is different from the findings in
510 Bae and Jun (2003) and Freestone (2002), as their research has shown that the greenbelts
511 decentralised population to places beyond the greenbelts while confining jobs in the city centre,
512 which caused a jobs-housing imbalance. The situation in Beijing is different, because without
513 transport improvements, economic activities would not be diverted to new towns easily and a
514 wide greenbelt would still cause overconcentration in the main city.

515 In terms of location, modelling results suggest a greenbelt should be placed at a distance from
516 the urban built-up edge to give development a buffer area to contain future growth. Scenario S1-
517 N2 shows that a greenbelt right next to the immediate urban built-up boundary is harmful. Such
518 an area is normally productive and could have been used to enhance the productivity of the city.

519 Such an immediate greenbelt would cause a substantial decrease in consumer surplus. On the
520 contrary, Scenario N1-S2 shows that a greenbelt which gives a development buffer zone in
521 advance performs better in terms of consumer's well-being.

522 The modelling results show that greenbelt interventions could greatly affect household welfare
523 and impact the economic performance of Beijing. Although existing studies have proved
524 environmental benefits from greenbelts (Carter-whitney & Esakin, 2010; Han & Long, 2010; J.
525 Yang & Zhou, 2007), findings from this paper show that some negative economic impacts may
526 have largely impeded policy implementation. As the urban expansion of Beijing sped up after
527 2010, the greenbelt implementations are under even greater pressure, and stringent greenbelt
528 policies are unlikely to be suitable. Meanwhile, no-greenbelt intervention is not beneficial either,
529 as it decreases greenspaces in Beijing while economic well-being is not improved.

530 We suggest that when revising current greenbelt plans and designating future greenbelts, sites
531 with good transport conditions in the designated greenbelt, if not ecologically sensitive, could be
532 allowed for development, while the implications for environment and natural ecology should be
533 carefully assessed alongside the development plan. Meanwhile, to fulfil the aim of relieving the
534 overconcentration in the city centre and redistributing populations to new towns, it is crucial to
535 improve the transport connections between the city and new towns, so that the in-between
536 greenfield land around the city can be preserved more effectively and greenbelt policies
537 implemented more smoothly.

538 5.2.Intellectual contributions and future work

539 This counterfactual model offers a tool to measure the potential economic costs and benefits
540 between alternative propositions. It quantifies the impacts of greenbelts through three cross-
541 sections over two decades. Compared to independent cross-sectional predictions, the recursive
542 modelling structure is capable of showing the effects of chronic and large scale land use changes.
543 A temporal dimension enables it to reveal the growth inertia and path dependency of greenbelt
544 evolution from the previous decade.

545 The ultimate aim of this model is to answer what-if questions about future greenbelt policy
546 interventions. However, it is necessary to have an often omitted stage of reviewing and
547 understanding the historic performances of a certain policy. Such revisions not only provide
548 insight into future policy design, but also provide a better understanding of the model's
549 prediction capability and validity. This is carried out here through reproducing the reference
550 scenarios of 2000 and 2010 under a calibrated 1990 model. A validated model gives a stronger
551 platform for testing real-world scenarios. Furthermore, compared to what-if tests of future
552 scenarios, the historic-what-if tests are simpler to analyse, because such tests are free of the
553 uncertainties in background trend assumptions, and they are run under better controlled
554 conditions. It is therefore a logical step towards building valid prediction models for future
555 scenarios.

556 The spatial equilibrium model presented in this paper is a parsimonious model that reveals the
557 basic interactions among the labour market, housing market and product market with a fairly
558 small number of easy-to-interpret parameters. The model can be extended to reflect the more

559 precise socio-economic, land use and transport context of Beijing in greater granularity. The
560 amenity value of greenbelts can be better captured under smaller geographical zones as well.
561 Moreover, the model does not develop a platform for comparing overall costs (including
562 economic costs and other potential costs) with overall benefits (including environmental benefits
563 and other potential benefits) of greenbelts. In the future, the model can interface with other
564 models that are specialised in quantifying environmental impacts to generate a more complete
565 picture to assist decision making.

References

- Adkin, K. (2009). *India's garden city? Bangalore's disappearing greenbelt: green to gone. Master degree thesis, University of Delaware.*
- Amati, M. (2005). *A study on the planning processes and future directions of the London Green Belt An investigation of local level planning.* University of Tsukuba.
- Amati, M. (2008). Green Belts : A Twentieth-century Planning Experiment. In M. Amati (Ed.), *Urban green belts in the twenty-first century* (pp. 1–17). New York: Routledge.
- Amati, M., & Yokohari, M. (2006). Temporal changes and local variations in the functions of London's green belt. *Landscape and Urban Planning*, 75(1–2), 125–142.
<http://doi.org/10.1016/j.landurbplan.2004.12.007>
- Anas, A., & Liu, Y. (2007). A Regional Economy, Land Use, and Transportation Model (Relu-Tran): Formulation, Algorithm Design, and Testing. *Journal of Regional Science*, 47(3), 415–455. <http://doi.org/10.1111/j.1467-9787.2007.00515.x>
- Anas, A., & Rhee, H.-J. (2006). Curbing excess sprawl with congestion tolls and urban boundaries. *Regional Science and Urban Economics*, 36(4), 510–541.
<http://doi.org/10.1016/j.regsciurbeco.2006.03.003>
- Bae, C.-H. C., & Jun, M.-J. (2003). Counterfactual Planning: What if there had been No Greenbelt in Seoul? *Journal of Planning Education and Research*.
<http://doi.org/10.1177/0739456X03022004004>
- Beijing Municipal Government. [1994] No 7 The Approval from Beijing Municipal Government on the Proposal from Beijing Municipal Commission Regarding Designation of the Greenbelt, Pub. L. No. jingzhengfa(1994)7 (1994). China.
- Beijing Municipal Government. [2003] No 7 The Approval from Beijing Municipal Government on the Proposal of Establishing the Second Greenbelt, Pub. L. No. Jingzhenghan(2003)7 (2003). China.
- Buxton, M., & Goodman, R. (2003). Protecting Melbourne's Green Belt. *Urban Policy and Research*, 21(2), 205–209. <http://doi.org/10.1080/0811140309954>
- Carter-whitney, M., & Esakin, T. C. (2010). *Ontario 's Greenbelt in an International Context.* The Canadian Institute for Environmental Law and Policy.
- Deng, B., Denman, S., Zachariadis, V., & Jin, Y. (2015). Estimating traffic delays and network speeds from low-frequency GPS taxi traces for urban transport modelling. *European Journal of Transport and Infrastructure Research*, 15(4), 639–661.

- Evans, A. W., & Hartwich, O. M. (2006). *Better Homes, Greener Cities*. London: Policy Exchange.
- Fogel, R. (1964). *Railroads and American Economic Growth: Essays in Econometric History*.
- Freestone, R. (2002). Greenbelts in city and regional planning. In K. c. Parsons & D. Schuyler (Eds.), *From garden city to green city: the legacy of Ebenezer Howard* (pp. 67–98). Baltimore and London: The Johns Hopkins University Press.
- Gan, L. (2012). Analyses of the effects of Beijing's greenbelts based on remote sensing images. *Beijing Planning Review*, (5), 37–40.
- Hall, P. (1974). The Containment of Urban England. *The Geographical Journal*, 140(3), 386–408.
- Han, H., & Long, Y. (2010). Research on the effects of the first greenbelt in Beijing. *Beijing Planning Review*, 3, 59–63.
- Jin, Y., & Echenique, M. (2012). Employment location modelling within an integrated land use and transport framework: taking cue from policy perspectives. In *Advances in Spatial Science* (pp. 133–158). Springer, Heidelberg. <http://doi.org/10.1007/978-3-642-31779-8>
- Jin, Y., Echenique, M., & Hargreaves, A. J. (2013). A recursive spatial equilibrium model for planning large-scale urban change. *Environment and Planning B: Planning and Design*, 40(6), 1027–1050. <http://doi.org/10.1068/b39134>
- Jun, M.-J. (2011). The effects of Seoul's greenbelt on the spatial distribution of population and employment, and on the real estate market. *The Annals of Regional Science*, 49(3), 619–642. <http://doi.org/10.1007/s00168-011-0461-5>
- Kim, J., & Kim, T. (2008). Issues with Green Belt Reform in the Seoul Metropolitan Area. In M. Amati (Ed.), *Urban green belts in the twenty-first century* (pp. 37–57). New York: Routledge.
- Lee, C.-M. (1999). An Intertemporal Efficiency Test of a Greenbelt: Assessing the Economic Impacts of Seoul's Greenbelt. *Journal of Planning Education and Research*, 19(1), 41–52. <http://doi.org/10.1177/0739456X9901900104>
- Long, Y., Gu, Y., & Han, H. (2012). Spatiotemporal heterogeneity of urban planning implementation effectiveness: Evidence from five urban master plans of Beijing. *Landscape and Urban Planning*, 108(2–4), 103–111. <http://doi.org/10.1016/j.landurbplan.2012.08.005>
- Ma, M., & Jin, Y. (2014). Understanding Beijing's Moving Urban Fringe through a Spatial Equilibrium Model. *International Review for Spatial Planning and Sustainable Development*, 2(2), 14–38. http://doi.org/10.14246/irspsd.2.2_14

- Ma, M., & Jin, Y. (2015). Alternative Configurations of Beijing ' s Greenbelt : New Insights from a Recursive Spatial Equilibrium Model. In *14th International Conference on Computers in Urban Planning and Urban Management*.
- Ma, M., & Jin, Y. (2016). Does built form matter in a moving urban fringe ? Evidence from a Land Use-Transport Interaction (LUTI) model. In *56th European Regional Science Association Congress*.
- MacRaild, D. M., & Black, J. (2007). *Studying History*. Palgrave Macmillan.
http://doi.org/10.1007/978-1-349-14396-2_6
- McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In *Frontiers in Econometrics* (pp. 105–142). Academic Press: New York.
- Nelson, A. C. (1999). Comparing states with and without growth management analysis based on indicators with policy implications comment. *Land Use Policy*, 16, 121–127.
[http://doi.org/10.1016/S0264-8377\(00\)00034-X](http://doi.org/10.1016/S0264-8377(00)00034-X)
- Okata, J., & Murayama, A. (2011). Tokyo ' s Urban Growth , Urban Form and Sustainability. In A. Sorensen & J. Okata (Eds.), *Megacities: Urban Form, Governance, and Sustainability* (pp. 15–41). Heidelberg: Springer. http://doi.org/10.1007/978-4-431-99267-7_2
- Siedentop, S., Fina, S., & Krehl, A. (2016). Greenbelts in Germany's regional plans-An effective growth management policy? *Landscape and Urban Planning*, 145, 71–82.
<http://doi.org/10.1016/j.landurbplan.2015.09.002>
- Tan, Q. (2008). *Investigation and Exploration of Beijing Green Belt Planning - A Case Study of Sijiqing Township*. Master Degree Thesis, Tsinghua University.
- Tang, B. S., Wong, S. W., & Lee, A. K. W. (2007). Green belt in a compact city: A zone for conservation or transition? *Landscape and Urban Planning*, 79(3–4), 358–373.
<http://doi.org/10.1016/j.landurbplan.2006.04.006>
- Wang, K. (2015). Beijing-Tianjin-Hebei Coordinating Development Under New Normality. In *Conference proceedings of China Annual National Planning Conference 2015*. Beijing, China.
- Woo, M., & Guldmann, J.-M. (2011). Impacts of Urban Containment Policies on the Spatial Structure of US Metropolitan Areas. *Urban Studies*, 48(16), 3511–3536.
<http://doi.org/10.1177/0042098011399594>
- Yang, J., & Zhou, J. (2007). The failure and success of greenbelt program in Beijing. *Urban Forestry and Urban Greening*, 6, 287–296. <http://doi.org/10.1016/j.ufug.2007.02.001>
- Yang, X. (2008). *Research of Beijing's Greenbelt Policy: History Review, Implementation and*

Problems. Tsinghua University.

Yokohari, M., Takeuchi, K., Watanabe, T., & Yokota, S. (2000). Beyond greenbelts and zoning: A new planning concept for the environment of asian mega-cities. *Landscape and Urban Planning*, 47, 159–171. http://doi.org/10.1007/978-0-387-73412-5_50

Zhang, Y. (2007). Comments on the Planning and Implementation of the Second Greenbelt. *Beijing Planning Review*, (6), 90–93.

List of Tables

Table 1 Zone types and land use variations by scenario

Table 2 Inputs for year 1990, 2000 and 2010

Table 3 Production quantities across scenarios

Table 4 Utility levels across scenarios

Table 1 Zone types and land use variations by scenario

Number of zones		Scenarios						
		Reference 2000, 2010	S1	N1	S1-S2	S1-N2	N1-S2	N1-N2
Type 1	17	The central city encircled by GB1						
Type 2	20	The planned GB1 area, land use varies according to scenario specifications.	<i>Observed land supply</i>	<i>Fully enforced GB1 control</i>	<i>No growth GB1 control in 2000</i>	<i>Fully enforced GB1 control</i>	<i>No growth control in 2010</i>	<i>No growth control in 2010</i>
Type 3	9	The settlements between the designated GB1 and GB2						
Type 4	23	The planned GB2 area, land use varies according to scenario specifications.	<i>Observed land supply</i>	<i>No growth control in 2000</i>	<i>No growth control in 2000</i>	<i>Fully enforced GB2 control in 2000</i>	<i>No growth control in 2010</i>	<i>Fully enforced GB2 control in 2010</i>
Type 5	16	The new towns beyond the designated GB2						
Type 6	27	The far suburb						
Type 7	18	The ecological protection area						

Table 2 Inputs for year 1990, 2000 and 2010

Year	1990	2000	2010
Total employed residents (thousands)	6271	7116	11805
Total workers (thousands)	6271	7116	11805
Income per person per year (RMB)	3871	8641	22246
Household size (persons per household)	3.20	2.90	2.45
Total housing supply (m ²)	169,723,859	284,832,535	575,393,422
Total business floorspace supply (m ²)	125,420,000	142,331,749	236,824,134

Table 3 Production quantities across scenarios

Scenarios	Base	2000 Scenarios			2010 Scenarios				
		Ref	S1	N1	Ref	S1-S2	S1-N2	N1-S2	N1-N2
Total production (million units)	3985	4545	4521	4528	7419	7446	7377	7451	7407

Table 4 Utility levels across scenarios

Scenarios	Base	2000 Scenarios			2010 Scenarios				
		Ref	S1	N1	Ref	S1-S2	S1-N2	N1-S2	N1-N2
Average household utility	7.907	7.972	7.972	7.971	7.974	7.968	7.969	7.973	7.973
Consumer surplus as percentage of money income %, compared to References	-	-	-0.4%	-0.3%	-	-2.5%	-2.1%	-0.4%	-0.4%