Land Markets and Inequality: Evidence from Medieval England*

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Abstract

The Hundred Rolls survey of 1279 documents substantially more inequality in the distribution of peasant landholdings than does the Domesday survey of 1086. Twelfth century innovations in property rights over land induced peasants to expand the role of land market trades in their portfolio of risk coping strategies. We argue that these events are related. Simulation analysis suggests that the primary source of the increasingly unequal distribution of peasant landholdings was the interaction between distress land sales and population growth driven by high fertility rates in households with large landholdings.

Keywords: economic history, land market, Hundred Rolls, Domesday, inequality, risk, poverty, asset markets, simulation analysis, economic development

JEL Classifications: N23, N53, O15, J11

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1 Introduction

During the 12th and 13th centuries the English peasantry experienced large increases in inequality and poverty. Dyer (2002, p. 183) notes that one of the most important aspects of this increased inequality was “the gap between those with landholdings adequate to feed a family, and those with insufficient land who needed income from wages or non-agricultural activities.” The Domesday survey of 1086 indicates that the majority of free peasant households produced income levels above subsistence working their own holdings exclusively. In contrast, the Hundred Rolls survey of 1279-80 indicates that most free peasant households achieved subsistence only by supplementing harvest realizations with wage income, “The danger of the proliferation of families attempting to live on small amounts of land was becoming all too obvious by the 1290s” (Dyer, 2002, p. 186).

This paper argues that the primary factors responsible for the substantial increase in inequality in the distribution of freehold land in 13th century England were demographics, inheritance practices, and land market transactions. We are not the first to stress these relationships. Land markets and population growth (coupled with partible inheritance) are traditional explanatory variables for the increase in inequality in this period. We employ a new approach to understanding the causal connection between these traditional variables and inequality, including evaluating the relative importance of alternative causal channels.

The paper contends that the land market’s effect on inequality resulted from free peasants incorporating land market transactions into their risk coping portfolio. We find that the practice of buying and selling small parcels of land in response to harvest shocks dramatically reduced subsistence risk for substantial landowners but, at the same time, helped create a large class of smallholder and landless peasants.

Our model of population growth is driven by the high fertility rates characteristic of peasant households with large landholdings. Smallholders had so few surviving heirs that their households often could not replace themselves.

We explicitly model the changing distribution of landholdings, employing simulation analysis to estimate the discrete effects of population growth/partible inheritance and land trades motivated by


periodic subsistence crises. Starting with estimates of the distribution of free peasant landholdings at the time of the Domesday survey, we benchmark the simulation by replicating aspects of the distribution of freehold land in the Hundred Rolls survey. As a second benchmarking exercise we simulate the increase in landlessness in the west midlands parish of Halesowen over the period 1270 to 1320. We engage in extensive robustness testing to establish the plausibility of our results. Counterfactual runs of the benchmarked simulation indicate that the independent effects of population growth/partible inheritance and land markets on inequality were quite modest, and that the most significant contributor to inequality was the interaction between these two channels of effect.

Putting the elements of our analysis together yields the following dynamic. Population growth coupled with egalitarian bequest motives broke up large holdings into middle and small sized holdings. Late 12th century land market reforms motivated middleholders and smallholders to increasingly sell land in response to frequent crisis-level harvest realizations. These distress land sales resulted in middleholders becoming smallholders, and smallholders becoming landless.

Recent work in development economics has explored the theoretical relationship between inequality and asset markets, including the role played by incomplete markets, subsistence constraints, and the interaction of market and non-market activities. Twelfth century improvements in the market for freehold land, and the subsequent increase in inequality in landholdings, presents an opportunity to explore the empirical relationship between the introduction of asset markets and wealth dynamics. Our simulations imply a large impact on inequality triggered by the expansion of land trades motivated by risk management. Additional consequences include shifting the majority of the vill’s subsistence risk onto smallholders, significant increases in poverty, and the emergence of a large pool of wage laborers long before the introduction of Parliamentary enclosure and industrialization.

2 The Changing distribution of peasant land, 1100 to 1300

In this section and throughout the paper we assume a standard holding (virgate) of 30 acres. Peasants are categorized as largeholders (a full virgate or more), middleholders (one-half to a full virgate), or smallholders (less than one-half virgate).

7Croix and Doepke (2003), Piketty (1997).
Dyer (1989, pp. 117-18) describes the economic circumstances of each group. Largeholder households rarely faced subsistence crises, even during bad harvests, and could expect to produce a relatively large surplus in an average year after paying for hired labor. Middleholder households could expect to “have broken even in normal years” working their own land exclusively, relying on alternative sources of income during bad harvests. Smallholder households were unable to earn a subsistence income on their own holding and led “a precarious existence relying on wages because of the small contribution that their land made to their income.” Smallholders worked from one-third to one-half the year for others even during good harvests.

Razi (1980, pp. 87-88) describes how each group typically responded to harvest shocks. Largeholders “suffered losses along with everyone else in the village when the harvests failed, but they were able to sustain these losses better than other villagers. During these crises they not only succeeded in feeding their families, but were able to lend money and corn to their poorer neighbours and to buy and lease their lands.” Middleholders, “when the harvests failed, as they often did in the pre-plague era...could not make ends meet...often they had no choice but to sub-let or sell land.” Among the poorest families, “The incomes which cottagers and smallholders obtained from their land or small workshops were too low to satisfy the needs of their families. In order to subsist, poor villagers had to supplement their incomes by working on the demesne or on the farms of better off villagers.”

2.1 Estimating the distribution of land ownership

Data from individual estates, tax records, royal surveys, and court rolls have been summarized and analyzed in Miller and Hatcher (1978), Dyer (1989, 2002), Hatcher and Bailey (2001), and Britnell (2004). All comment on the increasing inequality and fragmentation of holdings between the 11th century and the end of the 13th century. We consider two surveys that document the changing distribution of land holdings over this period: (i) the Domesday survey of 1086; 8 and (ii) the Hundred Rolls survey of 1279-80. 9

8The Domesday survey includes all the counties of England except for Northumberland, Durham, Westmorland, Cumberland and the northern parts of Lancashire, which were apparently not surveyed. Volume I (Great Domesday) contains the summarized record of all the counties surveyed except Essex, Norfolk, and Suffolk. Volume II (Little Domesday) contains the full return for the “eastern circuit.” An early draft of the southwestern circuit (Exon Domesday) also provides detailed data. Useful summaries of the Domesday data are found in Britnell (2004), Darby (1952-67), Darby (1977), Lennard (1959), and Miller and Hatcher (1978).

9Our source for Hundred Rolls data is Kanzaka (2002). The surveys of vills contained in the Hundred Rolls yield data on both large ecclesiastical manors and small knightly manors. The area covered was biased towards the highly manorialized vills of central England and includes Cambridgeshire, Huntingdonshire, Warwickshire, and some of Oxfordshire. The Hundred Rolls resulted from government commissions attempting to establish rights of the crown and other lords.
To estimate the distribution of land held by unfree peasants at the time of Domesday we start with estimates for population categories of unfree peasants who held arable land (Miller & Hatcher, 1978: p. 22): villani (large and middleholders of unfree status), 109,000; bordari and cottars (smallholders of unfree status), 87,000. We allocate land among villani using estimates from Middlesex Domesday (Miller & Hatcher, p. 24): one-third held between one and two virgates, two-thirds held between one-half and one virgate. Thus the total unfree population of 196,000 is allocated roughly as 19 percent largeholders, 37 percent middleholders, and 44 percent smallholders.

Table 1 compares the distribution of customary holdings at the time of Domesday with the distribution from the Hundred Rolls, revealing only a slight increase in inequality.  

<table>
<thead>
<tr>
<th>Source (Date)</th>
<th>Largeholders</th>
<th>Middleholders</th>
<th>Smallholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domesday (1086)</td>
<td>19%</td>
<td>37%</td>
<td>44%</td>
</tr>
<tr>
<td>Hundred Rolls (1279-80)</td>
<td>22%</td>
<td>31%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Measuring the change in landholdings among free tenants is more difficult. Kanzaka’s (2002) analysis of the Hundred Rolls reveals a detailed distribution for freehold land while extant studies of Domesday do not. Even so, other observations from the Domesday survey, in combination with manorial surveys from the 11th century, place some constraints on the distribution. Miller and Hatcher (1978, pp. 22-3) contrast differences between peasants as follows: “[some held] a fair amount of land… enough to live on or more...” others worked holdings so small that they “must have relied on supplementary earnings for some part of their daily bread… Very roughly the line of division corresponds to that between villani, liberi homines and sokemen on the one hand and bordars and cottars on the other—but only very roughly. There were bordars with half a virgate (around 15 acres); there were sokemen and freemen with the tiniest holdings.” Postan (1966, p. 611) comments that there were likely more freemen than unfree in “the topmost layer of village society, i.e. among the few villagers with holdings of two or more virgates.” In sum, the distribution of land among free peasants appears to be similar to that of villani, but with relatively more largeholders and some smallholders.  

10 At the time of Domesday around 10 percent of peasants were classified as servi. These peasants did not hold arable land and instead worked exclusively for the lord of the manor. They are not included in Table 1 since this category of peasants probably disappeared soon after the Domesday survey (Miller and Hatcher, 1978, pp. 24-5).

11 This view is consistent with Domesday data on the size of population categories relative to the size of land holdings. From Miller and Hatcher (1978, p. 22), villani comprised 41 percent of the rural population and held 45 percent of the land, liberi homines and sokemen (peasants of free status) comprised 14 percent of the rural population and held 20 percent of the land.
We propose the following distribution of land among free peasants at the time of Domesday as the initial seed for our simulation exercise: 40 percent greater than one virgate, 40 percent between one-half and one virgate, and 20 percent less than one-half virgate. While this allocation seems reasonable, we cannot rule out other seemingly reasonable distributions. One strategy for dealing with this indeterminacy is to show that our benchmarking results are robust to alternative seeds (see section 4.3).

Another issue concerns the geographical consistency of our seed and our target. The Hundred Rolls data is drawn from specific areas in the midlands, the Domesday data is aggregated over a much wider geographical area. The inconsistency between the two surveys results in geographic and manorial diversity between our seed and our target. Since we are unable to control for this diversity, we undertake extensive robustness tests on those parameters in our simulation most subject to geographic heterogeneity (mean harvests, variance in the harvest, depreciation on stored grain, etc.), and manorial heterogeneity (rate of pooling, storage rates, etc.).

A final issue regarding the distribution of freehold land concerns the inclusion of “landless” peasants. Landlessness in our context refers to peasants who do not have property rights over arable land and hence are not counted in the Hundred Rolls. It does not preclude, for example, property rights over land used for private gardens. Our simulations predict that distress sales of arable land will result in some peasants losing all of their arable land. Thus for benchmarking purposes, estimates of landlessness need to be included in the land holding distribution for the Hundred Rolls.

It is well accepted that the number of landless households had increased dramatically by the time of the Hundred Rolls. From Miller and Hatcher (1978, p. 55), “The impression from every quarter of the land... is that the number of landless or near landless men grew steadily in the ensuing generations [after the Domesday survey in 1086], even though no small proportion of them are screened from our view.” Fox (1996, p. 540) finds that for two vills in 13th-century Glastonbury between 50 and 55 percent of peasants were landless. His estimate, however, includes a number of servants employed by landed households. Razi (1981) finds that 30 percent of peasants in the Parish of Halesowen lost all of their arable land between 1270 and 1320.

Table 2 provides estimates of the distribution of freehold land by combining the Kanzaka data for the Hundred Rolls with alternative assumptions about the percentage of landless peasants. Assuming that between 20 percent and 40 percent of free peasants became landless, the target of our benchmark simulation becomes 11-14 percent largeholders, 7-10 percent middleholders, 76-82 percent...
smallholders/landless.

Table 2: Distribution of freehold land (smallholders includes landless)

<table>
<thead>
<tr>
<th>Source</th>
<th>Largeholders</th>
<th>Middleholders</th>
<th>Smallholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domesday</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>Hundred Rolls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20% landless</td>
<td>14%</td>
<td>10%</td>
<td>76%</td>
</tr>
<tr>
<td>30% landless</td>
<td>13%</td>
<td>8%</td>
<td>79%</td>
</tr>
<tr>
<td>40% landless</td>
<td>11%</td>
<td>7%</td>
<td>82%</td>
</tr>
</tbody>
</table>

3 Peasant Landholdings

A wide range of factors impacted the distribution of peasant landholdings in the middle ages. One set of factors tended to produce more equal landholdings. Labor sharing across households (formal or informal) involved high transaction costs due to induced shirking and high monitoring costs. As a result, static efficiency implied limiting each household’s exposure to the labor market by allocating land such that most households were fully employed on their own holding.\(^{12}\) Additional factors tending to equalize holdings included the desire of manorial lords to keep traditional holdings together in order to minimize administration costs, familial solidarity, and community norms.\(^{13}\)

Another set of factors tended to produce more unequal landholdings. Population growth (coupled with partible inheritance) and the peasant land market are the dominant variables stressed in the literature.\(^{14}\) Additional factors are suggested by the following correlations: (i) the percentage of smallholdings were highest in areas characterized by commercial development, freehold tenure, and recent assarts; (ii) the percentage of smallholdings was lowest in traditional manorial areas characterized by strong lordship (Dyer, 1989, pp. 119-20).

The large variation in inequality in landholdings across geographical regions has prompted some to question the applicability of simple explanations. A prime example of a simple causal hypothesis, often implicit in the historical literature, is that population growth/partible inheritance alone could explain increasing inequality. For theoretical as well as empirical reasons, this hypothesis is difficult to support.

While population growth could reasonably be expected to reduce the average size of landholdings

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\(^{12}\)See Fenoaltea (1975), North and Thomas (1973), and the Chayanov thesis (Smith, 1984). We interpret Dyer’s (1989, Chapter 5) discussion of the “normal” workings of the peasant land market in this light.


(all else equal and assuming constraints on bringing new land under cultivation), it is unclear why it should increase inequality. Since every surviving heir inherits land, partible inheritance cannot easily explain an increase in landlessness. Furthermore, while partible inheritance might explain why there were so few families farming very large holdings, since population growth resulted from wealthy families having large numbers of surviving children, it has difficulty explaining the proliferation in holdings of less than an acre. Finally, there is evidence that vills similar in all respects other than inheritance rules produced similar levels of inequality. Medieval peasants could and did distribute bequests of land to their children prior to dying.\(^\text{15}\) It seems that preferences for egalitarian bequests were not overly constrained by formal inheritance rules.\(^\text{16}\) This was especially true for freehold land, “overlaying these local variations was the broad distinction between the impartible inheritance of bond land and the partible inheritance of much free land....[the] free land of peasants and most sokeland could be transmitted to all surviving children and be held by them in joint tenancy or—a much more widespread practice—be divided among them in equal portions” (Postan, 1966, p. 613).

### 3.1 The impact of land markets on inequality

Land markets have long been central to the study of economic stratification within peasant communities. Early work focused on a “natural peasant land market” operating largely within manorial traditions.\(^\text{17}\) Households with surplus family labor (early in their lifecycle) were natural buyers of land, households with deficient family labor (late in their lifecycle) natural sellers. More recent scholarship has found a complex mix of land trades motivated by traditional lifecycle concerns,\(^\text{18}\) bequest motives,\(^\text{19}\) investment possibilities,\(^\text{20}\) and risk coping strategies.\(^\text{21}\)

The nature of property rights in land at the time of Domesday hindered transferability, rendering

\(^\text{15}\)Dyer (1989, p. 124) notes that “...in villages where the custom of impartible inheritance prevailed, fathers were anxious to provide for their non-inheriting sons and daughters. Custom allowed them to give away land that they had acquired in their own lifetime.” From Razi (1981), “where impartible inheritance was practiced, parents usually endowed non-inheriting children with land. The commitment to do so was so strong that parents did not hesitate, if they failed to acquire additional land during their lifetime, to reduce the size of the original landholding given to the heir, in order to provide the non-inheriting siblings with land.” Examples of egalitarian inheritances to daughters through dowries are documented and analyzed in Botticini (1999) and Botticini and Siow (2003).

\(^\text{16}\)Williamson’s analysis of Norfolk manors finds that Gressenhall and Martham (areas of partible inheritance) showed no more fragmentation than Sedgeford (an area of impartible inheritance). Williamson (1984, p. 103) notes “...in their effects on peasant holdings there was less difference between partible and impartible inheritance in the thirteenth century than a bare description of the two systems would suggest....Whatever the letter of the local inheritance law, tenants generally seem to have used their land to provide for as many of their immediate family as possible.”

\(^\text{17}\)For example, see Smith (1984a) for an overview of Postan’s and Chayanov’s theories of the peasant land market.


land trades an expensive (and therefore seldom used) form of risk coping relative to traditional means that included diversification through scattered landholdings, storage, charity, and pooling.22 In the early 12th century traditional risk coping mechanisms came under stress from population growth and commercial development. These stresses were at least partially offset by the strength of informal tradition and the implementation of new formal rules, including harvest by-laws, long term relationships between wealthy and poor peasants (the former exchanging food in bad times for secure labor in good times), increased gleaning rights for the poor, and an increased commitment to the elderly (Dyer, 2002, p. 185). By the late 12th century, England entered a period that “favored individual initiative, but the peasants who showed these entrepreneurial and selfish tendencies were still contained within highly cohesive communities. No doubt some individuals were held back by the restrictions of common agriculture, but many more welcomed the security that came from belonging to a group with many shared interests” Dyer (2002, p. 185-86).

The picture that emerges is one of traditional risk coping mechanisms stressed by changing economic conditions and evolving social norms. It was in this context that the mid 12th century reforms of Henry II separated title for freehold land from personal obligations.23 This innovation in property rights lowered transaction costs in the freehold land market, rendering land trades relatively more attractive as a risk coping strategy. There is extensive evidence of a vibrant market in freehold land by the late 12th century. The development of an efficient market in customary land followed with a lag. While trades of customary land are observed in these early periods, they are relatively rare. Since the 12th century land market reforms were not extended to land held by peasants of unfree status, potential transactions in customary land continued to be confounded with rights over personal obligations. Selling land in response to poor harvests remained a difficult option for unfree peasants. In addition to the problem of transferability of property rights over land, unfree peasants faced higher costs in settling land disputes. From Campbell (2006, p. 197) “Over the course of the thirteenth century the royal courts attracted much business by developing cheap and effective legal procedures for resolving the growing number of disputes which arose from the rapidly expanding market for free land. A market in customary land developed more fitfully and unevenly and was mostly handled by manorial courts.”

22In this connection Dyer (1989, p. 257) stresses the critical role of “networks of neighbors and friends” for avoiding widespread starvation. For a general discussion of the concept of reciprocal exchange see Kranton (1996), for applications to medieval landholding and consumption smoothing see Kimball (1988), and Reed and Bekar (2003).

Efficient markets in customary land did eventually follow those for free land, “It is usually thought that a market in free land... developed first and that this prepared the way for the development of an equivalent market in customary land” (Campbell, 1986). Customary land markets existed in parts of England from the mid thirteenth century. By the late thirteenth century such markets were widespread. Campbell (2009, p. 92) finds that the land market became a “buffer against hard times,” and that “As a last resort, tenants could raise the cash they needed to survive by selling off tiny parcels of land, in the hope of recouping those losses when better times came.” In addition, Campbell (1984, pp. 112-14) finds that many small plots of land were offered for sale to finance food purchases, and “whereas the propensity of individuals to sell land was increased by bad [harvests], it was reduced by good harvests. Furthermore, the effect of successive bad harvests appears to have been cumulative.” Campbell (2006, pp. 208-9) notes that subsistence concerns often overwhelmed peasant ties to familial land so that those “with limited amounts of land from which to support their families adopted strategies aimed at minimising risk... those who could... bought and sold land; but until the fifteenth century the individual amounts involved were often tiny—specifically a single strip, plot, or parcel in the open fields. This active buying and selling of land demonstrates that there was no indissoluble emotional bond between family and its land. Instead the strategic acquisition and disposal of land was part of the complex strategy by which, in an age that lacked institutionalised welfare provision, individuals maintained themselves and their families through good times and bad.”

Razi (1980, p. 37) finds that “Lean years are reflected in the court rolls by a rise in the number of pleas of debt, of inter-peasant land transactions and of illegal gleaners. The reason for the rapid quickening of the inter-peasant land market during periods of economic crises is that smallholders and to a lesser extent half yardlanders had to sub-let and to sell land either to remit debts or to pay rents and fines and to buy food, seed corn, and livestock.” Furthermore, he finds that during these lean years it was the largeholders who typically entered the market as buyers or to take up vacated holdings (Razi, 1980, p. 96, tables 18-19). Schofield (1997), Jordan (1996, pp. 102-106), and Duby (1968, pp. 254-57) all find that activity in the customary land market is correlated with years of dearness.

Although the close relationship between land transactions and risk coping has been more extensively documented for customary land, it appears that markets in freehold land played a similar role in this regard. Employing evidence from the Feet of Fines for the early 14th century, Davies and Kissock (2004, p. 228) find that, like markets in customary land, “a similar pattern existed in the
freehold land market. The sale of lands, as recorded in the feet of fines, reveals a pattern which was exceptionally sensitive to the price of grain.” They also find evidence of the familiar pattern of unfortunate families being forced to sell off fractions of their holdings in bad years to their more fortunate neighbors. Hyams (1970, p. 30) notes that some of the earliest leases and land sales may have been linked to securing subsistence for peasants “with land but not enough to eat.”

We propose a simple hypothesis linking land transactions to inequality in landholdings. Agents who sell land in response to a negative harvest shock in period \( t \) (the unlucky) are more likely to be sellers in period \( t + n \), since their diminished land position today increases the probability of a subsistence crisis tomorrow. Agents who buy land in period \( t \) (the lucky) are more likely to be buyers in \( t + n \) because of their enhanced land position. Over time this dynamic will lead to increased inequality and poverty as peasants, whose land benefited from positive productivity shocks, accumulate land at the expense of their less fortunate neighbors. The dynamics of the process are far from straightforward, however, when one includes the interactions between risk coping through land sales, the differential production of heirs by landholding, and inheritance practices. We adopt a simulation strategy to better understand these complex dynamics.

4 Simulation Strategy

A peasant’s consumption sequence \( \{c_1 \ldots c_t\} \) is a function of their harvest sequence \( \{H_1 \ldots H_t\} \), which is in turn a function of their landholding sequence \( \{L_1 \ldots L_t\} \). We develop a simulation model in order to rank the relative importance of demography and land markets to the evolution of \( \{L_1 \ldots L_t\} \). The primary output of the simulation is a sequence of landholdings for each agent \( n \) in each period \( t \) as a function of their harvest history and a vector of exogenous parameters \( x \), \( L = \{L_0^n(H_0^n \mid x) \ldots L_{t-1}^n(H_0^n \ldots H_{t-1}^n \mid x), L_t^n(H_0^n \ldots H_t^n \mid x)\} \forall n \) agents. Other outputs include the vill’s population \( (N) \), each agent’s consumption sequence \( \{c_1 \ldots c_t\} \), and each agent’s consumption risk.

Our model abstracts from many historical factors that played a role in determining inequal-
ity and poverty: capital markets, strength of manorial tradition, proximity to market centers, the intensity of sheep husbandry, etc. Decisions regarding pooling, saving, labor supply, and land transactions are rule based. To establish the applicability of our simulation we: (i) constrain the parameter values and behavioral assumptions with accepted historical data and analysis whenever possible, (ii) reproduce critical aspects of the distribution of freehold land in the Hundred Rolls conditional on starting with the Domesday seed, (iii) simulate the increase in landlessness in Halesowen from 1270 to 1320, (iv) reproduce historical rates of population growth, and (v) test the sensitivity of our simulation to possible errors in specification and parameterization.

4.1 The simulation

The agent in our simulation is a household, the unit of time is one harvest/year. Peasants buy and sell land only after all other risk coping methods have been exhausted. This rule is consistent with the view that peasants appreciated the intertemporal nature of the risk environment (selling land today increases subsistence risk tomorrow) as reflected in the tradition of familial land, “despite the legal situation which allowed landholders to alienate their farms, they had a strong moral obligation to their families which prevented them from doing so” (Razi, 1981: p. 6).

The baseline simulation proceeds as follows:

1. Agents are endowed with homogeneous land according to their status from Table 2 (largeholders = 35 acres, middleholders = 20 acres, smallholders = 10 acres).

2. Agents draw harvests from a normal distribution transformed by the requisite mean and variance. The mean standardized harvest produces 110 units of grain with a standard deviation of 48.4 (McCloskey, 1975a, 1975b, 1976; Bekar, 2001). Harvest draws are independent across agents and through time. We attribute a dominant role to nature in determining harvest realizations. Thus, for purposes of simulating land holdings, we assume homogeneous agents with

24Campbell (2009) argues that early capital markets were important complements to developing land markets. Their absence in our model may introduce predictable biases into our results. First, since agents are not able to borrow to finance land purchases our model biases land purchases towards largeholders and the lucky (i.e., those able to finance purchases out of current harvest income). Second, to the extent that distress loans were part of a peasant’s risk-coping strategy, our model will tend to over predict distress land sales. On the other hand, Briggs (2009, p. 123) suggests “that the association between the transfer of land and the giving and receiving of credit were not as extensive in England between c. 1200 and c. 1350 as in some other rural settings of pre-industrial Continental Europe.” He finds only a weak link between credit markets and early freehold land markets (Briggs, 2009: p. 123).


26Closed-form models have been developed to analyze aspects of peasant consumption smoothing strategies with reference to the persistence of open field agriculture—see Kimball (1988), Richardson (2003), and Townsend (1993). These models assume a fixed population and distribution of land.

27The simulation is coded in Java and employs the Recursive Porous Agent Simulation Toolkit (REPast) libraries developed at the University of Chicago and Argonne National Laboratory. The simulation source code is available at [blinded, available upon request].
respect to farming abilities. It would be important to take into account differences in talent across peasant households and the potential role for land markets in improving matches between labor and land for other considerations (e.g., long run growth and the social welfare implications of emerging land markets).

3. Agents consume a subsistence bundle, 55% of output on a standard virgate (Bekar, 2001; McCloskey 1975a).

4. Agents pool 2.5% of their net harvest. The administration of pooling arrangements absorbs 20% of the pool’s value each period. Assets in the pool are distributed only to those experiencing a subsistence crisis. The largest transfer an agent can receive in any period is equal to the household’s subsistence deficit.

5. Agents store 2.5% of their net harvest at a 20% rate of depreciation.

6. Agents participate in the labor market when their landholdings are less than 15 acres. A unit of labor is defined as the time required to work one acre of land. Agents therefore supply one unit of labor for every acre less than fifteen that they hold (e.g., landless agents supply 15 units of labor, agents holding 15 or more acres supply none). Agents with more than 35 acres hire wage labor. Labor demand is perfectly elastic at the given wage. The wage is measured in grain and equal to 70 percent of mean output on an acre of land (Fox, 1996).

7. Agents still facing a subsistence crisis—after pooling and storage opportunities have been exhausted—offer land for sale. They continue to sell parcels until achieving subsistence. An agent sufficiently above subsistence (one-half standard deviation) purchases parcels. Transactions are in \( \frac{1}{4} \) acre fragments. Peasants typically bought and sold very small parcels of land. While smaller parcels are observed in the literature, \( \frac{1}{4} \) acre is a defensible average. In each period the price of land is a 10 year purchase price.

8. Agents below subsistence after depleting all landholdings experience a subsistence crisis. A subsistence crisis does not mean “death,” but a significant consumption event that produces increased hunger, disease, and economic stress on the household. The rules proposed for buying and selling land are consistent with minimizing subsistence risk.

9. Agents produce heirs as a function of their landholdings, with largeholders producing more heirs than smallholders. For Halesowen in the late 13th/14th century, Razi (1980, pp. 143-44) finds that “The rich peasants, who had in this period large holdings of a virgate or more, had 33 percent more children per family than half yardlanders and 53 per cent more children than smallholders and cottagers...”. Smith (1984) provides actuarial estimates of the probability of producing more than a single heir based on survivability (probability a child survives to the death of father) and number of children. See also Dyer (1989) and Clark (2007). Combining these estimates, and following Razi (1980, see table 30, p. 142) we assume: smallholder fertility is below replacement (mean heirs = .7); middleholders only rarely produced two heirs (mean heirs = 1); largeholders would produce two heirs with some regularity (mean heirs = 1.5).

10. Agents with more than one surviving heir have their holdings equally divided among their heirs, those producing no heirs have their holdings added to the land supply.

11. Assarting occurs. Two acres of homogenous land are added each period to the vill’s initial 1225 acres. The vill’s arable therefore grows by 360 acres over the 180 periods of the simulation, a 30% increase in arable land. Campbell (2000) estimates the English arable increased by 31% over the period.

12. All variables are updated, the year ends, and the simulation returns to step 2 for a another iteration. The simulation continues until the terminal year is reached.
Implementing these rules implies that each agent’s consumption stream \((c_t)\) evolves as follows,

\[c_t \leq H_t + \ell_t + w_t + k_t - \rho_t\]

with,

\[H_t = F(L_t) + \varepsilon_t\]
\[L_t = L_{t-1} + l_{t-1}\]
\[k_t, w_t \geq 0\]

and,

\[\ell_t = p_l l_t (1 - \delta_l)\]
\[w_t = G(L_t)\]

\[k_t = \begin{cases} 
H_t - z + (1 - \delta_s)k_{t-1} & \text{if } H < z \text{ and } k_t > 0 \\
 s(H_t - z) + (1 - \delta_s)k_{t-1} & \text{if } H_t \geq z \\
 0 & \text{otherwise}
\end{cases}\]

\[\rho_t = \begin{cases} 
p(H_t - z)(1 - \delta_p) & \text{if } H_t \geq z \\
 0 & \text{otherwise}
\end{cases}\]

Where \(H\) is the agent’s current harvest income as a function of landholdings \(L_t\), \(z\) subsistence consumption, \(\ell\) income/spending from land sales/purchases (\(l < 0\) if agent buys land, \(l > 0\) if agent sells land), \(w\) wage income, \(k\) stored grain, \(\rho\) contribution/transfer to the pool (all in the appropriate period \(t\)).

### 4.2 Simulation: Benchmarking

In this section we demonstrate that the predictions for land inequality from our baseline simulation closely resemble actual land inequality at the time of the Hundred Rolls. We also simulate the change in landlessness and population in Halesowen from 1270 to 1320.

#### 4.2.1 Benchmarking: Domesday to Hundred Rolls

The simulation is seeded with a population of 50 agents distributed according to Table 2 (20 large-holders, 20 middleholders, 10 smallholders) and run from Domesday to the Hundred Rolls (180

\[\text{Parameters: } p = \text{rate of pooling out of current harvest}, \ p_l = \text{price of land}, \ l_s = \text{land sales/purchases}, \ s = \text{rate of storage}, \ \delta_s = \text{cost of storage}, \ \delta_p = \text{cost of pooling}, \ \text{and } \delta_l = \text{cost using the land market.}\]
iterations). In order to highlight the impact of land trades on inequality, it is assumed that for the first 60 years peasants only have access to traditional risk coping mechanisms (i.e., storage and pooling), for the last 120 years they gain access to land trades. While the simulated land distributions are not much different from those generated from a simulation that allows land trades from the time of Domesday, delaying the possibility of land trades until the reforms of Henry II allows the simulation to offer insight into the allocation of risk within the village.

The simulation is run 100 times. The point estimates by landholding category are presented in Table 3. Compared to the Hundred Rolls, our simulation predicts similar shares for the landholding categories largeholders, middleholders, and smallholders/landless. In addition the Gini coefficient for the simulated distribution of landholdings is similar to the historical Gini from the Hundred Rolls distribution.\(^{29}\)

<table>
<thead>
<tr>
<th>Source</th>
<th>Largeholders</th>
<th>Middleholders</th>
<th>Smallholders</th>
<th>Avg. Holding</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domesday Seed</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
<td>29 ac.</td>
<td>(\approx .135)</td>
</tr>
<tr>
<td>Hundred Rolls</td>
<td>11%-14%</td>
<td>7%-10%</td>
<td>76%-82%</td>
<td>(\approx 13) ac.</td>
<td>(\approx .737 - .763)</td>
</tr>
<tr>
<td>Predicted</td>
<td>12%</td>
<td>10%</td>
<td>78%</td>
<td>(\approx 12) ac.</td>
<td>.680</td>
</tr>
</tbody>
</table>

Titow (1961) reports that population grew at an annual rate of 0.85% from 1209-1311, simulated annual population growth rates are 0.78%. The simulation predicts a little more than a doubling of the population from Domesday to the Hundred Rolls, consistent with reported changes from Wrigley et al. (1997).

Data from the Hundred Rolls allow us to disaggregate further. Table 4 reports the central estimate for each of Kanzaka’s (2002) landholding categories along with the simulated Gini coefficient (a range of plus or minus one standard deviation is also reported, with entries within one standard deviation of the historical range being noted with an asterisk).

While the landholding categories in Table 3 (small-, middle-, and largeholders) are the most relevant for measuring inequality and poverty, the more granular data in Table 4 provide additional precision to the benchmarking exercise. The simulation produces estimates with relatively small

\(^{29}\)Reported Gini coefficients for Domesday and Hundred Rolls are estimated from dissaggregated distributions. For Domesday we assume a simple distribution consistent with our seed. For Hundred Rolls we use our results from Table 4. Given the data limitations both results should be considered as rough estimates generated for purposes of benchmarking only. As a point of comparison Sussman (2006, p. 20) reports urban income Gini coefficients of .700 for London in 1292 and .750 for Paris in 1292. Otsuka et al (1992) report Gini coefficients on land ownership from South America and Africa in the 1970s running from .420 (Bangladesh) to .910 (Columbia). The average Gini coefficient from all twelve countries reported was .642.
Table 4: Simulating the Hundred Rolls, disaggregated comparisons

<table>
<thead>
<tr>
<th>Holding (in acres)</th>
<th>Historical (20%-40% Landless)</th>
<th>Simulation (µ, 100 runs)</th>
<th>Range (+/- one σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. &lt;1</td>
<td>46% - 66%</td>
<td>57%</td>
<td>54% ~ 60%*</td>
</tr>
<tr>
<td>2. 1-6</td>
<td>13% - 21%</td>
<td>5%</td>
<td>3% ~ 8%</td>
</tr>
<tr>
<td>3. 7-10</td>
<td>3% - 6%</td>
<td>9%</td>
<td>6% ~ 11%*</td>
</tr>
<tr>
<td>4. 11-15</td>
<td>2% - 3%</td>
<td>6%</td>
<td>4% ~ 8%</td>
</tr>
<tr>
<td>5. 16-20</td>
<td>4% - 7%</td>
<td>6%</td>
<td>4% ~ 9%*</td>
</tr>
<tr>
<td>6. 21-30</td>
<td>1% - 2%</td>
<td>4%</td>
<td>2% ~ 5%*</td>
</tr>
<tr>
<td>7. 31-40</td>
<td>4% - 7%</td>
<td>4%</td>
<td>3% ~ 6%*</td>
</tr>
<tr>
<td>8. 41+</td>
<td>5% - 8%</td>
<td>7%</td>
<td>5% ~ 9%*</td>
</tr>
<tr>
<td>Gini</td>
<td>.737 - .763</td>
<td>.680</td>
<td>.643 - .715</td>
</tr>
</tbody>
</table>

variances that, for the most part, fall within the historical range. Discrepancies between our simulated estimates and the historical record include overestimating the number of households holding 10-15 acres and 20-30 acres. More serious perhaps is the simulation’s underestimate of households holding 1-6 acres. In our view, the most likely explanation for this discrepancy is the absence from the simulation model of capital market transactions (agents are not able to borrow against their land), and the possibility of intensification of household labor and effort levels. Both borrowing in the capital market and supplying additional labor effort were mechanisms that peasants could be expected to use in order to avoid the sale of land, especially as landlessness became a strong possibility. Data constraints preclude adding these elements to the simulation.

4.2.2 Benchmarking: Halesowen

Data from the west midland parish of Halesowen allows for an additional benchmarking opportunity. Razi (1981) finds that from 1270 to 1320, 30 percent of landed families became landless, and that “court records show clearly that many of the families who lost their holdings sold them piecemeal to their wealthier neighbours.”

With a target of 30 percent landless and starting with the distribution of landholdings in Halesowen in 1270 (12 percent rich, 38 percent middle, 40 percent poor), our baseline simulation predicts that 32 percent of landed peasant households would end up landless by 1320. Over the same period the simulation predicts that Halesowen would experience 41 percent population growth. Razi (1980, see table 2, p. 31) reports that the historical rate of growth was 42 percent.

Benchmarking Halesowen 1270-1320 offers some advantages over benchmarking Domesday to Hundred Rolls in terms of overcoming potential errors in specification. In the case of Halesowen,
geography is held constant and the initial seed is accurately estimated. The major drawback for our purposes is that the data concerns customary tenants rather than freeholders. But as discussed in section 3.1, with regard to our key causal variable—the use of land trades for the purpose of risk management—freeholders and customary peasants faced similar land market opportunities by the later 13th century.

4.3 Simulation: Robustness testing

As mentioned in section 2, there is an element of irreducible uncertainty over the appropriate Domesday seed for the baseline simulation. Furthermore, since manors were not consistently surveyed between Domesday and Hundred Rolls we are unable to control for a number of manor specific variables (geography, strength of manorial control, etc.). We therefore conduct robustness tests to establish that our central results are not sensitive to these concerns. A general result is that our simulations always generate large increases in inequality and poverty unless critical parameters are changed such that there would be an almost complete lack of distress land sales (e.g., very low instances of harvest failure, very high levels of sharing through income pooling, extensive private storage for all peasants).

4.3.1 Robustness testing: initial seed, production parameters, and risk

Table 5 compares the Hundred Rolls’ land distribution for freeholders with the distribution generated from our simulations starting with two seeds with increased rightward skew (more rich relative to our baseline simulation), two seeds with increased leftward skew (more poor relative to our baseline simulation), and one seed with no skew (an equal distribution). Table 5 shows that the initial seed matters in determining the final distribution of land, but only at the margin. All of the simulations predict high proportions of smallholder/landless peasants and yield similar results with respect to the Hundred Rolls target distribution.

In addition to the initial seed, the most important parameters in the simulation concern production and risk. Holding risk coping strategies constant, the probability that a peasant experiences a subsistence crisis is determined by the number of standard deviations between the mean harvest and subsistence. When mean harvests are less than 1 standard deviation from subsistence peasants experience almost constant harvest failure; when mean harvests are more than 2.5 standard devia-

\*\* Additional robustness tests are presented in the appendix.\*\*
tions from subsistence harvests are far more stable than the historical record. Table 5 shows that the simulations are robust across this range.

Another important consideration is the type of risk faced by peasants. Although our baseline simulation models idiosyncratic risk exclusively, much of the risk in rural England may have resulted from aggregate shocks (i.e., region-wide climate shocks, crop disease, etc.) and was thus shared by all agents. Table 5 shows that little changes with regard to inequality when aggregate shocks are included in the baseline simulation.

Table 5: Robustness rests: initial seed and risk profile

<table>
<thead>
<tr>
<th>Hundred Rolls Target</th>
<th>Large (11 - 14%)</th>
<th>Middle (7 - 10%)</th>
<th>Small (76 - 82%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline simulation</td>
<td>12%</td>
<td>10%</td>
<td>78%</td>
</tr>
<tr>
<td>Production Parameters: Initial seeds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak leftward skew (more poor)</td>
<td>10%</td>
<td>11%</td>
<td>79%</td>
</tr>
<tr>
<td>Strong leftward skew (many more poor)</td>
<td>16%</td>
<td>13%</td>
<td>71%</td>
</tr>
<tr>
<td>No skew (equal)</td>
<td>11%</td>
<td>9%</td>
<td>80%</td>
</tr>
<tr>
<td>Weak rightward skew (more rich)</td>
<td>11%</td>
<td>10%</td>
<td>79%</td>
</tr>
<tr>
<td>Strong rightward skew (many more rich)</td>
<td>14%</td>
<td>5%</td>
<td>81%</td>
</tr>
<tr>
<td>Production Parameters: Risk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased subsistence risk</td>
<td>15%</td>
<td>10%</td>
<td>75%</td>
</tr>
<tr>
<td>Decreased harvest risk</td>
<td>11%</td>
<td>16%</td>
<td>73%</td>
</tr>
<tr>
<td>Aggregate shocks</td>
<td>13%</td>
<td>8%</td>
<td>79%</td>
</tr>
</tbody>
</table>

a. 20% largeholders, 40% middleholders, 40% smallholders. b. 20% largeholders, 20% middleholders, 60% smallholders. c. 33% largeholders, 33% middleholders, 33% smallholders. d. 60% largeholders, 20% middleholders, 20% smallholders. e. 70% largeholders, 15% middleholders, 15% smallholders. f. Distance from disaster = 1. g. Distance from disaster = 2.5. h. Agents face highly correlated shocks (50% of variance in harvests are common to all agents).

5 Simulating land markets

We now employ counterfactual simulations to estimate the relative contributions of the land market and demography to inequality.

The parameters in the baseline simulation (middleholders are 1.13 standard deviations from subsistence and experience a harvest crisis roughly every 12 years) are estimated from the literature on harvest failures and seed yields. On the historical distribution of harvest failures see Hoskins (1964), Jordan (1996), Schofield (1997), and McCloskey (1975, 1976). Bekar (2001) employs seed yield data and historical observations on harvest failures to calculate estimates for distance from disaster.

Hoskins (1964) estimates of the distribution of common harvest shocks using 15th century price data. He finds that 25% of harvests were deficient, 33.5% were average, and 41.5% were abundant. While Hoskins analysis concerns a later period, the results are broadly consistent with the pattern of earlier harvest failures and there is little reason to suspect a systematic difference in aggregate shocks relative to our time period.
5.1 Simulation results: sources of inequality

A sequence of harvests determines a sequence of landholdings through two channels of effect:

1. **Land Market Effect**: Distress land trades tend to increase the size of middle- and largeholdings while breaking up smallholdings.

2. **Demographic Effect**: The differential production of heirs tends to decrease the size of middle- and largeholdings and create more smallholdings.

The land market and demographic effects interact. The simulation’s behavioral rules produce a relatively stable dynamic. Initially land markets increase inequality, but the simulation reaches a point where largeholdings are accumulated but eventually broken up via higher fertility. Figure 1 plots the evolution of the disaggregated distribution of landholdings (i.e., Kanzaka’s eight landholding categories presented in Table 4). By facilitating the accumulation of larger holdings (Figure 1, “after 30 years” and “after 60 years”), land markets tend to increase population fertility, strengthening the demographic effect. Population growth, through partible inheritance, breaks up these larger holdings, increasing the number of peasants on smaller holdings (Figure 1, “after 90 years” and “after 120 years”), exposing them to the threat of increased distress sales, strengthening the land market effect. Together both effects produce large numbers of landless (Figure 1, “after 180 years”).

![Figure 1: Baseline simulation over 180 years (frequency distribution by acerage)](image)

The baseline simulation—with the land market and demographic effects working together—produces a 404 percent increase in inequality (the simulated Gini increases from .135 to .680). We estimate the discrete impacts of the land market and demographic effects by “shutting off” one of the relevant effects, seeding the simulation with the Domesday distribution of landholdings, and
running the baseline simulation for 180 years. Table 6 presents the counterfactual simulated impact for both channels of effect.

<table>
<thead>
<tr>
<th>Hundred Rolls Target</th>
<th>Large</th>
<th>Middle</th>
<th>Small</th>
<th>Gini</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domesday Seed</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
<td>.135</td>
</tr>
<tr>
<td>Baseline Sim</td>
<td>12%</td>
<td>10%</td>
<td>78%</td>
<td>.680</td>
</tr>
<tr>
<td>Demographic Effect (no land market)</td>
<td>2%</td>
<td>16%</td>
<td>82%</td>
<td>.232</td>
</tr>
<tr>
<td>Land Market Effect (no pop. growth)</td>
<td>68%</td>
<td>22%</td>
<td>10%</td>
<td>.161</td>
</tr>
</tbody>
</table>

In the absence of land trades, population growth with partible inheritance produces a 72 percent increase in inequality from Domesday to the Hundred Rolls, roughly 18 percent of the total baseline increase. The resulting distribution of landholdings is tightly clustered around a middleholding. All peasants hold at least one-quarter of a virgate and only participate in the labor market on a part time basis, one-third of peasants do not participate in the labor market at all.

With no population growth, land trades alone produce a 19 percent increase in inequality, roughly 5 percent of the total baseline increase. The resulting distribution of landholdings is skewed dramatically towards large holdings. Only 12 percent of peasants would be forced into the labor market, of those half would be part-time.

Within the context of the baseline simulation, neither the demographic effect (which explains 18 percent of the increase in inequality) nor land market effect (which explains 5 percent of the increase in inequality), in isolation, can explain the large increase in inequality in landholdings over the entire period, leaving roughly 77 percent of the increase to be explained by the interaction between the two effects.

5.2 Simulation results: inequality and risk

Figure 2 plots the evolution of the vill’s Gini coefficient and POD\(^{33}\) over a typical run of the simulation assuming no land market reforms. In the absence of land trades the vill remains relatively egalitarian (with only a modest increase in simulated Gini coefficients) within an increasingly risky environment (higher PODs).

\(^{33}\)For any given year, the vill’s POD is equal to the number of peasants experiencing a subsistence crisis in that year divided by the vill’s population.
Figure 2: Inequality and risk, no land market

Figure 3 plots the evolution of the vill’s Gini coefficient and POD over a typical run of the simulation assuming land market reforms are enacted in year 60. The introduction of land markets eliminates subsistence risk for the vill for 10 to 20 years. As smallholders and some middleholders are pushed to liquidate their landholdings over the next 40 to 50 years, subsistence risk in the vill rises again until almost doubling (from a POD of around .25 to around .50). Peasants would have faced a clear shortrun incentive to add land trades to their portfolio of risk coping strategies. However, while inequality is mostly stable in the first 60 years in the absence of land trades, it more than doubles with the introduction of land markets.
The introduction of land markets transitions the village from a relatively egalitarian risky environment to an inequalitarian higher-risk environment. While land trades reduce the risk faced by the village by close to 20 percent (POD of around .60 without land markets compared to a POD less than .50 with land markets), it does so by dramatically shifting who was exposed to consumption risk.

5.3 Simulation results: the distribution of risk

Dissaggregating our estimates of POD by landholding category reveals that the introduction of land markets shifts consumption risk away from middle- and largeholders onto smallholders. Figure 4 plots the evolution of POD by landholding category (with a quadratic best fit line) assuming no land market reforms. In the absence of land trades risk is shared, to varying degrees, by all landholders.
Figure 4: POD by landholding, no land market

Figure 5 plots the evolution of POD by landholding category (with a quadratic best fit line) assuming land market reforms in year 60. The introduction of land trades permanently eliminates subsistence risk for largeholders and middleholders and dramatically increases the subsistence risk of smallholders. By the time of Hundred Rolls smallholders come to expect a consumption crisis almost annually (their POD approaches unity by 1260).

Figure 5: POD by landholding, land markets introduced in 1146 (t=60)
6 Concluding Remarks

Rural England experienced a dramatic increase in the inequality of free peasant landholdings between the 11th and 13th centuries. We hypothesize that institutional innovations in the 12th century lowered the cost of operating in the land market, inducing free peasants to expand the use of land purchases and sales in their portfolio of risk coping strategies. At the same time, largeholdings were broken up due to the combination of egalitarian bequest motives and the larger families of wealthy peasant households. As a result, more households found themselves increasingly vulnerable to distress land sales as they worked ever-smaller holdings. Many of these small- and middleholder families eventually found themselves landless. This dynamic created a sequence of increasingly unequal landholdings and poverty over time. It also resulted in the creation of a large pool of wage laborers. With regard to risk, we find that improved land markets reduced the vill’s aggregate consumption risk, but at the same time shifted who bore the risk (to smallholders) and who claimed the harvest (to middle- and largeholders).

While our empirical focus is on intertemporal changes in the distribution of land ownership in the heavily manorialized regions of central England (i.e., those areas covered in the Hundred Rolls survey), our analytical framework suggests an approach to understanding cross sectional differences across England. This paper proposes the following causal relationships.

1. Land inequality depends on the extent to which large holdings are broken up through inheritance. This in turn depends on the size of largeholder families and inheritance practices.
2. Land inequality depends on the extent to which middle- and smallholders use distress land sales to manage risk. This in turn depends on the degree of risk and the use of alternative risk-coping mechanisms (e.g., pooling and saving).

Inheritance practices and land markets are standard variables invoked to explain the distribution of medieval landholdings. Many of our key causal variables—e.g., the relative size of largeholder families, harvest risk, the extent of pooling and storage—are considered less often, if at all. Our primary causal variables, in turn, suggest an additional set of variables for understanding the distribution of landholdings. Variables such as climate variability, capital improvements, and lower variance farming technologies might serve as indicators of regional levels of risk. Stable populations, homogeneous populations, and the relative absence of aggregate harvest shocks might indicate relative levels of pooling. Drier climates that might reduce spoilage could serve as an indicator of storage.
In addition to positing a more extensive list of explanatory variables, our simulation model incorporates the variables into a unified framework. Counterfactual analysis indicates that the power of these variables to explain land inequality lies in their interaction. Population growth, land markets, and inheritance practices are best thought of as complementary (rather than substitute) explanatory variables in explaining observed regional and temporal disparities in inequality.
Appendix

Robustness Testing: Manorial heterogeneity

Table 7 documents the simulation’s sensitivity to changes in the parameters related to parameters that may be effected by our inability to control for manorial heterogeneity.

<table>
<thead>
<tr>
<th>Hundred Rolls Target</th>
<th>Large 11 - 14%</th>
<th>Middle 7 - 10%</th>
<th>Small 76 - 82%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline simulation</td>
<td>12%</td>
<td>10%</td>
<td>78%</td>
</tr>
</tbody>
</table>

### Consumption Smoothing

<table>
<thead>
<tr>
<th>Parameter Description</th>
<th>Large 11%</th>
<th>Middle 15%</th>
<th>Small 89%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Poolinga</td>
<td>13%</td>
<td>14%</td>
<td>73%</td>
</tr>
<tr>
<td>Increase rate of poolingb</td>
<td>12%</td>
<td>15%</td>
<td>73%</td>
</tr>
<tr>
<td>Pooling twice as costlyc</td>
<td>13%</td>
<td>9%</td>
<td>78%</td>
</tr>
<tr>
<td>Pooling half as costlyd</td>
<td>11%</td>
<td>13%</td>
<td>76%</td>
</tr>
<tr>
<td>No storagee</td>
<td>11%</td>
<td>10%</td>
<td>89%</td>
</tr>
<tr>
<td>Store twice as muchfe</td>
<td>10%</td>
<td>15%</td>
<td>75%</td>
</tr>
<tr>
<td>Depreciation twice as highg</td>
<td>10%</td>
<td>10%</td>
<td>80%</td>
</tr>
<tr>
<td>Depreciation half as highh</td>
<td>11%</td>
<td>17%</td>
<td>72%</td>
</tr>
<tr>
<td>No labor marketi</td>
<td>10%</td>
<td>10%</td>
<td>80%</td>
</tr>
<tr>
<td>Higher wage ratesj</td>
<td>11%</td>
<td>13%</td>
<td>76%</td>
</tr>
<tr>
<td>Lower wage ratesk</td>
<td>11%</td>
<td>11%</td>
<td>78%</td>
</tr>
</tbody>
</table>

Sim a: Agents pool 0% of their net harvest.
Sim b: Agents pool 10% of their net harvest.
Sim c: The administration of pooling costs 20% of the pool’s assets.
Sim d: The administration of pooling costs 5% of the pool’s assets.
Sim e: Agents store 0% of their net harvest.
Sim f: Agents store 10% of their net harvest.
Sim g: The rate of depreciation on stored grain is 40%.
Sim h: The rate of depreciation on stored grain is 10%.
Sim i: There is no labor market, agents are unable to earn labor income.
Sim j: Wages are 30% higher.
Sim k: Wages are 30% lower.
Robustness testing: geographic heterogeneity

Table 8 documents the simulation’s sensitivity to changes in the parameters related to production, the land market, size of the vill, and inheritance rules.

<table>
<thead>
<tr>
<th>Hundred Rolls Target</th>
<th>Large 11 - 14%</th>
<th>Middle 7 - 10%</th>
<th>Small 76 - 82%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline simulation</td>
<td>12%</td>
<td>10%</td>
<td>78%</td>
</tr>
<tr>
<td><strong>Production Parameters: Initial seeds</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% smaller vill (fewer agents)$^a$</td>
<td>13%</td>
<td>15%</td>
<td>72%</td>
</tr>
<tr>
<td>100% larger vill (fewer agents)$^b$</td>
<td>10%</td>
<td>12%</td>
<td>78%</td>
</tr>
<tr>
<td>Price of land twice as high$^c$</td>
<td>12%</td>
<td>14%</td>
<td>74%</td>
</tr>
<tr>
<td>Price of land half as high$^d$</td>
<td>14%</td>
<td>11%</td>
<td>75%</td>
</tr>
<tr>
<td>20% lower mean harvest$^e$</td>
<td>11%</td>
<td>15%</td>
<td>74%</td>
</tr>
<tr>
<td>20% higher mean harvest$^f$</td>
<td>13%</td>
<td>13%</td>
<td>76%</td>
</tr>
<tr>
<td>Double rate of assarting$^g$</td>
<td>15%</td>
<td>12%</td>
<td>73%</td>
</tr>
<tr>
<td>Half rate of assarting$^h$</td>
<td>11%</td>
<td>8%</td>
<td>81%</td>
</tr>
<tr>
<td>Primogeniture$^i$</td>
<td>9%</td>
<td>9%</td>
<td>72%</td>
</tr>
</tbody>
</table>

**Sim a:** Reduce the number of agents by 50%, preserves shape of distribution.
**Sim b:** Double number of agents, preserves shape of distribution.
**Sim c:** Land sells for 20 year purchase price.
**Sim d:** Land sells for 5 year purchase price.
**Sim e:** Mean harvest is 92 units.
**Sim f:** Mean harvest is 130 units.
**Sim g:** Vill assarts 5 acres per annum.
**Sim h:** Vill assarts 1 acre per annum.
**Sim i:** Eldest heir is bequeathed one virgate, all others receive a fraction of remaining land.
References


