Urbanization on the Mongolian Plateau after economic reform: Changes and causes

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ABSTRACT
In response to changes in human and natural environments over the past three decades, transitional countries have experienced dramatic urbanization. In the context of socioeconomic and biophysical changes, our knowledge on these urbanization processes remains limited. Here, we used the Mongolian Plateau (i.e., Inner Mongolia (IM) and Mongolia (MG)) as a testbed and applied the coupled natural and human (CNH) concept to understand the processes and causes of urbanization. We selected six cities on the Mongolian Plateau, classified their urban built-up areas using Geographic Object-Based Image Analysis (GEOBIA) from 1990 through 2015, and examined the driving forces of urbanization (i.e., economy, social goods, and environmental variables) through Partial Least Squares Structural Equation Modeling (PLS-SEM). We found that the spatial characteristics of urbanization in IM and MG have both similarities and differences. The cities in IM and MG have experienced rapid urban expansion, with urban areas increasing by 4.36 times and 3.12 times, respectively, since 1990. Cities in IM, however, were less dense and more sprawling whereas cities in MG were linearly aggregated. We also found through PLS-SEM that multiple driving forces affected urbanization in IM and MG during the transitional period. Results (path coef.) demonstrated that economic development (0.559) is a major driver for urbanization in IM, whereas social goods (0.646) and economic development (0.433) strongly influence urbanization in MG. These differences are likely due to the divergent governmental roles in urban development and in infrastructure/social support, as well as the differing economic structures in IM and MG.

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1. Introduction

Urbanization is an adaptation of human society to socioeconomic and biophysical changes (Schneider & Woodcock, 2008; Seto, Sanchez-Rodriguez, & Fragkias, 2010). Since similarities between spatial extent and growth rates alone do not imply that the causes of urbanization are the same (Lambin & Meyfroidt, 2010; Seto et al., 2010), identifying the driving forces of urbanization is crucial to understanding the real urbanization mechanism. Consequently, an increasing number of studies have aimed to investigate these driving forces, and have suggested that urbanization has been mainly driven by geographical factors (e.g., slope and elevation), altered socioeconomic status (e.g., GDP and population), and land use policy (Liu, Zhan, & Deng, 2005; Seto & Kaufmann, 2003; Tian, Chen, & Yu, 2014; Zhang, Su, Xiao, Jiang, & Wu, 2013). There is, however, little understanding on how different socioeconomic and biophysical driving forces interactively influence urbanization.

Most cities in transitional economies have faced abrupt transformations in their economic and industrial structures over a relatively short period compared to cities in the global north (Kamata, Reichert, Tsevegmid, Kim, & Sedgewick, 2010; UN-Habitat, 2003). As Ma (2002) and Wu (2003) explained, cities in transitional economies have transformed into gateways, allowing marketization and globalization to develop a new economy. Unlike cities under a socialist regime that have suppressed consumption by regulating low wages and limiting markets, the cities in transitional economies have become highly marketized (Davis, 2000). This transformation consequently led to rapid urban growth. Economic growth and increased non-agricultural activities during the transitional period, particularly in China, are major driving forces...
for urbanization (Bai, Shi, & Liu, 2014; Fan, Xie, Qi, Chen, & Huang, 2014; He, Huang, & Wang, 2014; Li, Wei, Liao, & Huang, 2015). In the former Soviet countries, growth of the tertiary industry and job availability have also had a significant impact on urbanization (Molodikova & Makhrova, 2007; Rudolph & Brade, 2005; Tammaru, Kulu, & Kask, 2004).

While many previous studies have empirically explored the driving forces of urbanization in transitional economies as mentioned above, further insight can be gained if we consider the process of urbanization as an evolving coupled natural and human (CNH) system. In this regard, we employ the CNH concept (Alberti et al., 2011; Chen & Liu, 2014; Liu et al., 2007) as a framework to incorporate the socioeconomic and biophysical driving forces, thus increasing our knowledge on urbanization process. Changes in transitional economies not only transform economic structures and remove governmental controls, but also transform the entire CNH system with emerging properties (McMillan & Naughton, 1992; Roose, Kull, Gauk, & Tali, 2013). This framework will help to advance our understanding of the urbanization process and its implications for future urban sustainability (Xu & Wu, 2016).

We use the Mongolian Plateau (MGP) to comprehend the underlining mechanisms for urbanization in transitional economies. In this region, both Inner Mongolia (IM) and Mongolia (MG) have experienced economic reform and democratic liberalization. Historically, Mongolians were nomads due to limited natural resources (Fernandez-Gimenez, Batjav, & Baival, 2012), and held this traditional pastoral nomad lifestyle until 1990. During the last three decades, however, the collapse of the Soviet Union and the economic liberalization of China have brought dramatic changes to environmental and socioeconomic conditions that led to drastic increases in the urban population in MGP (Fan, Chen, & John, 2016; John, Chen, Lu, & Wilske, 2009). These changes can be illustrated in several dimensions. The responsibility of social good provision has transferred from central government to the individual (e.g., education and healthcare), income gaps between urban and rural areas have enlarged, and new grassland management policies have further accelerated urbanization (Chen, John, Zhang, et al., 2015; Endicott, 2012; Fernandez-Gimenez & Batbuyan, 2004; Wu, Zhang, Li, & Liang, 2015).

By using the MGP as a test bed, we synthesized the economic conditions, social goods, and natural environments, explored the spatiotemporal dynamics of urbanization, and quantified the impacts from socioeconomic and biophysical drivers within a CNH framework to comprehend the process of urbanization. Our primary research questions are: (1) How have spatiotemporal patterns of urbanization changed over the past three decades in IM and MG? (2) What were the major drivers of urban expansion in the Mongolian Plateau from 1990 through 2015? (3) What different relationships did IM and MG experience between urbanization, socioeconomic and biophysical factors? To address these questions, we conducted a spatial analysis with remote sensing images and used structural equation modeling (SEM) to investigate the urbanization process and its driving forces in IM and MG. This comparative analysis will enhance our understanding of the urbanization in transitional economies while considering different socioeconomic and institutional settings.

2. Study area, data, and methods

2.1. Study area

The MGP has experienced dramatic changes in its socioeconomic circumstances and in its relationship with the natural environment over the past three decades. Once collective farms and shareholding companies lost their competitiveness in the emerging market and the state safety net disappeared, jobs were diversified into many different sectors (Endicott, 2012). Major responsibility for employment, education, and health services were transferred from the state to private sectors and individuals. Despite the rapid economic growth during the transitional period, wealth concentrated in the cities of both IM and MG, which enlarged the income gap between urban and rural areas (Liu, Rao, Evans, Chen, & Hsiao, 2001). As a result, urban migration is considered a response to the relative deprivation of income and social goods (Gilbert & Gugler, 1992).

Several research teams (Chan & Zhang, 1999; Fan, 1999; Knight & Song, 1999; Zhao, 1999) have empirically examined the importance of jobs and education to the internal migration within China. Shifting economies on the MGP also affected the environment, as massive changes due to new anthropogenic disturbances arose. New land use policies took effect, including the Grassland Law (1985) and the Household Contract Responsibility Systems (1983) in IM, as well as the Law on Land (1994) in MG. These policies transferred the responsibility for grassland management from communities to individual households (Endicott, 2012; Fernandez-Gimenez & Batbuyan, 2004; Wu et al., 2015).

Consequently, accelerated overgrazing and environmental degradation was seen across the plateau (Brown et al., 2013; John et al., 2016; Liu et al., 2013; Ojima & Chuluun, 2008; Shao, Li, Dong, & Chen, 2016). Furthermore, growing mining industries have negatively influenced both the vegetation cover and the biophysical health of ecosystems (Qian, Bagan, Kinoshita, & Yamagata, 2014; Stubblefield et al., 2005).

We examined a total of six cities—three in IM and three in MG—that have experienced rapid urban and economic growth and shared a similar biome (i.e., temperate grassland) (Fig. 1). These cities were selected because they are either a capital, mining center, or transportation hub. This promotes comparability between cities, as the process of urban growth and its spatial arrangements depend on city characteristics and regional roles (Antrop, 2004; Kunzmann & Wegener, 1991). Furthermore, these cities are likely to be regional hubs for urban development in the future due to their importance as capital cities in both regions, the rising role of the mining sector in economic development, and due to the strategic location of their transportation routes. These cities are: Hohhot (40°49′N, 111°39′E), Baotou (40°39′N, 109°50′E), and Ulanqab (41°00′N, 113°08′E) of IM, and Ulaanbaatar (47°55′N, 106°55′E), Erdenet (49°01′40″N, 104°02′40″E), and DARKHAN (49°28′08″N, 105°57′27″E) of MG. Hohhot and Ulaanbaatar have experienced dramatic urbanization as the capital cities of IM and MG, respectively (Fan, Chen, & John, 2016). Hohhot, located in the southern center of IM, is a major industrial center and the home of one of China’s largest dairy producers. As an economic center and a participant in the Western Development Project in China, Hohhot has experienced rapid urbanization. Ulaanbaatar of MG is located near the center of the country and serves as the capital. It is an industrial, political, and cultural hub and has experienced a huge amount of urban migration since 1990. Baotou in IM and Erdenet in MG are industrial cities based on the mining industry. Baotou is the largest industrial city in IM and the home to the world’s largest rare earth mine (i.e., the Bayan-Obo mining district). Erdenet is located in the northern part of MG and was established in 1974 after large deposits of copper were discovered nearby. The city possesses the fourth largest copper mine in the world. Ulanqab in IM and Darkhan in MG are transportation hubs that connect their provinces to the country border. Ulanqab, located in the center of IM, connects MG and Hebei Province. The city lies at the intersection of the railway and the Chinese National Highway 208 and 110. Darkhan, Mongolian for “Blacksmith”, was built by the Soviet Union in 1961 as a manufacturing base on the Trans-Mongolian Railroad. It continues to play an important role as a transportation hub connecting Russia and Mongolia.
2.2. Urban land data processing: GEOBIA classification

Given the limited amount of socioeconomic data for MG prior to 1990 and the rapid urbanization following the collapse of the Soviet Union, we chose to study the period from 1990 to 2015. We extracted impervious areas from remotely-sensed images (i.e., 36 different Landsat images from 1990 through 2015, with 5-year intervals) to assess the urban expansion of the six representative cities in IM and MG. We performed two major pre-processing tasks for the images, i.e., Landsat radiometric calibration and Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH), using ENVI 5.1™ software. For the atmospheric correction, we assigned sub-arctic summer (SAS) and mid-latitude summer (MLS) for MG and IM, respectively, based on the MODTRAN standard (ITT, 2009).

Due to the complexity of urban features, Geographic Object-Based Image Analysis (GEOBIA), which classifies images based on spectral, geometric, and textual homogeneity, is a suitable tool to extract urban built-up areas rather than pixel-based classification (Hay & Blaschke, 2010). We first derived water and vegetation cover types from the images through multi-resolution segmentation with certain parameters (100 scale, 0.3 shape, and 0.5 compactness), which were derived empirically through iterative testing of the algorithm parameters. We selected 50 samples to develop functions in fuzzy classification. To extract water and vegetation cover, we re-segmented the rest of the area at a small-scale (50 scale) to delineate the urban features through fuzzy classification. Finally, we modified the classification results using visual interpretation to compare them with Google Earth and ground truth (photos taken by authors) to enhance the quality of the classifications. These procedures allowed us to effectively partition the built-up areas from bare soil and agricultural land. Through randomly selecting 50 polygons in a Test and Training Area (TTA) mask module in eCognition, we were able to confirm a sufficient level of overall accuracy (ranging from 0.78 to 0.98) for all images.

2.3. Measuring urbanization

Urbanization can be described as horizontal, vertical, or scattered expansion (Jiang, Liu, Yuan, & Zhang, 2007; Sevtsuk & Amindarbari, 2012). We assessed the degree of urbanization by examining total built-up area, net urban population density, and the scattered pattern of the urban patch from classified images to compare expansion, density, and discontiguity. We employed a discontiguity index (Sevtsuk & Amindarbari, 2012) for scattered expansion (i.e. leapfrog development). Because urban expansion does not always happen at the edge of cities, leapfrog development may indicate that a new regulation on land-use, affordability of land, and transportation costs. To calculate discontinuous growth, we used:

\[
\text{Discontiguity} = \sum_{n=1}^{N} \left( \frac{\sum_{i=0}^{N-1} A_i}{A_n} \right) \left( \frac{\sum_{i=0}^{N-1} A_i}{A_{total}} \right)
\]

Fig. 1. Location of the selected cities in IM and MG. The cities are selected by their urban characteristics in regards to their regional roles with similar ecological settings.
where $A_{\text{total}}$ is total built-up area ($\text{km}^2$), $A_n$ is the area of cluster $n$, and $n$ is the number of clusters.

### 2.4. Driving forces of urbanization

Given that urbanization is a result of compound processes, we employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to quantify the importance of socioeconomic and biophysical drivers on urbanization. PLS-SEM is a modeling approach used to employ the concept of Structural Equation Modeling (SEM) for non-normally distributed data (Hair, Hult, Ringle, & Sarstedt, 2013). PLS-SEM is more applicable to exploratory research with small samples compared to the Covariance-Based SEM (CB-SEM) (Hair et al., 2013). Bootstrapping analysis in the PLS-SEM setting can be used to test the stability of the estimated model parameters (Chin, 2010). In addition, PLS-SEM has a strong ability to identify the key model driver (Fan, Chin, Shirkey, et al., 2016; Hair, Ringle, & Sarstedt, 2011).

Defining ‘urban’ or ‘urbanization’ is challenging as their definitions vary from country to country. For example, urban area may be defined through different measures such as administrative boundaries, size and level of social services, or population density (Saksena et al., 2014). Because our primary goal is to understand the processes of urbanization between IM and MG, we used the total built-up area within the administrative boundaries, a widely acknowledged indicator, as our unit of measurement for urbanization. We utilized the area of built-up land from Landsat as an urban expansion variable instead of land-use statistics because of the long- questioned accuracy of Chinese governmental land-use data from the 1990s (Seto & Kaufmann, 2003) and because MG has limited statistics on land use. The following major socioeconomic and biophysical variables, featuring the economy, social goods, and environment, were selected based on literature (Bai et al., 2014; Brülhart & Sbergami, 2009; Chen, John, Shao, et al., 2015; Dore & Nagpal, 2006; Endicott, 2012; Fan, 1999; Gauri, 2004; Knight & Song, 1999; Zhang et al., 2013) and the field study (Table 1). In particular, Gauri (2004) addressed the importance of social goods (including education and healthcare) in the context of developing countries.

We employed four different socioeconomic variables and two biophysical variables in our PLS-SEM. To understand the economic condition of the urban area, we utilized the employed population ratio at the end of the year in each city and the GDP per capita (i.e., the annual gross regional domestic product per capita; Yuan for IM and Tugrik for MG). These two indicators have been widely used to indicate the economic development level of a place (Brülhart & Sbergami, 2009; Henderson, 2002). We calculated GDP per capita using the local currency rather than converting it to USD due to the fluctuating exchange rate in the transitional period of MG. In addition, we applied a student-to-teacher ratio and a ratio of medical personnel to population to represent the condition of social goods (Dempsey, Bramley, Power, & Brown, 2011; Gauri, 2004) and to quantify its level for each city. These variables were mainly retrieved from the statistical yearbooks of Inner Mongolia (1990–2012), China Data Online (http://chinadataonline.org/) (2012–2015), and from the Mongolia National Statistical Bureau (http://www.1212.mn/en/) (1990–2015). We utilized the composites (June–August) of two-band enhanced vegetation index (EVII2) and the Self-calibrated Palmer Drought Severity Index (scPDSI) to quantify the environmental conditions as the potential drivers for urbanization. Because EVII2 has improved sensitivity and long-term consistency (Kim, Huete, Miura, & Jiang, 2010), we used this as a proxy variable to indicate the condition of the grassland during the growing season. The data was obtained from the Vegetation Index and Phenology (VIP) dataset, created by the NASA MEASURES (Making Earth System Data Records for Use in Research Environments) program (http://vip.arizona.edu/). Since scPDSI is more reliable in comparing different locations and times than PDSI (Wells, Goddard, & Hayes, 2004), we adopted this method to indicate environmental stressors in the study area. This data ranged from −10 (dry) to +10 (wet) and was retrieved from the database of the Climate and Global Dynamics Laboratory (CGD) at the National Center for Atmospheric Research (NCAR) (http://www.cgd.ucar.edu/cas/catalog/climind/pdsi.html). All remote sensing data extracted for the province of each city was standardized prior to model application.

### 3. Results

#### 3.1. Urban expansion

During the study period of 1990–2015, the total urban area for each of the six cities doubled in size. These cities not only expanded but also lowered in population density. In IM, the urbanized area grew by 359% in Hohhot (a1), 333% in Baotou (b1), and 280% in Ulanqab. In MG, the urbanized area grew by 243% in Ulaanbaatar (a2), 138% in Erdenet (b2), and 112% in Darkhan (c2) (Fig. 2). Interestingly, the urban population density in both IM and MG decreased from 1990 to 2015, with dramatic declines of 57%, 68%, and 55% in Hohhot, Baotou, and Ulanqab, respectively, and 34%, 34%, and 42% in Ulaanbaatar, Erdenet, and Darkhan, respectively. IM and MG also differed in discontiguity, with an average discontiguity increase of 193% in IM versus a decrease of 26% in MG.

Although the cities’ growth rates varied in different time periods, they all showed positive growth rates in total built-up area for each five-year period (Fig. 3). In IM, Hohhot and Baotou exhibited similar trends (inverted-U curves) of urban growth over the study period, while Ulanqab showed a gradual increase in urban growth (Fig. 3a). In MG, urban growth rates fluctuated (Fig. 3b). While Ulaanbaatar showed a sharp increase in urban growth rates for 2000–2005 and 2010–2015, the other two cities in MG, Darkhan and Ulanqab, had relatively low growth rates.

The spatial patterns of urbanization in IM and MG also differed. The urbanization pattern in IM was more sprawled (low-density urban development and high discontiguity) than that of MG. Our correlation analysis verified that urban expansion and population

### Table 1

Selected socioeconomic and biophysical variables used in PLS-SEM (Partial Least Squares Structural Equation Modeling).

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urbanization</td>
<td>Built-up area</td>
<td>Total built-up area ($\text{km}^2$)</td>
</tr>
<tr>
<td>Economy</td>
<td>GDPpc</td>
<td>Annual gross regional domestic product per capita (Yuan, IM/Tugrik, MG)</td>
</tr>
<tr>
<td>Employment</td>
<td>Employment</td>
<td>Employed population ratio at the end of year</td>
</tr>
<tr>
<td>Social goods</td>
<td>Education</td>
<td>Number of teachers per number of students</td>
</tr>
<tr>
<td></td>
<td>Healthcare</td>
<td>Number of medical personnel per person</td>
</tr>
<tr>
<td>Environment</td>
<td>EVI2</td>
<td>The proxy of Leaf Area Index in the growing season (June, July, and August) of the province where cities are located</td>
</tr>
<tr>
<td></td>
<td>scPDSI</td>
<td>Self-calibrated Palmer Drought Severity Index (scPDSI)</td>
</tr>
</tbody>
</table>
density were negatively correlated for IM (Fig. 4a), but not for MG (Fig. 4b). This comparison indicates that the cities in IM tend to sprawl more than the cities in MG. Further analysis between discontiguity and urban expansion supported this finding. Urban expansion and discontiguity were positively correlated for cities in both IM (Fig. 4c) and MG (Fig. 4d). The correlation between urban expansion and discontiguity in IM was stronger than that of MG (Fig. 4c and d). Among the three cities in IM, Ulanqab showed a steeper trend for urban sprawl compared to Hohhot and Baotou (Fig. 4a and c).

3.2. Driving forces of urbanization

The PLS-SEM provided further empirical evidence on the importance of economic, social, and environmental factors on urban expansion in both IM and MG (Fig. 5). The collinearity statistics of the latent variables for both IM and MG models were high (variance inflation factor (VIF) > 0.2), with the latent variables of each at a high convergent validity (average variance extracted (AVE) > 0.5), suggesting that the results are statistically robust enough to explain the hypothesized causal connections. The four
latent variables had a different relationship in IM and MG, and the models’ explanations of urbanization also varied.

In the IM model, the combined factors of economy, environment, and social goods explained 42.2% of the variance in urbanization. The path coefficient between economy and urbanization was statistically significant, with economy having the strongest positive effect on urbanization (0.559). Two paths of the environment were statistically significant. The environment had a weak, negative effect on the economy (−0.209) and on urbanization (−0.212). However, the hypothesized path relationship between

![Diagram](image-url)

**Fig. 5.** Partial Least Squares Structural Equation Modeling (PLS-SEM) of socioeconomic and biophysical drivers on urbanization in both Inner Mongolia (IM) and Mongolia (MG). Latent variables are circular shapes, and measured variables are squares. The path coefficients describe the relationship between variables. The IM model illustrates that the economy is a major driver of urbanization ($R^2 = 0.422$) whereas the MG model demonstrates that both economy and social goods drive urbanization ($R^2 = 0.342$).
urbanization and social goods as well as economy and social goods were not statistically significant. Thus, we can conclude that economy is a strong predictor of urbanization, environment is a weak predictor, and that social goods do not predict urbanization directly in IM (Fig. 5a).

In the MG model, the combined factors of economy, environment, and social goods explained 34.2% of the variance in urbanization. Four paths were statistically significant in the model. Social goods had the strongest positive effect on urbanization (0.646), followed by the economy (0.433). In addition, the environment had the strongest positive effect on the economy (0.465), and the economy had the strongest negative effect on social goods (−0.403). Thus, we can conclude that social goods and the economy did not strongly predict the urbanization, and that the environment was not a direct predictor of the urbanization in MG (Fig. 5b).

Since we used five-year interval built-up area data from remote sensing analysis, the models have relatively small samples (N = 36, n = 18 for IM, and n = 18 for MG) compared to the standard sample size in CB-SEM. However, unlike CB-SEM, PLS-SEM does not require strict sample sizes (Chin, 2010; Fan, Chen, Shirkey, et al., 2016). To confirm the stability of estimated path coefficients, we proceeded with bootstrapping analysis (i.e., 500 iterations). The bootstrapping in PLS-SEM generates sub-samples randomly drawn from the original data to test statistical significances of estimated path coefficients (Hair et al., 2013). The estimated path coefficients of Economy to Urbanization in IM, Economy to Urbanization, Social goods to Urbanization, Environment to Economy, and Economy to Social goods in MG were statistically significant (Table 2).

4. Discussion

4.1. The role of local government on urbanization

Differences in local governance systems (i.e., key measures of institution) led to distinct urbanization processes in IM and MG. The decentralization of administrative and economic power from central to local governments in IM brought divergent pathways of urbanization. Local governments have taken key roles in new urban development since the reform (Ma, 2002, 2005). Local governments converted the urban fringe from rural collectives into state-owned urban lands to establish economic development zones and build infrastructure (World Bank, 2014). Meanwhile, they sold land use rights for these converted areas as means of increasing revenue under the name of marketization, consequently stimulating new residential development on the periphery of the city (Wong & Zhao, 1999; Wu & Yeh, 1999; Liu et al., in press). As a result, in the last three decades nearly 95% of urban growth in China occurred at its edges or in suburban areas, while only a small percentage occurred in the city center (World Bank, 2014). Our results also verified that IM is in line with the urban sprawl trend of China (Fig. 2a1, b1, & c1).

This urban sprawl has been continuous since 2000, as the Central Committee of the Chinese Communist Party and the State Council have encouraged small towns to attract investments through which residents could acquire urban household status if the town offered stable jobs (Ma, 2002). Since the new development often resulted in higher tax rates from increased employment and productivity, local governments encouraged the growth of collectively and privately owned small enterprises (Wei, Li, & Wang, 2007). This, in turn, has brought about the emergence of small urban towns near the city. In addition, the growth of local governance also promoted the growth of road development in China (Li et al., 2015). Thus, the growth of governance and resulting high accessibility of road infrastructure may encourage urban sprawl in IM (Liu, He, Tan, Liu, & Yin, 2016; Su, Jiang, Zhang, & Zhang, 2011).

Contrary to local government in IM, MG’s local government has a limited role in urban development. Local government in MG was not in charge of new development, and private sectors played a more important role (Diener & Hagen, 2013). Although the central government legislated the Medium-Term Development Strategy in 2003—a plan for encouraging regional development within select cities—detailed plans for providing adequate financial and infrastructure investment schemes for local governments were not established (Dore & Nagpal, 2006). In an effort by private developers, most urban developments occurred alongside existing infrastructure (Fig. 2a2, b2, & c2). The limited road infrastructure thusly resulted in a linear development pattern and restricted urban sprawl. The non-statistically significant relationship between urban growth and population also supported the argument that urban growth does not imply urban sprawl in MG (Fig. 4b).

MG’s land allocation laws further reinforced this urbanization pattern (Bauner & Richter, 2006). Under this law, married couples and households using the land for a residential purpose are free to gain land ownership. This encouraged incoming rural-to-urban immigrants to settle in the fringe areas, where they could ensure some accessibility to the downtown area within the otherwise limited road infrastructure (Tsutsumida, Saizen, Matsuoka, & Ishii, 2015). In summation, the limited roles of local government and insufficient infrastructures in MG resulted in a more densely populated urbanization compared to IM.

4.2. The role of economy on urbanization and the contrasting role of pastoral economy

Economic development is the major driver of urbanization for IM and MG (Fig. 5a and b). As Chen, John, Zhang, et al. (2015) and John et al. (2016) suggested, better-paying jobs and new job opportunities are critical to land-use change on the MGP. Increased GDP per capita and employment ratios explain the variance of urbanization in the model for IM (0.559) and MG (0.433) (Fig. 5a and b). After IM and MG were transformed into market-based

### Table 2

<table>
<thead>
<tr>
<th>Region</th>
<th>Path</th>
<th>Original sample estimate</th>
<th>Mean of resamples</th>
<th>Standard deviation</th>
<th>T-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Mongolia</td>
<td>Economy &gt; Urbanization</td>
<td>0.559***</td>
<td>0.622</td>
<td>0.205</td>
<td>2.754</td>
</tr>
<tr>
<td></td>
<td>Social goods &gt; Urbanization</td>
<td>−0.063</td>
<td>−0.021</td>
<td>0.249</td>
<td>0.254</td>
</tr>
<tr>
<td></td>
<td>Environment &gt; Urbanization</td>
<td>−0.212</td>
<td>−0.137</td>
<td>0.328</td>
<td>0.679</td>
</tr>
<tr>
<td></td>
<td>Environment &gt; Economy</td>
<td>−0.209</td>
<td>−0.331</td>
<td>0.241</td>
<td>0.985</td>
</tr>
<tr>
<td></td>
<td>Economy &gt; Social goods</td>
<td>−0.111</td>
<td>−0.171</td>
<td>0.382</td>
<td>0.295</td>
</tr>
</tbody>
</table>

| Mongolia       | Economy > Urbanization       | 0.433*                   | 0.390             | 0.245              | 1.767       |
|                | Social goods > Urbanization  | 0.646**                  | 0.660             | 0.286              | 2.256       |
|                | Environment > Urbanization   | −0.101                   | −0.212            | 0.170              | 0.553       |
|                | Environment > Economy        | 0.465***                 | 0.522             | 0.147              | 3.165       |
|                | Economy > Social goods       | −0.403**                 | −0.493            | 0.200              | 2.015       |

***p < 0.01, **p < 0.05, *p < 0.1.
due to the loss of subsidies from the Soviet Union. The national economies contributed to strongly attract rural migrants.

IM and MG, however, have different relationships between economy and environment, which correspond well with the level of importance that the pastoral economy holds. While both IM and MG hold long-lasting pastoral lifestyle and livestock herding traditions, the importance of the pastoral economy in IM over the last three decades has substantially decreased in relation to the overall regional economy (Chen, John, Shao, et al., 2015; Wu et al., 2015). The links between environmental conditions (e.g., grassland cover) and the economy for IM was not statistically significant (Table 2), as the economic system in IM was dramatically restructured to favor the secondary and tertiary sectors during the study period (Chen, John, Zhang, et al., 2015; Chen, John, Shao, et al., 2015). The portion of the primary industry contributing to GDP gradually decreased over time in IM from 35.3% in 1990 to 9.2% in 2014. During the same time period, the proportion of the secondary industry increased from 32.3% to 51.3% (China Data Center, n.d.). This declining share of the primary industry in GDP attenuated the linkages between economy and environmental conditions (i.e., primary productivity in grassland and drought). On the contrary, MG exhibited a stronger relationship (0.465) between economy and pastoral conditions (Fig. 5b). Livestock grazing and herding remain the major economic activities in MG (Dore & Nagpal, 2006; Ulaambayar, Fernández-Giménez, Baival, & Batjav, 2016). Approximately 25.2% of total MG households still practice livestock farming (National Statistical Office of Mongolia, 2015). Considering that the pastoral economy (i.e., livestock mortality and productivity) in MG is more sensitive to environmental variations due to the lack of infrastructure (i.e., animal shelters and hay storage), environmental conditions still play a major role in the economy of MG.

4.3. The role of social goods on urbanization

IM and MG have divergent connections between social goods and urbanization. While IM does not have statistically significant path coefficients (−0.063), MG has strong path coefficients (0.646). This indicates that social goods are strong drivers of urbanization in MG but not in IM (Fig. 5a and b).

In IM, strong governmental subsidies and support have lowered the importance of social goods as a driver of urbanization. Since the central government ubiquitously distributed social goods and offered social assistance programs to the region (Leung, 2003), the difference in social goods became small among all cities. The difference in urban and rural ratios for doctors to population in IM is relatively narrow compared to other parts of China (Bhalla & Luo, 2012). Promoted by the Western Development Project and the Compulsory Education Program, the central government supported IM by reallocating the education budget and by building schools in rural areas (Wang & Lewin, 2016). Following the guidelines of the central government, local governments also began evenly distributing social goods across the region (Duckett, 2013). For example, the current state policy “8337 Development Strategy” promotes development packages, including education and health facilities for suburban and rural areas, which improves the livelihood of the people. These facts imply that social goods are not the main stimulus for urban migration.

In contrast to IM, the MG government did not provide the same/similar level of social goods nation-wide, but instead concentrated social good provision in its capital and certain cities (Janzen, 2005), making social goods a strong stimulus for rural-urban and even urban-urban migration. Budget cuts to education in the early 1990s in MG serve as one example. The government has not been able to fully support educational systems since the beginning of the 1990s due to the loss of subsidies from the Soviet Union. The national educational expenditure dropped in 1992, matching only 56% of the level that was seen in 1990 (Hall & Thomas, 1999). The health care sectors also saw changes, with primary-level hospitals in rural areas insufficiently equipped with medical professionals or facilities (Spiegel et al., 2011). As individuals are ultimately responsible for their own education and healthcare, migration to cities has become a vital option to get necessary social services.

Many rural-to-urban migrants in the cities of MG were attracted by the relatively well-established availability of social goods. However, the cities soon experienced an excessive demand for these social goods. The path coefficient between the economy and social goods (−0.404) indicates that the growing economy has a negative relationship with the level of social goods, implying that the supply failed to meet the growing need for social goods. The current health care system situation in MG supports our view. Health care reform in the mid-1990s began to provide medical services in major city hospitals. Since 1990, the soum hospitals—mainly located in rural centers—declined in number as the gross number of medical doctors within cities increased. Nevertheless, the ratio of medical doctors to residents in the city has declined since 1990, owing in large part to the increasing populations and limited governmental investment and support that does not adequately accommodate them (UNFPA, 2012).

4.4. Implications for sustainable urban development

China ranks high in the avoidance of common urbanization issues, including urban poverty and unemployment, during the transitional period (World Bank, 2014). Our study verified that IM had a low level of disparity compared to MG in terms of social goods. Like other Chinese local governments, IM local governments played a critical role during the transition by triggering new urban development (Song & Zenou, 2012). Consequently, this new development offered employment opportunities and alleviated the severe disparity. However, growing concerns about the local governmental-led projects and efficiency have arisen due to the appearance of ghost towns and improvident urban development (Sorace & Hurst, 2015). While we do not equate dense urban development with efficiency, it is a necessary consideration in preventing more urban sprawl and more fragmented urbanization in IM. In this regard, it is important to focus on the balance of low and high-density urban development for urban sustainability in IM.

Although MG has a relatively low level of urban sprawl and a linear aggregation pattern of urbanization, which does not directly imply urban sustainability. As previously discussed, the supply of social goods and services are currently insufficient in selected cities of MG. These limited and unevenly distributed social goods led linearly aggregated urban form. Only 43.3% of households in Ulaanbaatar are fully equipped with basic utilities such as heating, electricity, and a fresh water/sewage system (The Asia Foundation, 2014). The remaining 56.7% of households suffer from a lack of these basic utilities. Therefore, as a fundamental first step toward urban sustainability, local and central governments would need to fulfill the basic needs of their citizens. In this regard, any future master plan based on substantive new development should incorporate the installation of basic infrastructure, access to social goods, and adequate public services for urban sustainability in MG.

5. Conclusions

The Mongolian Plateau, including IM and MG, provides an excellent example to study the processes and causes of urbanization in transitional countries where human and natural systems have experienced fundamental change. We found that IM and MG have similarities and differences in their urbanization processes.
Urban expansion occurred rapidly in both IM and MG, with the total built-up areas increasing by 4.36 times and 3.12 times than that of 1990 in the three cities of IM and MG, respectively. However, the cities of IM and MG exhibited different spatial characteristics. Cities in IM were characterized as less dense and more sprawled, while cities in MG showed linearly aggregated urban build-up. We also identified that economic development is a major driver for urbanization in IM, whereas social goods and economic development have both strongly influenced urbanization in MG. These differences may be due to the divergent roles of local government, the different economic structures, and the different governmental approaches for providing social goods in IM and MG. For urban sustainability in the Mongolian Plateau, special attention must be paid to the economy, environment, and social goods on the national, institutional, and environmental scale when developing future policies.

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