Urbanization and Property Rights

Yongyang Cai†, Harris Selod‡, and Jevgenijs Steinbuks§

October 16, 2015

Abstract

Since the industrial revolution, the economic development of Western Europe and North America was characterized by continuous urbanization accompanied by a gradual phasing-in of urban land property rights over time. Today, however, the evidence in many fast urbanizing low-income countries points towards a different trend of “urbanization without formalization”, with potentially adverse effects on long-term economic growth. This paper aims to understand the causes and the consequences of this phenomenon, and whether informal city growth could be a transitory or a persistent feature of developing economies.

We develop a dynamic stochastic equilibrium model of a representative city, which explicitly accounts for the joint dynamics of land property rights and urbanization. The calibrated baseline model describes a city that first grows informally, with the growth of individual incomes leading to a phased-in purchase of property rights in subsequent periods. The model demonstrates that land tenure informality does not necessarily vanish in the long term, and the social optimum does not necessarily imply a fully formal city, neither in the transition, nor in the long run. The welfare effects of policies, such as reducing the cost of land tenure formalization, or protecting informal dwellers against evictions are subsequently investigated, throughout the short-term transition and in the long-term stationary state.

JEL classification: O43, P14, R14

Keywords: agglomeration, economic development, informality, land property rights

†Yongyang Cai: Hoover Institution, Stanford University and Becker-Friedman Institute, University of Chicago. Email: yycai@stanford.edu.

1
1 Introduction

Throughout the middle age and the early modern period, only a small fraction, probably around one tenth of the world’s population resided in cities (Bairoch 1988). With the Industrial Revolution, Western Europe and North America began to experience a continuous process of urbanization that accompanied the progressive shift from agrarian towards industrialized societies (Bairoch and Goertz 1986, Michaels et al. 2012). Over the following centuries, urbanization rates steadily increased as migration out of rural areas provided the labor force necessary for the development of a large urban manufacturing sector, and as declining transport costs facilitated the trade of manufacturing goods between cities. In turn, urbanization accelerated economic development, particularly through innovation and dynamic human capital externalities (Lucas 1988, Romer 1990, Glaeser et al. 1992, Black and Henderson 1999, Bertinelli and Black 2004) as well as agglomeration effects whereby cities tend to be more productive when they become larger (Duranton 2014a and 2014b). In this sense, cities have been the engines of growth in Western Europe and North America (Henderson 2005 and 2010, Quigley 2009).

Several authors contend that these evolutions were made possible by the emergence of institutions conducive to economic growth (North 1990 and 1991, Chong and Calderón 2000), such as financial development (Bondenhorn and Cuberes 2010), democratization (Henderson and Wang 2007), and property rights (Acemoglu et al. 2005). Improvement in land property rights, in particular, played a crucial role as it favored the development of manufacturing activities by lowering transaction costs for the transfer of land to the emerging industries that were locating in cities, and by making investments not only more secure but also more productive (Knack and Keefer 1995). By stimulating the development of impersonal markets (Arruñada 2012) and enabling the reallocation of land to more productive uses, land property rights institutions very likely improved economic efficiency as well (as argued by Coase 1960, and Demsetz 1967). Even though only a handful of empirical studies have investigated the role played by property rights in general on urban development, these studies consistently point towards a significant and positive effect of property rights on the pace of urbanization (DeLong and Shleifer 1993, Acemoglu et al. 2005, Bogart and Richardson 2009).

It is important to note, however, that evolution of property rights systems is endogenous itself and responds to the changing economic context. This is illustrated by Acemoglu et al. (2005) who explain that Atlantic traders in Western Europe exerted pressure in the 16th century onwards to improve institutions that facilitated their merchant activities, subsequently leading to faster urbanization and income growth in West European countries than in East European countries.

1 Current cross-sectional data suggest that a one percentage point increase in the urbanization rate is associated with a five point increase in per capita gross domestic product (see Duranton 2014b).

2 According to the new institutional economics theory, property rights institutions will emerge or will be strengthened as the benefits of property rights increase (Demsetz 1967, Anderson and Hill 1975, Bubb 2013), and as the political groups that benefit from the recognition and enforcement of property rights become sufficiently powerful to weigh in on the legal and institutional framework governing property rights (Libecap 1986, Feder and Feeny 1991).
Similarly, Richardson and Bogart (2008) and Bogart and Richardson (2009) argue that the public demand for modifying rules governing land inheritance resulted in changes in local legislations causing some counties to experience faster urbanization than others in the decades surrounding the industrial revolution in Britain.

The objective of this paper is to analyze the joint dynamics of land property rights and urbanization, a key but, to our knowledge, unexplored relation underpinning the process of economic development. The focus on land property rights is justified by the important role of land markets—and more generally land systems—as enablers of growth, and by the severe economic costs incurred by economies when land systems are not functioning properly (World Bank 1993, Buckley and Kalarickal 2006, Duranton et al. 2015). Analyzing the relation between land property rights and urbanization requires a dynamic approach. As the historic case of Europe and North America illustrated, urban property rights are typically only gradually phased-in (Konig 1974) and once a system is legally in place, it can take decades, if not centuries, for the system to attain exhaustive coverage. With these elements in mind, our analysis aims to shed light on the context in which the positive relation between property rights and urbanization shown in the case of Western Europe and North America may prevail in the future when developing countries urbanize.

The issue of urbanization has become a crucial topic for developing countries (World Bank 2009). Contrary to Western Europe and North America, it is only in the twentieth century that developing countries began to urbanize, with a pace of urbanization that proved much higher than that of earlier industrializing countries at similar stages of urbanization. And in many parts of the developing world, dysfunctional urban property rights systems continue to prevail (Durand-Lasserve and Selod 2009). In African cities in particular, the inconsistent and inappropriate legal frameworks governing land, the poor capacity of land administrations, the lack of political will to reform land laws and practices, and the lucrative rent-seeking behavior of numerous stakeholders in the land sector combine to prevent large fractions of the population from accessing land under secure property rights (Durand-Lasserve et al. 2015). In this context, informal settlements have become a key feature of urbanization in developing countries, reflecting both the low income levels and the institutional weaknesses of these countries. In sub-Saharan Africa in particular,

---

3The phasing-in of land property rights systems can be explained by political constraints such as the opposition of landowners to registration because of their fear of increased taxation (Offer 1981, Bourillon et al. 2008), or more generally their opposition to the protection of property rights (Sonin 2003) as they may favor private and selective enforcement of property rights—for which they have a comparative advantage—over public enforcement mechanisms (Kerekes and Williamson 2010). Technical challenges also played an important role in delaying the completion of land property rights systems as illustrated by the repeated attempts over different centuries to establish a complete cadaster in France, where manually mapping properties remained extremely costly and time-consuming until the 19th century (Bourillon et al. 2008). Even with a functioning system in place, the costs of access to property rights (e.g. registration fees) may deter users until economic development and the ensuing increases in wealth or the decrease in fees make property rights more affordable to the population.

4While urbanization in Latin America rapidly caught up with developed countries, Asia and Africa remain predominantly rural (with respective urbanization rates of only 47.5 and 40.0 percent). It is in Asia and Africa, however, that the urban population grows at the fastest rate, with many large cities growing by 4 or 5 percent annually, raising tremendous challenges regarding the way those cities will grow in the coming decades.
it is believed that between 60 and 80 percent of the urban population live in informal settlements (UN-Habitat 2010). As informal settlements are very often slums, they may hinder the economic development of cities and exacerbate poverty through a variety of channels including lack of investment in education (Benabou 1993), adverse labor market outcomes (Rospabé and Selod 2006), high criminality (Glaeser and Sims 2015), and a negative impact on health (Sclar et al. 2006). The lack of formal land property rights in informal settlements further immobilizes capital that is “locked” and cannot be used for productive activities (de Soto 2000, Safavian et al. 2006). As a result, some developing countries (mostly African ones) are urbanizing with insecure land rights (Durand-Lasserve and Selod 2009) and in the absence of economic growth (Fay and Opal 2000, Jedwab 2015).

Will the dynamics of urbanization in developing countries replicate or diverge from the experience of North America and Western Europe? Will the combination of rapid urbanization with distorted property rights systems only affect the timing of urbanization and growth along a path that is comparable to that of industrialized countries? Or, on the contrary, will it set developing economies on a different path of “messy urbanization” with persisting slums and limited long-run economic growth? Arbitrarily projecting the experience of North America and Western Europe onto urbanization in the developing world, there seems to be an implicit consensus among development experts that the first scenario may be happening. In this respect, the “modernization” view of slums sees them as transitory (Marx et al. 2013) and bound to disappear with increases in income as in the case of developed countries.

Figure 1 (Panel A) plots the percentage of urban dwellers living in slums on the urbanization rate for a selection of developing countries. In support to this assumption, it shows a negative cross-sectional relation, and thus suggests that the pursuit of urbanization will indeed reduce slums. Similarly, longitudinal data over a short time period (15 years) also indicates a decrease in the prevalence of slums in almost all the countries in the sample (Figure 1, Panel B). The likelihood of this scenario to occur, however, hinges upon the assumption that property rights will continue to become increasingly accessible, either under existing institutions or because improved institutions will emerge and facilitate access to property rights. This seems to contrast with current observations of particularly high costs of accessing property rights in developing countries, inflated by the rent capture behaviors of land administrations and numerous stakeholders involved in the land sector (Durand-Lasserve et al. 2015). Some countries also seem unable to push forward significant institutional reforms in the land sector (Deininger et al. 2012) as those who benefit from the weaknesses of the land rights system exercise political clout to prevent change.\footnote{There is a high correlation between informal settlements and slums. The UN definition of slums includes a high prevalence of households residing under insecure tenure due to weak property rights as one of the possible criteria that determine slums.}

\footnote{North (1990) notes that bad institutional systems can persist over time with the creation of new organizations that have no incentive to create more efficient rules. “Palliative” service industries (e.g. lawyers, notaries) favor dysfunctional systems that increase the demand for their own service (Offer 1981, Arruñada 2012). More generally, the specific context of high inequality and corruption in developing countries may further make the collective design and enforcement of adequate property rights systems particularly problematic.}
Figure 1: Urbanization and slum prevalence

(a) 2009, cross sectional data

(b) 1990-2005, longitudinal data

Source: United Nations, Indicators for monitoring the Millennium Development Goals
Note: Countries are identified with the corresponding three-letter ISO code.
or because systems in place exhibit considerable inertia.\footnote{Libecap et al. (2011) and Arruñada (2012) highlight the issue of path dependency in the building of property rights systems.}

There are very few elements in the existing economic literature to answer these questions. The small empirical literature on urban property rights has been mainly concerned with assessing the capitalization of land tenure characteristics such as tenure security (Jimenez 1982 and 1984, Friedman et al. 1998, Kim 2004) or transferability (Lanjouw and Levy 2002). It has also attempted to evaluate the effect of formalization (i.e., transforming informal into formal tenure) on a variety of social and economic outcomes including increased labor market participation, reduced child labor, housing improvement, health, and the facilitation of market transactions (see Field 2005 and 2007, Field and Torero 2006, Galiani and Schargrodsky 2010, Macours et al. 2010).

As for the emerging theoretical literature on urban property rights, it has mainly been concerned with explaining the demand for informal land tenure. In the wake of Jimenez (1985), a series of papers investigated how squatting can be sustained in an equilibrium where eviction may occur with some probability (Jimenez 1985, Hoy and Jimenez 1991, Turnbull 2008) or where eviction is absent as squatters take action to guard against it (Brueckner and Selod 2009, Brueckner 2013, Shah 2014). Selod and Tobin (2015) model the demand for land property rights in a spatial framework with endogenous land prices. All these models are static (with the only exception of Turnbull (2008), who explores the strategic choices of landowners regarding the timing of squatter eviction). None of these models accounts for the transformation of property rights over time.

Our paper fills this important gap by proposing a theory that accounts for both urbanization and the evolution of property rights in a dynamic perspective. We model urbanization through the migration of heterogeneous agents from a representative rural area to a representative city. The prevalence of land tenure informality is determined by urban dwellers’ decisions whether and when to purchase a property right. As land prices increase with agglomeration, formalization becomes more desirable. However, formalizing may be too costly for less productive workers. These workers, who may not be able to afford both a land plot and a land title, will postpone the decision to formalize, making themselves potential prey to land grabbers. The model can flexibly account for the variety of situations regarding urbanization dynamics as its behavior critically depends on key parameters regarding institutional quality (the cost and enforcement strength of land property rights), the potential for agglomeration effects, and macroeconomic uncertainty.

Contrary to the modernization view of slums, and in line with the observation that “informality may be here to stay”, the model allows us to exhibit plausible contexts in which land tenure informality remains in the long run. Deconstructing common-sense intuitions, the model also sheds lights on situations where some level of informality is actually socially desirable. This is because, under the parameters of the economy, informality provides access to the city to low
income workers who would not be able to contribute to the urban economy under compulsory formal property rights. In this context, enforcement of strict eviction policies would be counterproductive. The model also provides insights into leaving urbanization to the market, which can be suboptimal under adverse structural parameters, in particular when the potential for agglomeration is low and when the land administration charge high fees.

The rest of the paper is organized as follows. Section 2 below presents the model which takes the form of a discrete-time dynamic stochastic game under infinite time but a finite number of states and actions. Section 3 then presents our concepts of social planner and decentralized solutions. Section 4, followed by the conclusion, presents the main results from simulations.

2 The model

We consider an economy with a set of $N$ individuals. Individuals live forever and may either reside in the rural area or in the city. In the city, individuals are exposed to a risk of conflict over land that may result in their eviction from the plot they occupy (a “land grab”). Urban dwellers can nevertheless pay to establish a property right on their plot instead of holding it informally. Whereas informally holding a plot does not provide tenure security, formally held plots are protected against land grabs and their owners cannot be evicted. Formally, let us denote $x_i^{\text{t}} = (x_i^{U,i}, x_i^{F,i})$ the vector of state variables for a representative individual $i$ at time $t$. $x_i^{U,i}$ is the location variable for individual $i$. It takes value 1 if the household resides in the urban area and 0 if the individual resides in the rural area at time $t$. $x_i^{F,i}$ is the property right variable. $x_i^{F,i}$ takes value 1 if the household holds a property right at time $t$ and 0 otherwise. We assume that property rights can only be obtained in the urban area so that living in the rural area with a property right is never a possibility in the model.$^8$

When living in the city over the period $(t, t + 1)$, the individual $i$ earns a wage $w_i^{U,i}$ for his work during the period but faces a congestion cost $c_t$, which we assume to be the same for all individuals. If residing in the rural area, the individual earns rural income $w_t^R$ which we assume is the same for all rural dwellers.$^9$ There is no congestion cost in the rural area. Wages and the congestion cost in the urban area will be endogenous in the model. In addition, if settling in the city at time $t$, an individual must purchase a land plot at a price $R_t$ on the land market. Although the price of land is endogenous in the city, because land is abundant in the rural area, we assume for simplicity that the price of land in the rural area is equal to zero without any loss of generality.$^{10}$

$^8$The prevalence of property rights in rural areas is very low in many countries. This is the case for instance when tenure in rural areas is overwhelmingly customary. Some countries may not have a land registration system or a cadastre for rural areas. Relaxing this assumption would not change the main outcomes of the model while adding unnecessary complexity.

$^9$Productivity in the rural area is low and does not depend on individual intrinsic characteristics.

$^{10}$$R_t$ could also be interpreted as the time-varying difference between the urban and rural land prices. Under this alternative definition—which would assume an initial land endowment in the rural area for each individual—
In our dynamic setting, the land price in the city is determined at the beginning of each period by a macro-economic relation that accounts for city composition and economic conditions (see below). The prevailing land price then drives location choices and grabbing decisions within the period, which in turn affects the fundamentals of the land price for the next period. We assume that there are absentee landlords who, in each period, sell land to urban in-migrants upon arrival to the city and purchase it from voluntary out-migrants upon departure from the city, as well as from land grabbers who resell grabbed land. In our modeling, absentee landlords are price takers over a single period of time. They play the role of “market makers” allowing for a simplified representation of the land market.\(^{11}\)

2.1 Decisions

At the beginning of each period \((t, t + 1)\), an individual makes two choices: whether to migrate and whether to purchase a property right.

Let us denote \(d^i_t = (d^U,i_t, d^F,i_t)\) the vector of choice variables made by individual \(i\), where \(d^U,i_t\) is the migration decision and \(d^F,i_t\) is the land tenure decision.

\(d^U,i_t\) takes the value 1 when the individual decides to migrate to (or remain in) the urban area between time \(t\) and \(t + 1\), and the value 0 if the individual decides to migrate to (or remain in) the urban area between time \(t\) and \(t + 1\).

Because property rights provide protection against land grabs, formality is preferable over informality. It is, however, costly to establish: an individual residing on an informal plot in the city at time \(t\) needs to decide whether to pay a formalization fee \(f_t\) to obtain a property right between time \(t\) and \(t + 1\) or not to pay anything and continue to hold the plot informally.\(^ {12}\) The fee is proportional to the value of the land:

\[
f_t = \mu R_t\tag{1}
\]

with \(0 < \mu < 1\). It is a one-time payment (e.g. registration in a cadastre) and does not need to be paid again in subsequent periods as long as the individual uses the plot, i.e. as long as the individual remains in the city. \(d^F,i_t\), the land tenure choice variable, takes the value 1 when the individual decides to establish a property right between time \(t\) and \(t + 1\) and takes the value 0 otherwise.

\(^{11}\)The existence of absentee landlords is also a standard assumption in static urban economics models where they sell land to households competing for land (see Fujita, 1989).

\(^{12}\)In practice, fees can be paid for the formalization of an informally held plot, or following transactions of formal plots to ensure that they do not revert to informality (for instance by paying to update the registry with the new owners’ name).
2.2 Shocks

Individuals move in and out of the urban area and in and out of residential formality throughout their infinite lifetime. Movements between locations and between land tenure situations are governed by migration and land tenure decisions (as individuals may seek property rights when residing in the city) in the face of productivity shocks and land grab shocks.

Let us start with shocks and denote \( e_i^t = (\epsilon_i^P, \epsilon_i^{G,i}) \) the vector of shocks faced by individual \( i \) in period \((t, t + 1)\).

Firstly, \( \epsilon_i^P \) is a negative productivity shock that affects the wage in the rural area in period \((t, t + 1)\). \( \epsilon_i^P \) takes the value 1 when the shock occurs and 0 otherwise. This occurs with exogenous probability \( \pi^P \).

Secondly, \( \epsilon_i^{G,i} \) is a “land grab opportunity” that affects informal urban dwellers to the potential benefits of land grabbers. \( \epsilon_i^{G,i} \) takes the value 1 if an opportunity to grab the plot of individual \( i \) arises between time \( t \) and \( t + 1 \) and 0 otherwise. The shocks \( \epsilon_i^{G,i} \) for \( i = 1, \ldots, I \) are assumed to be i.i.d. and occur with exogenous probability \( \pi^G \). \( \pi^G \) reflects tenure insecurity on informal plots. It may reflect the probability that an agent of the land administration or a judge will be willing to facilitate an eviction. It also inversely reflects the degree of protection that informal dwellers may have under current legislation and practices (e.g. if evictions are banned by local authorities and if this ban is implemented, then \( \pi^G = 0 \)). In the absence of a land grab opportunity (\( \epsilon_i^{G,i} = 0 \)) or if the plot is held formally (and is thus secure in terms of land tenure), the plot cannot be grabbed in period \((t, t + 1)\) irrespectively of the value of \( \epsilon_i^{G,i} \). In other words, \( \epsilon_i^{G,i} = 1 \) is a necessary condition for a plot to be grabbed, but not a sufficient one. We will detail below, after a brief presentation of the timing of decisions and shocks, the actual mechanism whereby an informal plot facing a land grab shock may or may not end up being grabbed.

2.3 Timing of decisions and shocks

In the model, state variables \((x_t^{U,i} \text{ and } x_t^{F,i})\) are defined at discrete points in time generically denoted \( t \). Decisions \((d_t^{U,i} \text{ and } d_t^{F,i})\) and shocks \((\epsilon_t^P \text{ and } \epsilon_t^{G,i})\) occur within time periods generically denoted \([t, t + 1]\). \(^{13}\) We specify here the exact timing of events within a period \([t, t + 1]\). We assume the following sequence: at time \( t \), individuals are located either in the city or the rural area and may or may not have a property right. Shortly after time \( t \), individuals simultaneously decide where they want to locate (possibly relocate) and whether they want to purchase a property right (if they have not done so earlier for the plot they occupy). Immediately after this decision is made, they may then migrate (possibly involving the sale or purchase of land from absentee landlords) and pay for the property right for those settling in the city and wishing

\(^{13}\) We index these middle-of-the-period shocks, along with intermediary variables introduced later, with subscript \( t \).
to formalize. In the first half period \((t, t + 0.5)\), the city faces land grab opportunity shocks and then idiosyncratic probabilities of land grab opportunities are drawn. At time \(t + 0.5\), land plots exposed to grabbing may get grabbed if the right conditions are met (see below), and the city faces a productivity shock. Both the productivity shock and land grab activities can affect urban wages for the second half of the period (directly in the case of the productivity shock and through a change in the city composition as individuals that lose their plot are forced to move to the rural area shortly after time \(t + 0.5\)). It is important to note here that, in order to be consistent with the nature of our shocks and our modeling of the land market, we assume a period length of several years (exactly 10 years in our simulations).

2.4 Migration

Individuals may choose to migrate between the rural area and the city in response to the difference in the urban and rural incomes (net of housing and congestion costs) and given tenure insecurity in the city and the possibility to formalize and the cost of formalization. In our model, in each period, the rural-urban difference in income is affected by the rural productivity shock at time \(t + 0.5\), implying:

\[
\begin{align*}
    w^R_s &= \left\{ \begin{array}{ll}
        W^R_{t,1} \equiv w^R & \text{for } s \in (t, t + 0.5] \\
        W^R_{t,2} \equiv w^R(1 - \eta \varepsilon^P_t) & \text{for } s \in (t + 0.5, t + 1] 
    \end{array} \right.
\end{align*}
\]  

where \(w^R\) is agricultural productivity in the “good” state of the nature, and \(w^R(1 - \eta \varepsilon^P_t)\) is agricultural productivity in the “bad” state of the nature when the rural productivity shock \(\varepsilon^P_t\) (e.g. low rainfall) kicks in. \(\eta\) is the rural income elasticity to the shock with 0 < \(\eta\) < 1.

2.5 Land grabs

Formal and informal residents in the city may grab land from other informal residents after a land grab opportunity arises (\(\varepsilon^{G,i}_t = 1\)) for an urban plot that is informally held. Let us denote \(\mathcal{I}_t\) the set of informal dwellers in the city during the first half period \((t, t + 0.5)\) before the land grab opportunity shocks happen. These are households who choose to live in the city at the beginning of the period \((d^U_{t,i} = 1)\), who did not hold a formal property right at the beginning of the period \((d^F_{t,i} = 0)\), and who did not become formal during the period \((d^F_{t,i} = 0)\). By definition, \(\mathcal{I}_t = \left\{ i | d^U_{t,i} (1 - x^F_{t,i}) (1 - d^F_{t,i}) = 1 \right\}\) or \(\mathcal{I}_t = \left\{ i | d^U_{t,i} (1 - x^F_{t,i}) = 1 \right\}\). The land grab opportunity shocks are drawn at a time in \((t, t + 0.5)\), defining a subset \(\mathcal{I}^R_t \subseteq \mathcal{I}_t\) of informal resident households. The relocations that occur shortly after time \(t + 0.5\) only reflect land grabs and do not result from the location decision which is made at time \(t\) and implies relocation shortly after time \(t\).

Productivity shocks can relate to business cycles, which occur over several years. We assume that land can be fully purchased within one period, which requires a mid-term time horizon. Choosing relatively long periods does not qualitatively alter the results of the model. Calibrated parameters are chosen accordingly.
residents at risk of being grabbed, with $I_t^R = \{i|\epsilon_t^{G,i} \cdot d_{t}^{U,i} \cdot (1 - x_{t+1}^{F,i}) = 1\}$. At time $t + 0.5$, if a plot $i \in I_t^R$, is grabbed, grabbers can immediately sell off the plot on the land market (to absentee landlords) at the prevailing market land price $R_t$. The set of informal dwellers who get grabbed $I_t^G \subseteq I_t^R$ is defined by

$$I_t^G = \begin{cases} I_t^R, & \text{if } I_t^R \neq \mathcal{H}_t \\ \emptyset, & \text{if } I_t^R = \mathcal{H}_t \end{cases}$$

where $\mathcal{H}_t = \{i|d_{t}^{U,i} = 1\}$ is the set of city dwellers over $(t, t + 0.5)$. The set of non-grabbed dwellers is $J_t = \mathcal{H}_t \setminus I_t^G$. It includes all urban households who were not grabbed in period $t$. It is easy to see that $J_t = \{i|\epsilon_t^{G,i} \cdot (1 - x_{t+1}^{F,i}) = 1\}$ or $J_t = \{i|x_{t+1}^{F,i} = 1\}$. Alternatively, we could have considered that redistribution occurs with equal shares $\frac{1}{|J_t|}$ or that it reflects an idiosyncratic ability or willingness to exert corruption.

The aggregate profit from land grabbing in period $t$ is

$$\mathcal{P}_t^G = \sum_{i \in I_t^G} R_t = \sum_{i = 1}^{N} R_t \cdot \epsilon_t^{G,i} \cdot d_{t}^{U,i} \cdot (1 - x_{t+1}^{F,i})$$

We assume that the land grabbing profit is redistributed to all remaining city-dwellers $i \in J_t$. Each individual remaining in the city after $t + 0.5$ ($i \in J_t$) thus obtains an additional income from grabbing activities:

$$\mathcal{G}_t^i = \frac{\mathcal{P}_t^G}{\sum_{i \in J_t} w_t^i}$$

2.6 Agglomeration and congestion

Considering that an individual resides in the city during time sub-interval $(t, t + 0.5]$ if and only if $d_{t}^{U,i} = 1$, and during time sub-interval $(t + 0.5, t + 1]$ if and only if $x_{t+1}^{U,i} = 1$, the population size in the city for those two time intervals can be expressed by the formula

$$N_s = \begin{cases} \sum_{i = 1}^{N} d_{t}^{U,i}, & \text{for } s \in (t, t + 0.5] \\ \sum_{i = 1}^{N} x_{t+1}^{U,i}, & \text{for } s \in (t + 0.5, t + 1]\end{cases}$$

16$I_t^R = \mathcal{H}_t$ is the pathological case where all individuals should be grabbed but no one would be left in the city to be a grabber, which cannot be possible. In this (unlikely case), we simply assume that no one gets grabbed in the period.

17The set of non-grabbed dwellers is $J_t = \mathcal{H}_t \setminus I_t^G$. It includes all urban households who were not grabbed in period $t$. It is easy to see that $J_t = \{i|d_{t}^{U,i} \cdot (1 - \epsilon_t^{G,i} \cdot (1 - x_{t+1}^{F,i}) = 1\}$ or $J_t = \{i|x_{t+1}^{F,i} = 1\}$. Alternatively, we could have considered that redistribution occurs with equal shares $\frac{1}{|J_t|}$ or that it reflects an idiosyncratic ability or willingness to exert corruption.
There are benefits and costs associated with an increasing urban population, which we present sequentially. Benefits are captured through agglomeration effects, where the productivity (and thus the wage) of each individual in the city depends on the size and composition of the urban labor force (see Duranton, 2014a) as well as on land tenure. The latter assumption reflects the fact that informal plot owners have a reduced labor supply as shown for example by Field (2007) in the case of Lima, Peru. Assuming that each individual is characterized by an exogenous ability $a_i > 0$ and contributes $a_i$ units of labor to production when residing formally in the city and $(1 - \kappa) a_i$ with $0 < \kappa < 1$ when residing informally in the city, we can further define the total efficient labor in the city as

\[
L_s = \begin{cases} 
L_{t,1} = \sum_{i=1}^{N} a_i \left( 1 - \kappa \right) \left(1 - x_{t+1}^F \right) \cdot d_t^{U_i} & \text{for } s \in (t, t + 0.5] \\
L_{t,2} = \sum_{i=1}^{N} a_i \left( 1 - \kappa \right) \left(1 - x_{t+1}^F \right) \cdot x_{t+1}^{U_i} & \text{for } s \in (t + 0.5, t + 1] 
\end{cases}
\] (7)

If residing in the urban area, the wage of individual $i$ can then be specified as

\[
w_{s}^{U_i} = \begin{cases} 
W_{t,1}^{U_i} = a_i \sigma \left[ 1 + L_{t,1} \right]^{1/\gamma} \quad \text{for } s \in (t, t + 0.5] \\
W_{t,2}^{U_i} = a_i \sigma \left[ 1 + L_{t,2} \right]^{1/\gamma} \quad \text{for } s \in (t + 0.5, t + 1] 
\end{cases}
\] (8)

where $\sigma > 0$, and $\gamma > 0$. 19

Let us now turn to congestion. For simplicity, we assume that congestion translates into a monetary cost borne by city dwellers and is expressed in monetary units. It is measured by a congestion function which depends on the size of the city.20 We have

\[
c_s = b \cdot [N_s]^{\delta} = \begin{cases} 
C_{t,1} \equiv b \cdot \left[ \sum_{i=1}^{N} d_t^{U_i} \right]^{\delta} & \text{for } s \in (t, t + 0.5] \\
C_{t,2} \equiv b \cdot \left[ \sum_{i=1}^{N} x_{t+1}^{U_i} \right]^{\delta} & \text{for } s \in (t + 0.5, t + 1] 
\end{cases}
\] (9)

where $N_s$ is defined by (6), for $s \in (t, t + 1]$. Here, $w_s^i$, $c_s$, $W_{t,1}^i$, $W_{t,2}^i$, $C_{t,1}$, $C_{t,2}$ are measured per period. Because of the existence of possible shocks, both $W_{t,2}^i$ and $C_{t,2}$ are random.

Equation (9) captures the negative externalities associated with agglomeration.21

19The formula can be derived by assuming a production function

\[
Y = \frac{\sigma \left[ 1 + L \right]^{1/\gamma + 1}}{1/\gamma + 1}
\]

with $w_s^i = a_i \frac{dY}{dx}$.

20Congestion here reflects the various externalities associated with city size, including travel distance and time (Izraeli and McCarthy 1985), pollution (Lamsal et al. 2013) or criminality (Glaeser and Sacerdote 1999).

21The formula can be derived as the average transport cost in a mono-centric city with convex transport costs (see Fujita 1989).
2.7 Land prices

As for land costs, they are only incurred upon arrival in the city (when the individuals need to purchase a land plot). We assume that each individual consumes one unit of land and that there is a unique price for land in the city at any given point in time.\(^{22}\) We assume that the ratio of the land price to the average income is constant. This long-term relation has been established at the city level both theoretically and empirically in the literature (see Ried and Uhlig 2009, Malpezzi 1999, and Leung 2014). Since transactions only occur during the first half of the period (households purchase or sell land at the beginning of the period, and grabbers sell off grabbed land at time \(t + 0.5\)), the price is a function of the population and wage that prevail during \((t, t + 0.5]\), so we have

\[
R_t = \lambda \frac{\sum_{i=1}^{N} W^{U,i} d^{U,i}_t}{\sum_{i=1}^{N} d^{U,i}_t} \tag{10}
\]

where \(0 < \lambda < 1\).\(^{23}\)

2.8 Land transactions

Land is transferred whenever there are population movements between the city and the rural area or when land is grabbed (and immediately sold off).

Migrants to the city only purchase land upon arrival. We can thus define a variable that measures land purchases as \(P^i_t = R_t\) if individual \(i\) arrives in the city shortly after time \(t\) and \(P^i_t = 0\) otherwise. This is modeled using the formula

\[
P^i_t = R_t \cdot d^{U,i}_t \cdot (1 - x^{F,i}_t) \tag{11}
\]

Conversely, individuals who voluntarily decide to leave the city shortly after time \(t\) sell their land back upon departure at a price \(R_t\). We can define a variable that measures land sales as \(S^i_t = R_t\) if individual \(i\) voluntarily leaves the city during period \((t, t + 1]\) and \(S^i_t = 0\) otherwise.\(^{24}\) This is

\(^{22}\)This can be viewed as the average price of land in the city. We could adopt a more sophisticated representation of land with prices that vary depending on within-city location as in Selod and Tobin (2015) but this would make the model more complex without affecting the main results.

\(^{23}\)Although the land price fluctuates within each period because of involuntary population movements between the first and the second half of each period, transactions only occur at the beginning of the first half of the period following voluntary location decisions. We also assume that sales of grabbed land occur at the current land market price, which can be justified by stickiness. It should also be noted that the expression for \(R_t\) can also be written as \(\lambda w_t p_t / N_t\) where \(w_t = a_t w_t^{max}\) and \(w_t^{max} = \sigma [1 + \sum_{i=1}^{N} a_i (1 - x^{F,i}_{t+1})] d^{U,i}_{t} \cdot x^{F,i}_{t+1}/\lambda\), which can be interpreted as the wage of the most able individual if residing in the city and \(L_t/N_t\) as the average ability of urban residents.

\(^{24}\)Individuals who are victim of a land grab must leave the city and cannot recoup their land investment.
obtained for $S_i^t = R_t(1 - d^{U,i}_t) x^{U,i}_t$ (12)

2.9 Location and land tenure transitions

We now turn to the general definition of transitions, which are defined by the correspondence

$$\Gamma : x^i_t \rightarrow x^i_{t+1}$$

as a function of $x^i_t, d^i_t$ and $\epsilon^i_t$ where $x^i_t \in \{0, 1\}^2$, $d^i_t \in \{0, 1\}^2$ and $\epsilon^i_t \in \{0, 1\}^2$.

This correspondence completely defines what happens between time $t$ and time $t + 1$ to the location and tenure (state variables) of an individual in all possible states and facing all possible combinations of shocks.

We can now infer the laws of motion that fully characterize the transitions between $t$ and $t + 1$ as functions of states at time $t$ and decisions and shocks between time $t$ and time $t + 1$. We have

$$x^{U,i}_{t+1} = d^{U,i}_t \cdot \max \left\{ x^{F,i}_t, d^{F,i}_t, 1 - I_{R_t = \theta} W^{G,i}_t \right\}$$  \hspace{1cm} (13)

$$x^{F,i}_{t+1} = d^{U,i}_t \cdot \max \left\{ x^{F,i}_t, d^{F,i}_t \right\}$$  \hspace{1cm} (14)

(13) states that in order to reside in the city at time $t + 1$, individual $i$ must have decided to remain in or to move to the city between time $t$ and $t + 1$ and either already held a property right for his urban plot at time $t$, decided to formalize between time $t$ and time $t + 1$, or did not face a profitable land grab shock between time $t$ and $t + 1$. (14) recognizes that to have a property right at time $t + 1$, the individual must have decided to remain in or to move to the city between time $t$ and $t + 1$ and either already had a property right at time $t$ or acquired one between time $t$ and $t + 1$.

3 Stochastic game and social planner solution

We will now determine how the system evolves under two different optimization problems and associated solution concepts (stochastic game and social planner optimum). This involves determining how states at the beginning of one period are followed by policy functions during

Note that in each period the total net payment received by absentee landlords is $\Pi_t = \sum_{i=1}^{N} (P^i_t - S^i_t) - \sum_{i \in H^i} R_t$, which can be positive or negative. In the long run, when the population of the city and the share of informal dwellers stabilize, this is expected to be zero as there will be as many sales as purchases.
the period (decisions in our framework) that determine states at the beginning of the following period. To do this, let us define the strategy for individual $i$ as the function from the vector of states $x_t = \{(x_{U,i}^t, x_{F,i}^t)_{i=1,...,N}\}$ into individual decisions $d_t^i = (d_{U,i}^t, d_{F,i}^t)$, which we simply denoted $D_t^i(x_t)$. 

To understand how strategies are determined, we now need to understand how individuals are affected by decisions. To do that, observe that at time $t$, when individual $i$ decides to live in the rural area during the period $(t, t + 1]$ (i.e. $d_{U,i}^t = 0$), he will receive $\left(W_{R,t,1} + W_{R,t,2}\right)/2 + S_{i}^t$ in the period. When individual $i$ decides to live in the urban area during the period, he will pay $d_{F,i}^t f_t + P_i^t$ at the beginning of the period, receive wage $W_{U,i}^t, 1/2$ and incur the congestion cost $C_{t,1}/2$ during the first half period. During the second half period, if the individual is forced to leave the city because a profitable land grab activity happens at $t + 0.5$ (i.e. $\epsilon_{t}^{G,i} = 1$ and $1_{R_{t-0.5},W_{U,i}^t} = 1$) and the individual did not have a property right (i.e., $x_{t+1}^{F,i} = 0$), then he will receive $W_{R,t,2}/2$; otherwise, he will receive a wage $W_{U,i}^t, 2/2$, incur a congestion cost $C_{t,2}/2$, and receive his fraction of the land grab proceeds $G_{i}^t$. The net income of the individual who decides to reside in the city in $(t, t + 1]$ is thus

$$y_t = \begin{cases} \frac{1}{2} \left(W_{U,i}^t - C_{t,1} + W_{R,t,2}\right) - P_i^t & \text{if } 1_{R_{t-0.5},W_{U,i}^t} = 1, \epsilon_{t}^{G,i} = 1, x_{t+1}^{F,i} = 0, \\ \frac{1}{2} \left(W_{U,i}^t - C_{t,1} + W_{U,i}^t - C_{t,2}\right) + G_{i}^t - d_{F,i}^t f_t - P_i^t & \text{otherwise.} \end{cases}$$

Thus, we have the utility of individual $i$ over the period $(t, t + 1]$

$$u_t^i = u^i(x_t, d_t) = \begin{cases} \frac{\left((W_{R,t,1} + W_{R,t,2})/2 + S_{i}^t\right)^{1-\alpha}}{1-\alpha} & \text{if } d_{F,i}^t = 0, \\ \frac{g_{i}^{1-\alpha}}{1-\alpha} & \text{otherwise.} \end{cases}$$

The relevant part of the expression when the individual decides to reside in the rural area does not include the term $d_{F,i}^t f_t$ because, by definition, a household will not simultaneously decide to formalize and migrate to the rural area. The specification reflects risk-aversion through the parameter $\alpha$.

With the above framework, we can now solve the two different optimization problems that respectively correspond to the social planner solution and the stochastic game solution that results from individual choices.

\[\text{Note that because decisions are made before shocks occur in each period, they are only functions of the current states but not of the realization of the shocks.}\]
3.1 Social planner solution

At the beginning of each period $t$, the planner assigns to individuals a sequence of location and formalization decisions so as to maximize the expected value of the sum of discounted stream of aggregated utilities and profits, considering the exogenous shock probabilities (and likelihood of transitions between states). The social planner’s objective function at time $t$ is

$$\max_{\{d_t, d_{t+1}, \ldots\}} \mathbb{E}\left[U(x_t, d_t) + \sum_{\tau=t+1}^{\infty} \beta^{\tau-t} U(x_{\tau}, d_{\tau})\right]$$ \hspace{1cm} (16)

where $U(x_t, d_t) = \sum_{i=1}^{N} u_{i}^t(x_t, d_t)$ aggregates individual preferences and $\mathbb{E}$ is the expectation operator and $\beta \in (0, 1)$ is the discount factor and the expectation is taken over the random productivity and land grab opportunity shocks. Note that the shocks enter in (16) through $x_{\tau}$ which, as we have seen, is a function of $x_{\tau-1}$, $d_{\tau-1}$ and $\epsilon_{\tau-1}$. The transition laws of $x_t$ are given by (13) and (14) for each individual. For simplicity, we denote the transition laws as $x_t = g(x_{t-1}, d_{t-1}, \epsilon_{t-1})$.

Because it is an infinite-horizon problem, the decision depends only on the current state and we can write the corresponding Bellman equation (Bellman 1957) as

$$V^*(x) = \max_{d} \mathbb{E}\left\{U(x, d) + \beta V^*(x_{+})\right\}$$ \hspace{1cm} (17)

where $x$ is the current-period state, and $x_{+}$ is next-period state dependent on $x$, decision $d$, and the shocks $\epsilon$, i.e., $x_{+} = g(x, d, \epsilon)$. The optimal policy function is $D^i(x)$ for individual $i$.

**Definition of social planner solution:** We define the social planner solution as the value function $V^*(x)$ and the set of individual policy functions $D(x) = \{D^i(x) : i = 1, \ldots, N\}$ that solve the Bellman equation (17) given the Social Welfare Function $U$.

3.2 Stochastic game

Here we are trying to solve the stochastic game problem where every individual wants to maximize the present value of his own expected stream of utilities. Mathematically, instead of (16), we now have the multi-objective optimization problem:

$$\max_{\{d_t, d_{t+1}, d_{t+2}, \ldots\}} \mathbb{E}\left[u^t(x_t, d_t) + \sum_{\tau=t+1}^{\infty} \beta^{\tau-t} u^\tau(x_{\tau}, d_{\tau})\right] \text{ for } i = 1, \ldots, N$$ \hspace{1cm} (18)

Note that $x_t$ and $d_t$ are still states and decision vectors for all individuals in the economy.

---

27We consider a utilitarian social welfare function but any other social welfare function can be used.
Since every individual has his own value function $V^i(x)$ and policy function $D^i(x)$ which depend on the states of all individuals, we also need to replace (17) with the following set of Bellman equations (one per individual):

$$V^i(x) = \max_{d^i} \mathbb{E} \left\{ u^i(x, d) + \beta V^i(x_+) \right\} \quad \text{for } i = 1, ..., N$$

(19)

where $x_+ = g(x, d, \epsilon)$.

In this context, our concept of equilibrium is the stationary Markov-perfect equilibrium as in Maskin and Tirole (1987, 1989a, and 1989b).28 It is a natural equilibrium concept to adopt in a dynamic setting such as ours where individuals optimize their own discounted utility taking into account other individuals’ decisions.

**Definition of equilibrium**: We define a stationary Markov-perfect equilibrium as the set of value functions $V^{all}(x) = \{ V^i(x) : i = 1, ..., N \}$ and the set of individual policy functions $D(x) = \{ D^i(x) : i = 1, ..., N \}$ such that for any individual $i = 1, ..., N$ and for any vector of states $x$ and other players’ actions $d^{-i} = (d^1, ..., d^{i-1}, d^i, ..., d^N)$ with $d^j = D^j(x)$ for $j \neq i$, the value function $V^i(x)$ solves the Bellman equation in (19), and the individual strategy $D^i(x)$ solves the right-hand side of the equation (19).

4 Simulation Results

We calibrate the model parameters based on econometric estimates in the economic literature on urbanization and development. When econometric estimates are not available, we calibrate the remaining model parameters to match observed patterns of urbanization in developing countries. For most significant model parameters, we conduct a sensitivity analysis over the range of their plausible values. Further details on model calibration are shown in the technical appendix, section A.1. We set the number of economic agents to 5 in order to balance the model’s computational feasibility with tractability. We interpret the number of agents as population quantiles. As the model does not have a closed form analytical solution we solve equations (17) and (19) numerically as explained in the technical appendix, section A.2 for a set of parameter values described in section A.1 to obtain the value functions that can be used to infer stationary states and corresponding optimal decision rules. We then simulate dynamic urbanization paths corresponding to the social optimum and the Markov perfect equilibrium based on the realization of randomly drawn shocks $\epsilon^P_t$ and $\epsilon^{G,i}_t$.

Figure 2 illustrates one of such simulated paths that corresponds to solving for a Markov-perfect equilibrium under a low formalization cost, low agglomeration potential and low risk of eviction.

---

28The same equilibrium concept has been widely applied in the literature on industry dynamics, see e.g., Ericson and Pakes (1995), Maskin and Tirole (2001), and Doraszelski and Satterthwaite (2010).
Figure 2: Example of Urbanization Path, Markov-perfect Equilibrium

![Urbanization Path Diagram]

Note. Simulated path assumes the following parameter values: \( \gamma = 100, \mu = 0.3, \pi^G = 0.05 \).

For all simulations we start with an empty set of the city with no residents.\(^{29}\) We see that in the second period the most productive agent moves into the city, and stays informal. Next period, this agent faces an increase in wage income while purchasing a title for his plot. In period 4, another, less productive, agent moves into the city, and chooses to stay informal. The wage incomes of both agents 4 and 5 increase as the agglomeration effect dominates the congestion effect and agent 4 chooses to formalize. The stationary state is obtained in period 5 as agents 1, 2, and 3 do not find it optimal to move into the city when the agglomeration potential is low. In this stationary state the urbanization rate is 40 percent and the rate of informality is 0 percent (all residents eventually choose to formalize their land plots). We can also see that welfare (defined as the sum of agent’s discounted utilities \( \sum V^i \) in the stationary state and normalized to 100 in period 1 for illustration purposes) increases as agents move in the city and become formal. This result is consistent with earlier theoretical and empirical evidence of the welfare improving aspects of urbanization (Bertinelli and Black 2004) and secure property rights (Feder and Feeny 1991).

While Figure 2 is illustrative of the urbanization dynamics in our model, it is not generalizable

\(^{29}\)We have also run simulations for an alternative assumption of one, the most productive, informal resident in the initial state. The results were very similar.
as each simulation path results in a different stationary state given initial states and the history of productivity and land grab shocks. To obtain generalizable results, we simulate dynamic urbanization and formalization paths 100,000 times for each initial state and parameter values, and calculate expected urbanization and land formality rates.

Figures 3 and 4 show expected urbanization and land formality rates that correspond to the simulated Markov-perfect stationary equilibria (panel a) and social optima (panel b). Figure 3 illustrates variation in urbanization and land formality outcomes given different sizes of agglomeration potential and probabilities of land eviction when the land formalization cost is low ($\mu = 0.3$). Figure 4 shows the same simulation results when land the formalization cost is high ($\mu = 0.9$).

Beginning with Figure 3 (panel a), we see that when agglomeration potential is high and eviction probabilities are low to moderate, the Markov-perfect stationary equilibria is consistent with an expected urbanization rate of 60 percent. When agglomeration potential is low or moderate and eviction probabilities are high, the expected urbanization rates declines to 40 percent. Figure 4 (panel a), shows a similar pattern. These results lead to the following proposition:

Proposition 1a: The urbanization rate in the Markov-perfect stationary equilibrium increases when (a) eviction enforcement is weak, and (b) agglomeration potential is high.

The underlying intuition behind Proposition 1a is as follows. The urbanization dynamics in our model are driven by the realized benefits of moving to the city. Agents with lower abilities can only find it individually optimal to move to the city when agglomeration potential is high enough to compensate for the urban rent and congestion costs. Even in these situations the decision to move to the city is not warranted. As their income is not sufficient to pay for formalization costs, agents choose to stay informal for some time before they can afford paying for land titles. When the probability of land eviction is high, low productive and risk-averse agents will find it suboptimal to move to the city.

Now, let us turn to Figure 3 (panel b), which represents simulated results for the social optimum, and let us compare these results to those from panel (a). We see that irrespective of variations in model parameters, the expected urbanization rate is 60 percent. The expected urbanization rates are the same for the social optimum and the Markov-perfect stationary equilibrium when agglomeration potential is high and eviction probabilities are low to moderate. The expected urbanization rates are, however, higher for the social optimum that for the Markov-perfect stationary equilibrium for low or moderate agglomeration potential and high eviction probabilities. A similar pattern is observed when we compare panels (a) and (b) of Figure 4, although the expected urbanization rate of 60 percent is not always sustained when land tenure formalization costs are higher. These results lead to the following proposition:

---

30The numerical values of expected urbanization and land formalization rates that correspond to the model simulations are shown in appendix Table A.1.
Figure 3: Expected Urbanization and Informality Rates, $\mu = 0.3$

(a) Markov Perfect Equilibrium

(b) Social Optimum

Note. Shaded areas correspond to the share of informal residents. Expected rates are calculated as average urbanization and informality rates over 100,000 simulations for each set of parameter values.
Figure 4: Expected Urbanization and Informality Rates, $\mu = 0.9$

(a) Markov Perfect Equilibrium

(b) Social Optimum

Note. Shaded areas correspond to the share of informal residents. Expected rates are calculated as average urbanization and informality rates over 100,000 simulations for each set of parameter values.
Proposition 1b: The urbanization rate under the Markov-perfect stationary equilibrium is lower than in the social optimum when (a) agglomeration potential is low, and (b) eviction enforcement is strong.

To understand the logic behind Proposition 1b, it is important to recall the important distinction between the allocation of urban residents under the social optimum and the Markov-perfect equilibrium. In the Markov-perfect equilibrium, all agents move sequentially and make their land formalization decisions simultaneously. In the social optimum all decisions are made by the joint welfare-maximizing social planner, who has discretion over the timing of individuals moving into the city. The social planner may then choose to move less productive agents into the city first and allow them to obtain land titles before they can be evicted by more productive agents entering the city. Proposition 1b makes an important claim that the path of urbanization itself matters for final urbanization outcomes - an issue completely overlooked in static models of urbanization.

Combining propositions 1a and 1b yields the following corollary:

Corollary 1: In cities that have low agglomeration potential and strong eviction enforcement, the urbanization rate is low and lower than the social optimum.

This finding resonates well with the observed over-enforcement of evictions in the developing countries. The model suggests that, in some contexts, local governments may have done more harm than good by checking migration to cities through eviction of informal settlements (see Lall et al., 2006, on the causes of over-restrictive internal migration policies and Durand-Lasserve and Selod, 2009, on eviction policies). Over-enforcement of evictions may have caused some cities to be undersized (i.e., overlooking the potential benefits of further agglomeration) in a way that is similar to the enforcement of migration restrictions (see Au and Henderson, 2006, on the case of Chinese cities).

The next important issue to investigate is that of land tenure formalization. We see from Figure 3 (panel a) that when land tenure formalization costs are low, all agents that choose to move to the city also choose to formalize. This does not always happen when formalization costs are high. Figure 4 shows that informal residency can be sustained in the Markov-perfect stationary equilibrium when the eviction probability is low. If the city exhibits medium to high agglomeration potential, the observed informality rate is two-thirds. When the city’s agglomeration potential is low, all residents are informal. These observations constitute the basis for the next proposition:

Proposition 2a: Informality can be sustained in the long run in the Markov-perfect stationary equilibrium. Informality is all the more likely to prevail as formalization costs are higher, eviction enforcement is weak, and agglomeration potential is low. For low land formalization costs, informality is resorbed.

The underlying explanation for Proposition 2a is fairly straightforward. Agents’ decisions to
formalize are determined by the difference between the expected marginal benefits of avoided eviction and potential gains from evicting other informal residents, and the realized marginal cost of formalizing land tenure. As the probability of land eviction declines, the latter effect tends to dominate and no one formalizes. When the city’s agglomeration potential is low, the city is smaller (Proposition 1a), and the expected gain from evicting other informal residents diminishes. This, in turn, leads to an even higher share of informal residents in the city.

Figure 3 (panel b) shows that even when formalization costs are low, informality is desirable in the social optimum when both the city’s agglomeration potential and the probability of eviction are low. In this case, the resulting urbanization rate (59 percent) is higher compared to that observed in the Markov-perfect equilibrium (40 percent). We observe a similar phenomenon when the formalization cost is high. Figure 4 (panel b) shows that for low to medium values of the city’s agglomeration potential and the eviction probability, informality is more prevalent under the social optimum, and the expected urbanization rate is higher (56 percent) compared to that observed in the Markov-perfect equilibrium (40 percent). This finding leads to the following proposition:

**Proposition 2b:** The social optimum does not necessarily require a fully formal city.

To understand this proposition it is important to point out that our model considers a utilitarian social optimum defined as the discounted sum of expected utilities of all economic agents. Under this utilitarian social optimum, the social planner may choose to relocate an individual to the city even if it is individually optimal for that agent not to migrate to the city. In this case, the social planner’s choice is driven by the positive agglomeration externalities this agent imposes on other city residents. If the expected utility gain from agglomeration externalities for other city residents exceeds the utility loss for that individual, the social planner will find it optimal to relocate the agent to the city. However, in view of the high formalization costs, the social planner may not find it optimal to require that individual to formalize, leading to greater informality.

Once we have established how urbanization and informality rates respond to the model parameters under different Markov-perfect equilibria and social optima, we can turn our attention to the welfare analysis. Table A.2 (see technical appendix) shows the values of the simulated value functions of the five economic agents under Markov-perfect equilibria (columns 3-8), the sum of their value functions (column 9), and the value function corresponding to the social optimum (column 10). We see from Table A.2 that the sum of agents’ utilities is highest in cities with the highest agglomeration potential ($\gamma = 5$) and the lowest formalization cost ($\mu = 0.3$) irrespective of the values of the eviction probability. In this case the sum of agents’ expected utilities is the same as the expected sum of utilities, which implies that the Markov-perfect equilibria are also the social optima. This result leads to the following proposition:

**Proposition 3:** Simulated Markov-perfect stationary equilibria Pareto dominate other equilibria and are socially optimal under (a) high agglomeration potential and (b) low formalization costs.
Proposition 3 implies that the equilibria observed in developed countries, where the agglomeration potential is high and formalization costs are low, are likely to be socially optimal. Urbanization can thus be left to the market when the parameters of the economy are favorable. The proposition also highlights that in the absence of effective policies to improve those parameters in developing countries (e.g., making formalization more affordable), urbanization will likely be inefficient.

Careful examination of Table 3 shows that other equilibria may not be ranked unanimously as economic agents rank them differently. The expected agents’ utilities are non-monotonous functions of (a) agglomeration potential, (b) eviction enforcement and (c) formalization costs. More productive agents that choose to reside in the city may face a trade-off between maximizing their wage (which depend on the city’s agglomeration potential and agent’s abilities) and increasing their gains from potential land grabs of informal residents’ land plots as these two effects may or may not go in the same direction.

To further elaborate on this point, consider a city with medium agglomeration potential ($\gamma = 11$). We can see from Table A.2 that, regardless of formalization costs, the social optimum is reached for low to medium probabilities of eviction. Strict eviction enforcement deters in-migration of less productive agents who cannot afford to pay for land tenure formalization before they can establish themselves in the city. However, by looking at individual payoffs under different land eviction regimes, we see that more productive agents (4 and 5) achieve higher levels of expected utility when the eviction probability is high. For these agents, the marginal costs exceed the marginal gains of having an additional agent migrate to the city. As these agents are likely to be economic and political elites that establish themselves earlier in the city, their preferred eviction regime may not necessarily reflect the socially optimal outcome. These observations combined yield the following proposition:

Proposition 4: **Strict eviction policies can be welfare reducing. It can be in the interest of the society but not necessarily in the interest of city elites to accept some level of informality in the short term.**

In line with Corollary 1, our model provides a theoretical insight into the political economy of over-eviction policies. Although evictions remain widespread in many developing countries, it is interesting to note that some countries have moved away from strictly enforced evictions and modified their legal frameworks to provide protection against eviction (Durand-Lasserve, 2007). Proposition 4 suggests that more democratic contexts are favorable to such changes.

## 5 Conclusion

We analyze the interplay between urbanization and evolution of land property rights, two features of economic development that interact in a very important way. Understanding this interaction is
crucial for developing countries as dysfunctional urban land property rights systems continue to prevail in many parts of the developing world, and their implications for the path of urbanization in the long run are not well understood. The model we develop provides a novel analytical framework to study this issue. It is a dynamic stochastic model of a representative city that jointly determines urbanization and evolution of land property rights. Each period, heterogeneous households decide whether to live in the city or in a rural area, and whether to pay for land property rights that will protect them from future eviction attempts. Holders of informal plots are randomly exposed to land seizure by other city dwellers, and seized plots can be resold on the land market. Population movements in and out of the city are thus affected both by land grabbing and productivity shocks. Agglomeration and congestion effects are endogenous to migration, affecting wages and land prices.

Our main result is that land property rights institutions, which are very difficult to reform, have a significant effect on the dynamics of urbanization in the long run. Contrary to the developed world experience, leaving urbanization to the market may be suboptimal because of the constraints imposed by dysfunctional property rights systems in developing countries. We also demonstrate that, under certain conditions, informality can be socially optimal, as it makes it possible for low-income residents to contribute to the urban economy. In these situations, strict urban eviction policies can be welfare reducing.

It is important to note that our major insights are conditional on structural fundamentals of prevailing land property rights systems. While our approach is justified given the persistence of land property rights institutions and apparent difficulties in reforming them, our comparative dynamics provides further insights into the political economy of changing land property rights systems. In future research it would be interesting to understand how the parameters of land property rights systems themselves evolve endogenously with urbanization and possibly shed light on the “institutional trap” that seems to be plaguing much of the developing world.

References


27


Appendix

A.1 Model Baseline Calibration

We choose values for the model parameters based on econometric estimates in the economic literature on urbanization and development. When econometric estimates are not available, we calibrate the remaining model parameters to match observed patterns of urbanization in developing countries. For most significant model parameters, we conduct a sensitivity analysis over the range of their plausible values. Table A.3 lists the model’s parameters and shows the chosen values.

We set the number of economic agents to 5 to balance the model’s computational feasibility with tractability. We interpret the number of agents as population quantiles. We consider a uniform distribution of abilities over $(0, 1]$ with $a_i = i/N$ for $i = 1, ..., N$. Agent $N$ is thus the individual of highest ability $a_N = 1$. We normalize the before-productivity-shock rural wage $w^R$ to 1. We set the informal residency penalty $\kappa$ equal to .2, consistently with Field (2007). We choose a value of 3 for $\sigma$. In developed economies for which state-of-the-art studies control for sorting according to ability, an increase in city size of 10 percent causes productivity to increase by between .3 and .8 percent (Duranton 2009). We thus choose a benchmark value of $\gamma$ of 11, which yields productivity increases of .4 to .7 percent depending on city size.\textsuperscript{31} We choose a value of .2 for the rural wage elasticity to adverse shocks, $\eta$, based on Jayachandran (2006) who estimated an rural wage elasticity of 17 percent to a weather shock. Wet set the probability of adverse income shock in rural area, $\pi^P$, to .3 based on Damberg and AghaKouchak (2013), who report 12 episodes between 1979 and 2013 where more than 20 percent of the land in the Southern Hemisphere was under moderate to severe drought. This corresponds to a drought every three years or a yearly probability of a drought of approximately 1/3.\textsuperscript{32}

As regards the congestion cost parameters, we choose a value of 1 for $b$ and .3 for $\delta$. These numbers are based on the average of Kahn (2010) estimates, who reports city-size elasticities of .14, .25 and .49 for commute times, carbon monoxide pollution and for violent crime respectively. Our choice of $\lambda$ is based on Malpezzi (1999), who reports a median housing price-to-income ratio in 133 US MSAs of 4.5. Assuming that land represent two thirds of total housing costs and considering that our period is 10 years, this leaves us with a value of .3.

For the formalization cost parameter, $\mu$, we choose a value of .3. There is a wide variety of situations in terms of formalization contexts, with costs ranging from a few percentages of land value to up to 100 percent or more of the value of the land (see Durand-Lasserve et al. 2015).

\textsuperscript{31} In our model, wage elasticity with respect to urban labor force size is $L/(1+L)$. Since $L$ is comprised between 1 and 5, a value of $\gamma$ comprised between 10.4 and 16.6 ensures that wage elasticities are comprised between 0.03 and 0.08 in any state of the economy.

\textsuperscript{32} .3 is a conservative estimate as other shocks affecting incomes such as conflicts, natural disasters or health crises can also occur (see Zceleczky and Yosef, 2014).
For $\pi^G$ we assume a value of .1 which is consistent with the high prevalence of conflicts in the cities of developing countries.

We set the value of the risk aversion parameter, $\alpha$, to 2, which is consistent with reported estimates in the meta-analysis conducted by Havranek et al. (2015). We use an annual discount rate of .985, which is consistent with the number adopted by long run dynamic computational forward-looking economic models, e.g., Nordhaus’ DICE model (Nordhaus, 2008). Given that a period spans over 10 years in our model, this translates to $(.985)^{10} = .86$.

Given a significant range of heterogeneity for some model parameters, we conduct a sensitivity analysis to demonstrate the model’s robustness to chosen parameter values. Specifically, we analyze our results’ sensitivity to variations in following model parameters: (a) income effect of agglomeration, $\gamma$, of 5 (high agglomeration potential) and 100 (low agglomeration potential); (b) cost of land tenure formalization, $\mu$, of .9 (high formalization cost); and (c) probability of land “grab”, $\pi^G$ of .05 (low chance of eviction) and .5 (high chance of eviction).

A.2 Numerical Implementation

A.2.1 Social planner solution

The right-hand side of the Bellman equation (17) can be expressed as $I(V^*(x))$ where $I$ is the Bellman operator. We see that the value function $V^*(x)$ is a fixed point of the Bellman operator, so we can use an iterative method to find $V^*(x)$. We apply the value function iteration, that is, we first choose an initial guess of $V^*_0(x)$, denoted as $V^*_0(x)$, and then compute $V^*_t(x) = I(V^*_{t-1})(x)$ for $t \geq 1$ until the iteration converges. A detailed discussion of value function iteration is available in Judd (1998).

A.2.2 Stochastic game

We denote the right-hand side of the system of Bellman equations $F(V^{all})(x)$, where $F$ is the Bellman operator vector. $V^{all}(x)$ is the fixed point of $F$. Thus, as for the the social planner problem, we can also solve for $V^{all}(x)$ by applying an iterative method. However, it is time consuming to compute $F$ for problems with large $N$, because of three levels of “curse-of-dimensionality”, whereby computational cost increases exponentially in the number of state variables, the number of decision variables, and the number of shock variables for computing expectation. To address this issue Pakes and Mcguire (1994) introduced a computational method for computing Markov-perfect Nash equilibria for stochastic games with continuous choices.33 In this paper, we use a variant of the method of Pakes and Mcguire (1994) to find a stationary Markov-perfect

---

33In a related work, Doraszelski and Judd (2012) analyze continuous-time stochastic games to avoid the curse of dimensionality in computing expectations.
equilibrium for our discrete-time, infinite-horizon stochastic game with discrete planner states and discrete choices. That is, we choose the optimal policy functions of the social planner problem as our initial guess of $D(x)$ for the stochastic game, denoted as $D_0(x) = \{D_0^i(x) : i = 1, \ldots, N\}$. We then let the initial guess of $V^{all}(x)$ be $V_0^{all}(x) = \mathbb{E}\{u'(x, D_0(x))\} / (1 - \beta)$. Denoting $(D_{i}^{-1}(x), d^i) = (D_{i}^{-1}(x), \ldots, D_{i}^{t-1}(x), d^i, D_{i}^{t+1}(x), \ldots, D_{N}^{t}(x))$, we compute

$$V_{i}^{t}(x) = \max_{d^i} \mathbb{E}\{u'(x, D_{i}^{t-1}(x), d^i) + \beta V_{i}^{t-1}(x)\},$$

for each $i = 1, \ldots, N$, and let $D_{i}^{t}(x)$ be the optimizer for individual $i$ at the $t$-th iteration for $t \geq 1$. At iteration $t$, we know the value function and policy functions at the previous iteration $t-1$ for every individual. Each individual determines his own optimal decision under the assumption that the other individuals make their decisions at $t$ that replicate their policy functions at $t-1$. Note that although the $F$ operator has to be solved jointly for all individuals, equation (A.1) can be solved separately for each individual $i$. This makes equation (A.1) much easier and faster to solve. We iterate over $t$ until both $V^{all}_t$ and $D_t(x)$ converges. The converged value and policy functions are the solution to the stochastic game.

From Maskin and Tirole (2001), we know that there exists a Markov-perfect equilibrium for our stochastic games with finite action spaces. However, our stochastic games may still have multiple equilibria, although Maskin and Tirole (2001) point out that the Markov-perfect equilibrium concept, a refinement of the Nash equilibrium, can be applied to eliminate or reduce the multiplicity of equilibria in dynamic games. Recently, Borkovsky et al. (2010) applied the homotopy approach to detect equilibrium multiplicity for games with continuous strategies, and Judd et al. (2012) developed all-solution homotopy methods to find all equilibria of static and dynamic games with continuous strategies. Yeltekin et al. (2015) provide a numerical method for computing all subgame-perfect equilibria of dynamic games with both discrete and continuous strategies, but their examples consist of only two or three-player dynamic games even with massive parallelization. As our examples are stochastic games and have a large number of players (in our example $N = 5$ players and $2N = 10$ dimensions of states), it is still challenging to find all equilibria for such a large-dimensional problem, so we leave this for future research.
## Tables

Table A.1: Expected Urbanization and Informality Rates

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Social Optimum</th>
<th>MPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\gamma$</td>
<td>$\mu$</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.05</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>0.05</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td>0.05</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>11</td>
<td>0.9</td>
<td>0.05</td>
</tr>
<tr>
<td>11</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>11</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>100</td>
<td>0.3</td>
<td>0.05</td>
</tr>
<tr>
<td>100</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>100</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>100</td>
<td>0.9</td>
<td>0.05</td>
</tr>
<tr>
<td>100</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>100</td>
<td>0.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note. MPE corresponds to Markov-perfect stationary equilibrium.
### Table A.2: Simulated Value Functions

<table>
<thead>
<tr>
<th>$\gamma$</th>
<th>$\mu$</th>
<th>$\pi^{G}$</th>
<th>$V^1$</th>
<th>$V^2$</th>
<th>$V^3$</th>
<th>$V^4$</th>
<th>$V^5$</th>
<th>$\sum V^i$</th>
<th>$V^s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.05</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.93</td>
<td>-1.92</td>
<td>-1.43</td>
<td>-21.04</td>
<td>-21.04</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.1</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.93</td>
<td>-1.92</td>
<td>-1.43</td>
<td>-21.04</td>
<td>-21.04</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.5</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.93</td>
<td>-1.92</td>
<td>-1.43</td>
<td>-21.04</td>
<td>-21.04</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>0.05</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-3.41</td>
<td>-2.09</td>
<td>-1.44</td>
<td>-21.70</td>
<td>-21.50</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>0.1</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.93</td>
<td>-1.92</td>
<td>-1.43</td>
<td>-21.04</td>
<td>-21.04</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td>0.5</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-1.94</td>
<td>-1.45</td>
<td>-25.54</td>
<td>-21.04</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td>0.05</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-3.64</td>
<td>-2.32</td>
<td>-1.70</td>
<td>-22.42</td>
<td>-22.42</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td>0.1</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-3.64</td>
<td>-2.32</td>
<td>-1.70</td>
<td>-22.42</td>
<td>-22.42</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td>0.5</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.26</td>
<td>-1.68</td>
<td>-26.08</td>
<td>-22.42</td>
</tr>
<tr>
<td>11</td>
<td>0.9</td>
<td>0.05</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-4.31</td>
<td>-2.49</td>
<td>-1.69</td>
<td>-23.25</td>
<td>-23.16</td>
</tr>
<tr>
<td>11</td>
<td>0.9</td>
<td>0.1</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-3.64</td>
<td>-2.32</td>
<td>-1.70</td>
<td>-22.42</td>
<td>-22.42</td>
</tr>
<tr>
<td>11</td>
<td>0.9</td>
<td>0.5</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.26</td>
<td>-1.68</td>
<td>-26.08</td>
<td>-24.25</td>
</tr>
<tr>
<td>100</td>
<td>0.3</td>
<td>0.05</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.54</td>
<td>-1.87</td>
<td>-26.55</td>
<td>-23.77</td>
</tr>
<tr>
<td>100</td>
<td>0.3</td>
<td>0.1</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.54</td>
<td>-1.87</td>
<td>-26.55</td>
<td>-23.73</td>
</tr>
<tr>
<td>100</td>
<td>0.3</td>
<td>0.5</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.54</td>
<td>-1.87</td>
<td>-26.55</td>
<td>-23.73</td>
</tr>
<tr>
<td>100</td>
<td>0.9</td>
<td>0.05</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.70</td>
<td>-1.96</td>
<td>-26.81</td>
<td>-24.35</td>
</tr>
<tr>
<td>100</td>
<td>0.9</td>
<td>0.1</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.54</td>
<td>-1.87</td>
<td>-26.55</td>
<td>-24.08</td>
</tr>
<tr>
<td>100</td>
<td>0.9</td>
<td>0.5</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-7.38</td>
<td>-2.54</td>
<td>-1.87</td>
<td>-26.55</td>
<td>-25.85</td>
</tr>
</tbody>
</table>

### Table A.3: Parameter Values of Calibrated Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I$</td>
<td>Number of economic agents</td>
<td>5</td>
</tr>
<tr>
<td>$a_i$</td>
<td>Agents’ ability</td>
<td>{0.2,0.4,0.6,0.8,1}</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Informal residency penalty</td>
<td>0.2</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Agglomeration scaling factor</td>
<td>3</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Income effect of agglomeration</td>
<td>5, 11, 100</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Rural wage elasticity of adverse shocks</td>
<td>0.2</td>
</tr>
<tr>
<td>$b$</td>
<td>Congestion scaling factor</td>
<td>1</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Congestion elasticity of agglomeration</td>
<td>0.3</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Land price to rent ratio</td>
<td>0.3</td>
</tr>
<tr>
<td>$\mu$</td>
<td>Cost of land tenure formalization</td>
<td>0.3, 0.9</td>
</tr>
<tr>
<td>$\pi^{P}$</td>
<td>Probability of adverse shock in rural area</td>
<td>0.3</td>
</tr>
<tr>
<td>$\pi^{G}$</td>
<td>Probability of land grab event</td>
<td>0.05, 0.1, 0.5</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Risk aversion parameter</td>
<td>2</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount rate (10 year period)</td>
<td>0.86</td>
</tr>
</tbody>
</table>
Appendix References


