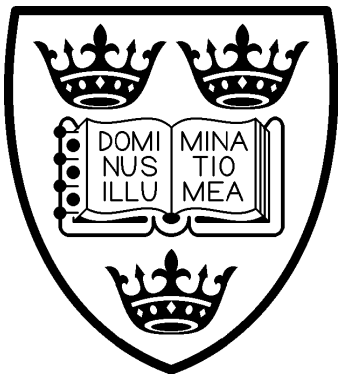

UNIVERSITY OF OXFORD

Discussion Papers in Economic and Social History

Number 79, October 2009

RISK, ASSET MARKETS AND INEQUALITY: EVIDENCE FROM MEDIEVAL ENGLAND

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Abstract

Between the eleventh and fourteenth centuries English peasants faced large income shocks relative to mean incomes. Innovations in property rights over land induced peasants to respond by trading small parcels of land as part of their risk coping strategy. The same period witnessed a dramatic increase in inequality in the distribution of peasant landholdings. We argue that these events are related. When agents are able to trade their productive assets to manage risk, wealth dynamics become unstable and generate increasing inequality over time. We analyze the effects of these dynamics in the context of medieval English land markets and peasant landholdings.

Introduction[1]

During the 12th and 13th centuries the English peasantry experienced large increases in poverty and inequality. The Domesday survey of 1086 indicates that the vast majority of free peasant households held land sufficient to generate income levels above subsistence by working their own holdings exclusively. In contrast the Hundred Rolls survey of 1279-80 indicates that, depending on estimates of the number of landless peasants, only 15 to 30 percent of free peasant households held plots large enough that they could achieve subsistence without supplementing harvest realizations with wage income.

Dyer (2002, p. 183) argues 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." This growing inequality strained medieval English society and threatened the survival of the poorest, "Those numerous villagers with a few acres or a cottage were dependent for their living on wage-earning...the purchasing power of the daily wage—the amount of food that a worker could buy after a day's work—shows that a very low point was reached in the 1270s...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). One of the mysteries of the middle ages is how this group of peasants survived. In an inter-generational sense they did not; evidence on differential fertility rates indicates smallholders failed to reproduce themselves.[2]

We argue that the dominant cause of the observed changes in the distribution of land was peasant demand for insurance through land market transactions. Twelfth century land market reforms (see Campbell, 2005a) allowed free peasants to more easily trade land in response to bad harvest realizations, creating a path dependent sequence of land holdings leading to increased inequality. The land market reforms were not extended to peasants of unfree status, for whom land transactions in customary land continued to be confounded with rights over personal obligations. Consistent with our analysis, the aggregate distribution of customary land changed very little.

Recent work in development economics has explored the relationship between inequality and market activity,[3] including the role played by incomplete markets[4] and the interac-

[1]This paper has benefited from comments and suggestions from audiences at an ASSA Cliometric session in Chicago (2006), the CNEH Conference in Montreal (2008), and Oxford University (2008). We are indebted to Bruce Campbell, Jeff Dunbar, Rui Esteves and Alex Karaivanov for comments and encouragement. Rick Bekar helped with coding the simulations. Tamma Carleton provided valuable research assistance. All are absolved of responsibility.

[2]Dyer (1989) finds evidence that large wealthy peasants produced more surviving heirs than poor peasants. In his analysis of court roll data Razi (1981) finds a strong correlation between fertility and landholdings in 14th century Halesowen. Analyzing wills in a later period Clark and Hamilton (2006) find a positive relationship between fertility and broad measures of wealth.

[3]Fafchamps (2005) models the empirical relationship between asset trading and inequality. See also Dercon (2005), Mookherjee and Ray (2001) and Carter and Zimmerman (2003).

[4]Heaton and Lucas (1996) and Fafchamps (1999).

tion of market and non-market activities.[5] Improvements in the market for freehold land and the subsequent increase in inequality in landholdings present an exceptional opportunity to explore the empirical relationship between asset markets and increased wealth inequality. How large is the asset market effect in an historical application? Can risk management through asset transfers generate inequality without assuming that the risk coping strategy of the rich differs from that of the poor?[6]

We use simulation analysis to generate estimates of the quantitative impact of land trades (motivated by behaviour toward risk) on the distribution of landholdings. Starting with estimates of the distribution of free peasant landholdings at the time of Domesday (1086), we benchmark the simulation by replicating the distribution of freehold land in the Hundred Rolls survey (1279-80) and the time path of population growth over the period. Counterfactual simulations reveal that:

1. Land trades generated large increases in inequality and poverty between Domesday and the Hundred Rolls.

2. Population growth coupled with partible inheritance—traditional variables used to explain the increased inequality in landholdings—generated only marginal increases in inequality and poverty between Domesday and the Hundred Rolls.

3. The interaction of land trades, differential fertility by landholding class, and partible inheritance was an important source of increased inequality between Domesday and the Hundred Rolls.

In section 2 we summarize the estimates of the changing distribution of land between Domesday and the Hundred Rolls. In section 3 we review previous explanations and develop our own. In section 4 we present our simulation results. Section 5 summarizes our findings and sketches potential extensions.

[5] Croix and Doepke (2003) and Piketty (1997).

[6] For example, see Zimmerman and Carter (p. 234). In our model peasants store grain, pool harvests, and buy and sell land. They are homogenous with respect to access to risk coping strategies.

The Data

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 eleventh century and the end of the thirteenth century.[7]

Three sets of observations present data on the distribution of land holding over this period: (i) the Domesday survey of 1086;[8] (ii) Postan's (1966) sample of 104 manors drawn from the late twelfth and thirteenth centuries; (iii) the Hundred Rolls of 1279-80.[9]

Changing distribution of peasant land, 1100 to 1300

We assume a standard holding (virgate) of 30 acres.[10] Peasants are categorized as largeholders (a full virgate or more), middleholders (one-half to a full virgate), or smallholders (less than one-half virgate). Largeholders could expect to produce a relatively large surplus in an average year—after paying for hired labor—and rarely faced subsistence crises, even during bad harvests. Middleholders—working their own land exclusively—could expect to "have broken even in normal years" (Dyer, 1989, p. 117), relying on alternative sources of income during bad harvests. Smallholders were unable to make a living on their own holding and led "a precarious existence relying on wages because of the small contribution that their land made to their income" (Dyer, 1989, p. 118). Smallholder households were es-

[7]Fragmentation refers to the proliferation of non-standard holdings and is minimized when each peasant possess a multiple of a standard holding. Inequality refers to an increase in the measured gini coefficient. Our focus in this paper is on inequality.

[8]The 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).

[9]The surveys of vills contained in the Hundred Rolls yield data on both large ecclesiastical manors and also small knightly manors. The area covered was biased towards the highly manorialized vills of central England and includes the following counties: Cambridgeshire, Huntingdonshire, Warwickshire, and some of Oxfordshire. The Hundred Rolls resulted from government commissions attempting to establish rights of the crown and other lords. Previous to Kanzaka (2002) the standard reference was Kominsky (1956).

[10]This is a common assumption in the literature (Dyer (1989); Razi (1981)). In practice standard holdings varied over time and between manors. However, Dyer (1989, p. 119) notes that "Fortunately such units tend to average around 30 acres for a yardland or 15 acres for an oxgang, so in large-scale comparisons the local differences are reduced in importance." Further the problem for measuring inequality is lessened by the relationship between virgate size and the fertility of the soil (see Vinogradoff (1905, p. 162)). Harvey (1984, p. 11) notes that, "At Gillingham (Kent) the yokes demonstrably varied in size, apparently reflecting the varying quality of the soil." In all cases, a peasant household holding a virgate or more of land was considered well-off, ½ virgate indicated a marginal farming existence, and less than ½ virgate implied wage labour and poverty.

Table 1: Distribution of land among unfree tenants

Source (Date)	Largeholders	Middleholders	Smallholders & landless
Domesday survey(1086)[a]	19%	37%	44%
Postan (late 12th & 13th cent.)	22%	33%	45%
Hundred Rolls (1279-80)	22%	31%	47%[b]

a. The Domesday results follow from a two-step process. We first calculate the size of the population categories: villani (109,000, 41% of rural population, held 45% of land); bordari and cottars (87,000, 32% of rural population, held 5% of land); liberi homines and sokemen (37,000, 14% of rural population, held 20% of land); servi (28,000, almost always landless, "full-time workers on the land of their lord"); and, "a few minor groups of small moment" (Miller and Hatcher, 1978, p. 22). Second we allocate land among villani: 1/3 held between 1 and 2 virgates, 2/3 held between half and 1 virgate (from Middlesex Domesday, see Miller and Hatcher, p. 24).
b. Allocation of unfree smallholders from Kanzaka (2002): 6 percent held between 10-15 acres, 5.5 percent held between 6 to 10 acres, 14.2 percent held between 1 and 6 acres, 21.7 percent held less than 1 acre.

sentially wage laborers, working from one-third to one-half the year for others even during good harvests (see Britnell (2004, p. 172), Dyer (1989, p. 117), and Kitsikopoulos (2000) who find a significant change in labor market activity when holdings fall below one-half the standard holding).

The least problematic comparison is between customary holdings (land held by villeins/unfree peasants) at the time of Domesday and the Hundred Rolls. Table 1 shows only a slight increase in inequality over the period for this group. Measuring the change in landholdings among free tenants is more difficult. While the Hundred Rolls reveals a detailed distribution for freehold land, the Domesday survey does not. Nevertheless, observations from the Domesday survey constrain the possible dimensions of the distribution. Freeholders (liberi homines and sokemen) constituted 14 percent of the rural population and held 20 percent of the land. 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" [and 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) notes 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."[11]

[11]Postan (1966, p. 618) defines his categories as follows: the "middle" grouping of peasants is comprised of "men in possession of customary holdings larger than those of substantial cottagers holding quarter virgates but smaller than those of full-fledged villains with entire virgates and more." This implies a rough correspondence to the categories used in the Domesday survey.

Table 2: Distribution of land among free tenants

Source (Date)	Largeholders	Middleholders	Smallholders & landless
Domesday survey (1086)	50.0%	40.0%	10.0%
Hundred Rolls (1279-80)	18.4%	11.6%	70.0%

It appears reasonable, therefore, to infer that the distribution of land among free peasants was similar to that of villani, but with more largeholders and few smallholders. As a starting point, we propose the following distribution of land among free peasants at the time of Domesday: 50% greater than one virgate, 40% between one-half and one virgate, and 10% less than one-half virgate.

At the time of Domesday around 10% of peasants were classified as servi. These peasants did not hold land and instead worked exclusively for the lord of the manor. They are not included in Tables 1 and 2 for two reasons: the comparison surveys do not include landless peasants, and servi probably disappeared soon after the Domesday survey.[12] At the time of the Hundred Rolls, however, many peasants had become landless. Estimating the number of landless in 1279-80 with precision is not possible since the Hundred Rolls only report peasants with positive landholdings. It is well accepted, however, that the number of landless increased over time. 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." They provide the example of Wotton Underwood in early 14th century: the village population included 22 tenants of land and also "31 valetti who appear to be landless." Razi (1981, p. 5) finds that in a roughly 50 year period (Halesowen from 1270 to 1320), 30% of landed families became landless. Over the period 53 of 174 landholding families lost the entirety of their holdings, with 0% of wealthy families becoming landless, 10% of middling families becoming landless, and 65% percent of the poor families becoming landless.

Table 3 provides a distribution of landholdings for free peasants for alternative assumptions about the number of landless. Assuming, conservatively, that 30% of free peasants were landless, the target of our simulation is: 12.8% largeholders, 8.2% middleholders, 79% smallholders.

[12] Miller and Hatcher (1978, pp 24-5).

Table 3: Distribution of land among free tenants, including landless

Source	Largeholders	Middleholders	Smallholders & landless
Domesday	50.0%	40.0%	10.0%
Hundred Rolls			
0% Landless	18.4%	11.6%	70.0%
10% Landless	16.5%	10.4%	73.1%
20% Landless	14.4%	9.3%	76.1%
30% Landless	*12.8%*	*8.2%*	*79.0%*
40% Landless	11.1%	6.9%	82.0%
50% Landless	9.3%	5.7%	85.0%

Theories of Medieval Land Distribution

The dominant explanation for increasing inequality in landholdings is population growth coupled with partible inheritance.[13] Supplemental explanations derive from the following correlations: (i) the percentage of smallholdings was highest in areas characterized by commercial development, freehold tenure, and recent assarts (i.e., land cleared for arable production); (ii) the percentage of smallholdings was lowest in traditional manorial areas characterized by strong lordship (Dyer, 1989, pp. 119-20).

Little progress has been made in apportioning relative weights to the quantitative impact of population growth and/or partible inheritance.[14] There is reason to believe, however, that the effect of population growth and partible inheritance on inequality was relatively small. First, since every surviving heir inherits land, partible inheritance cannot easily explain an increase in landlessness. Second, population growth resulted from wealthy families having large numbers of surviving children, smallholders as a group were not able to produce enough surviving children to replace themselves (Clark and Hamilton, 2006; Dyer, 1989, p. 134). Thus while partible inheritance might explain why there were so few families farming very large holdings, it has difficulty explaining the rate of increase in the percentage of smallholders. Furthermore, there is evidence that vills, similar in all respects but inheritance rules, produced similar levels of inequality.[15] Medieval peasants could and did distribute bequests of land to their children prior to dying. It would seem that preferences for egalitarian bequests were not constrained by the dictates of the legal environment with regard to inheritance at the time of death.[16]

[13]For summaries of existing explanations see Miller and Hatcher (1978); Dyer (1989, 2002); Hatcher and Bailey (2001); Britnell (2004).

[14]See, for example, Miller and Hatcher (1978, pp. 45-59 and pp. 134-39), Dyer (1989, pp. 119-20), Whittle (2000, pp. 85-100).

[15]In discussing the effects of partible 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." Williamson's analysis of Norfolk manors finds that land in Sedgeford, which practiced impartible inheritance, showed no less fragmentation then Gressenhall and Martham.

[16]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).

English Medieval land markets and risk

Elsewhere (Reed and Bekar, 2003; Bekar and Reed, 2003) we demonstate that the buying and selling of land was an effective method for peasants to mitigate subsistence crises relative to other forms of insurance, and that this explains why English peasants held their land in small scattered strips. The link to inequality in landholdings is straightforward. Those who sell land in period t (the unlucky) are more likely sellers in period $t+n$; their diminished land position today increasing the probability of a subsistence crisis tomorrow. Similarly, those who buy in t (the lucky) are more likely buyers in $t+n$. Campbell (1984, p. 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." In this way consumption smoothing through land trades produces a more unequal distribution of land holdings through time.

Our theory requires the existence of a land market that allowed peasants to effect marginal changes to their land position in times of crisis. In English medieval land markets: (i) transactions were dominated by the frequent and extensive exchange of small parcels of land; (ii) bad harvest years were correlated with high levels of land market activity; (iii) land transactions were dominated by sales between families, not within families; (iv) land transactions were dominated by transfers of arable land.

A natural question concerns the distribution of land at the time of Domesday: why was it ever relatively equal? Low transaction costs in the land market were not realized until the reforms of Henry II (1160 to 1170) separated land title for freehold land from personal obligations (Campbell, 2005). The relative lack of inequality in traditional manorial regions is explained by the fact that manorial lords resisted the fragmentation of holdings as a means of minimizing administration costs (Campbell, 2005, p. 46). Additionally, static efficiency required the minimization of (formal or informal) labour sharing across households. labour sharing involved high transactions costs due to induced shirking and high monitoring costs.[17] Maximizing current output, by allocating land such that most households were fully employed on their own holding, pushed the distribution of land towards equality.

Consider the application of these ideas to land allocation in the middle ages. Before 1100 property rights in land titles hindered transferability and so trading land was expensive. Consumption smoothing was largely accomplished through charity and reciprocal exchange in what Dyer (1989, p. 257) refers to as "networks of neighbors and friends"—a method of smoothing that is distributionally neutral over time.[18] In this period static effi-

[17] High transaction costs in the labour market are a central focus in Fenoaltea (1975) and the Chayanov thesis (see Smith, 1984). We interpret Dyer's (1989, Chapter 5) discussion of the "normal" workings of the peasant land market in this light.

[18] From Fafchamps (2005), "With perfect pooling of risk, individual consumption is only a function of aggregate income... even though individual consumption and welfare might change over time (as aggregate resources expand or dwindle), inequality remains constant in some fundamental sense." For a general dis-

ciency considerations determined the distribution of peasant land. By 1170 the emergence of more efficient land markets made trading land much less expensive for free peasants. Concurrently, population growth led to an increase in the coefficient of variation in harvests. Dynamic risk considerations came to dominate static efficiency considerations in the allocation of land.

The Model

Formally the peasant's problem is,

$$Max \sum_{t=0}^{T} \beta^t U(c_t)$$

subject to,

$$c_t \leq H_t + \ell_t + w_t + k_t + \rho_t$$
$$H_t = F(L_t) + \varepsilon_t$$
$$k_t = sH_{t-1} + (1-\delta_s)k_{t-1}$$
$$\rho_t = \left[\sum_{n=1}^{N} pH_t\right](1-\delta_p)$$
$$\ell_t = [p_l l_t](1-\delta_l)$$

where,

$$L_t = L_{t-1} + l_{t-1}$$

with the solution taking the form of,

$$c_t^* = c(L_t, k_t, \rho_t, \ell_t, w_t)$$

Where H is harvest income as a function of landholdings (L), ℓ income/spending from land sales/purchases ($l_t < 0$ if agent buys land, $l_t > 0$ if agent sells land), w wage income, k grain stores, ρ pooling contribution/receipt (all in the appropriate period t).[19] As the peasant's maximization problem makes clear, current landholdings are a function of harvest histories which are in turn a function of past landholdings.

We simulate the model employing an agent based modeling strategy in which decisions regarding pooling, saving, labour supply, and land transactions are rule based.[20] Agents are initially endowed with an exogenous landholding. Each period agents draw a harvest realization from a random normal distribution transformed by the requisite mean and vari-

cussion of the concept of reciprocal exchange see Kranton (1996), for its application to medieval history see Kimball (1988), and Reed and Bekar (2003).

[19]Where p = rate of pooling out of current harvest, p_l = price of land, l_s= land sales/purchases, s = rate of storage, δ_s = cost of storage, δ_p = cost of pooling, and δ_l = cost of land market. See table 6 in the Appendix for the parameter values in the standard simulation.

[20]The simulation is coded in Java and employs the REPAST libraries—Recursive Porous Agent Simulation Toolkit—developed at the University of Chicago and Argonne National labouratory (http://repast.sourceforge.net). We show in the appendix that our simulation results are robust to alternative rules.

ance.[21] Harvests are independent across agents and through time.[22] Agents pool and save out of current harvests. Smallholders work in the labour market; largeholders hire labour.[23] Incomes are compared to a subsistence consumption bundle. An agent facing a subsistence crisis with a positive land position offers a parcel of land for sale.[24] If, after depleting their land position, the agent is is still below subsistence it experiences a subsistence crisis. An agent sufficiently above subsistence (one half a standard deviation) purchases parcels offered for sale. Agents sell land only when all other forms of insurance have been exhausted and they still face a serious subsistence crisis—treating land sales as an insurance mechanism of last resort.[25]

Population growth occurs continuously. Poor peasants produce heirs as a function of their landholdings, with largeholders producing more heirs than smallholders.[26] If more than one heir is produced the agent's landholding is divided according to specified inheritance rules. A household producing no heir has their land position added to the supply of land.

The sequence of harvest histories determines the distribution of landholding through two channels of effect:

1. **Land Market Effect**: Increasing the incidence of distress land sales increases the rate at which largeholdings are accumulated and small- and middleholdings broken up (increasing inequality and poverty).

2. **Demographic Effect**: Increasing average fertility in the population increases the rate

[21] We use the production parameters from the literature on open fields (McCloskey 1975a, 1975b, 1976, and Bekar 2001) to parameterize our simulation. A virgate is 30 acres and produces a mean harvest of 110 units of grain with a variance of 48.4. A subsistence harvest is 55% of output on a standard virgate.

[22] In testing for robustness (see appendix) we incorporate historical data on the frequency of aggregate shocks and find little change in our simulated results.

[23] When a peasant's holding falls below 15 acres, the peasant works as a wage labourer; when a peasant's holding exceeds 35 acres, the peasant hires wage labourers. Wages are constant and exogenous.

[24] From Harvey (1984), land sells at a 10 years purchase price. Agents buy and sell in ¼ acre fragments. Peasants typically bought and sold very small parcels of land. While smaller parcels are observed in the literature, ¼ acre is a defensible average (see Harvey 1984 and Smith, 1984).

[25] Modeling land sales this way reduces the impact of the land market relative to other possible rule specifications. We argue the rule models the agent's appreciation of the intertemporal nature of the risk environment (selling land today increases subsistence risk tomorrow), and is reflected in the tradition of "familial land." Razi (1981, p. 6) notes that "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."

[26] In 14th century Halesowen Razi (1981, p. 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...". Clark and Hamilton (2006) provide evidence on completed family size and levels of wealth. Smith (1984) provides actuarial estimates of producing more than a singe heir based on survivability (probability a child survives to the death of father) and number of children. See also Dyer (1989). Combining these estimates suggest that the probability small- and middleholders produced two male heirs is quite low; largeholders would produce two male heirs with some regularity.

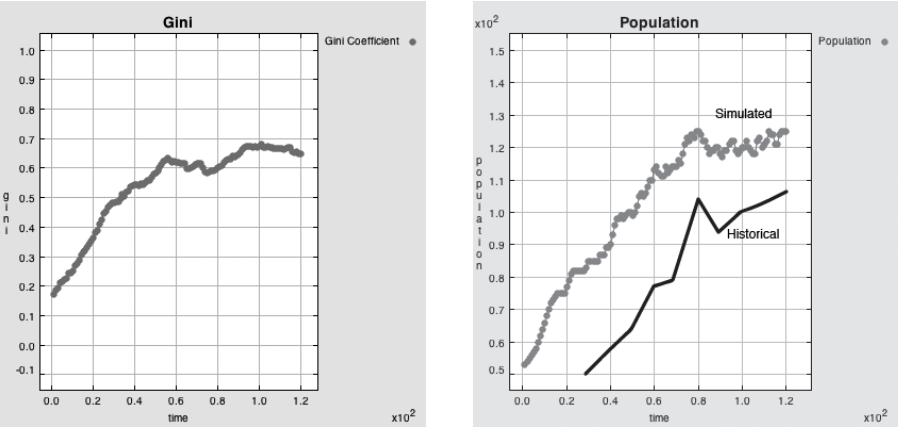
at which largeholdings are broken up (decreasing inequality).

The land market and demographic effects interact. By facilitating the accumulation of largeholdings land markets tend to increase population fertility, strengthening the demographic effect. By breaking up largeholdings population growth tends to increase the number of smallholders, strengthening the land market effect.[27]

Simulating the Hundred Rolls

We now simulate the period between the land reforms of 1170 and the Hundred Rolls of 1289. The simulation is seeded with a population of 50 agents distributed according to Table 2 (25 smallholders, 20 middleholders, 5 largeholders) and iterated 120 periods. Figure 1 shows the evolution of the gini coefficient and population over a 120 year sample run.

Figure 1: Sample Run: Evolution of gini and population over 120 years



Since population is normalized to 50 agents, simulated population levels are not directly comparable to historical populations. We do, however, benchmark our fertility parameters to produce historically consistent population growth rates.[28] We produce a distribution of estimates by generating 100 runs of the simulation. Table 4 reports the central estimate for each landholding category and the standard deviation around that estimate.

[27]From Razi (1981, p. 9) "[Halesowen] court records show clearly that kulaks usually accumulated land from their unfortunate neighbours. Yet...the size of their holdings remained remarkably stable. This happened because the rich villagers who had usually more than one adult child to provide for used the additional land they had acquired to endow their non-inheriting siblings."

[28]The reporting of 12th century English populations was inconsistent in its geographic coverage and collection methodology. See Britnell (2004, p. 81) for summary estimates of population growth. Titow (1961) reports an annual growth 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, consistent with reported changes from Wrigley et al (1997) (the source of the historical series in Figure 1).

Table 4: Simulating the Hundred Rolls

Landholding	Hundred Rolls (Kanzaka)	Sim Average	Sim Std Dev
0-1 acres	66.4%	64.43%**	2.68
1-6 acres	16.2%	2.97%	1.11
6-10 acres	5.4%	6.38%**	1.93
10-15 acres	3.3%	5.74%*	1.37
15-20 acres	4.4%	4.33%**	1.63
20-30 acres	1.3%	6.70%	1.68
30-40 acres	4.2%	3.56%**	1.36
40+ acres	5.1%	5.89%**	1.07

* average of 100 runs within two standard deviations of measured, ** average of 100 runs within one standard deviation of measured.

Collapsing the distribution from Table 4 into our broader categories yields table 5.

Table 5: Distribution of land among free tenants

Source	Largeholders	Middleholders	Smallholders & landless
Domesday survey	50.0%	40.0%	10.0%
Hundred Rolls	12.8%	8.2%	79.0%
Simulated	9.5%	11.0%	79.5%

The simulation: (i) reproduces the historical distribution of landholdings relatively well; (ii) is consistent with aggregate population changes; and (iii) is robust to alternative starting values and behavioral rules (see tables 7 and 8 in the appendix). From table 5 above we get 9.5% simulated rich versus 12.8% measured; 11% simulated middle versus 8.2% measured; and 79.5% simulated poor versus 79% measured.[29] The initial seeding of our simulation corresponds to a gini coefficient on land ownership of .135, after 120 years the gini coefficient increases to .625 (standard deviation = .026), a 413% increase in inequality.[30]

Simulated large and middle holdings experience sharp declines with a dramatic increase

[29] A possible reason for why our simulation under-predicts the extent of large holdings in the hundred rolls data is that the size of holdings was also influenced during the 13th century by an increase in sheep husbandry, a heavily land intensive activity.

[30] For comparison, 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 was .642. Sussman (2006, p. 20) reports urban income gini coefficients of .700 for London in 1292, .750 for Paris in 1292.

in smallholdings (especially those holding less than an acre). Since over 120 years the (simulated) median landholding falls to roughly 10 acres—less than half a standard virgate—the median landholder is no longer able to produce a subsistence income farming their own land. This decline in subsistence farming is mirrored by a sharp increase in simulated levels of labour market participation. By the end period of the simulation fully two-thirds of free peasant households rely almost exclusively on wage income and labour market participation increases from a little under 50% to around 90%. Increased fragmentation results in less than 5% of agents holding a multiple of a standard holding.

Counterfactual simulations

We now turn to estimating the discrete impact of the land market and demographic effects. We do this by "shutting off" one off the relevant effects, seeding the simulation with the Domesday distribution, and iterating for 120 years. We hold all parameters and rule specifications (from section 4) constant in each case.

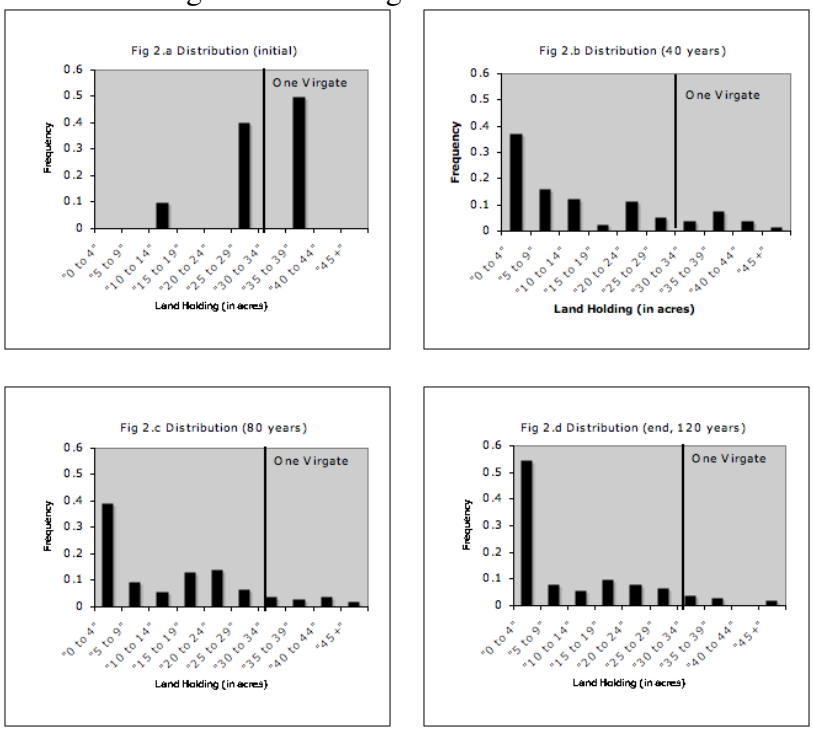
We first shut off the land market. With no land market operating the only factor impacting the distribution of land is population growth and partible inheritance. Simulating the deomographic effect alone results in a 54% increase in inequality from Domesday to Hundred Rolls (.135 to .208). The resulting distribution of landholdings is tightly clustered around a middleholding (71% of peasants hold from 6 to 10 acres, 29% hold 11 to 20 acres). All peasants hold at least 1/4 virgate and would participate in the labour market only on a part time basis, one-third of peasants would not participate in the labour market at all.

Next we shut off population growth. In the absence of population growth land trades alone determine the distribution of land, producing a 120% increase in inequality (.135 to .297). The resulting distribution of landholdings is skewed dramatically towards large holdings (44% of all peasants hold more than 40 acres, 80% hold more than 20 acres). Only 12% of peasants would have to participate in the labour market, of those half would be part time.

So roughly 15% of the total change in the gini coefficient ($\triangle$gini = .490) from Domesday to Hundred Rolls is explained by the demographic effect and 33% by the land market effect. Neither effect predicts the large rise in observed poverty (demographic effect explains 0% of landlessness, the land market effect roughly 10%). This leaves over half of the change in inequality to be explained by the interaction between land markets and demographics. Figure 2 presents a the changing distribution of land over the course of a sample run (the distribution is displayed every 40 years). The simulation demonstrates that early on the land market leads to the accumalation of some very largeholdings of more than two virgates (see Fig. 2.b); the families holding such large farms experience high fertility which tend to break up the holdings and produce a number of middleholders (holding from 15 to 25 acres); these small-scale middle holders are quite vulnerable to bad harvests which pushed

them into distress land sales with greater frequency (see Fig. 2.c). Over the last period the large numbers of peasants holding less than a virgate means the land market effect dominates, creating large numbers of smallholders (see Fig. 2.d).

Figure 2: Evolving distribution of land



Concluding Remarks

Rural England experienced a dramatic increase in the inequality of peasant landholdings between the late 11^{th} and late 13^{th} centuries. Our explanation focuses on the role of risk reduction through land transactions and differential fertility rates. We argue that free peasants were induced to include land purchases and sales in their portfolio of risk coping strategies as a result of institutional innovations that lowered the cost of operating in the land market. This created a path dependent process that generated highly unequal landholdings over time. The distribution of land for unfree peasants, whose access to the land market was far more restricted, remained relatively unchanged. Operating as an insurance mechanism the land market produced inequality and poverty by creating a large class of small holders and landless peasants.

We test our explanation by simulating the dynamics of the land market, including differential reproductive success, partible inheritance, pooling and saving behavior, production parameters linking harvest realizations through time, crisis levels of income, wage rates, and land prices. Our simulations reveal that transactions in the land market coupled with population growth produce levels of inequality and skew consistent with those observed in the data. Population growth alone, coupled with partible inheritance, can only explain a small portion of the observed inequality.

A larger perspective

Our analysis explains an important historical case of increasing inequality and poverty. Our findings also have a broader relevance. Fafchamps (2005, pp. 101-2) notes that one 'novel result' of the literature exploring incomplete markets and risk is that asset markets in which the asset is in finite supply naturally generate inequality—"From an equity point of view, there might therefore be a rationale for shutting down certain asset markets, i.e., those for which supply is finite. This is because allowing accumulation is likely to result in polarization. This conclusion applies primarily to land, manpower, mineral resources, and the environment." Our analysis of medieval English land markets is consistent with this theoretical result. While small scale land transactions constituted an effective risk coping mechanism for medieval peasantry, in the longer run these same land sales were important contributers to increased inequality and poverty.

Examining recent evidence on the relationship between globalization and inequality, Goldberg and Pavcnik (2007) find that there is little empirical support for the view that "trade openness" benefits the poor. This constitutes a potential puzzle for traditional trade theory. Goldberg and Pavcnik go on to note that recent work on liberalization and increased inequality highlight new channels of effects. They detail the role of improved capital markets, increased volatility of labour income, and the displacement of traditional informal economic activities (i.e., household production). Our results suggest a potentially interesting link between these channels. When the poor in developing countries are exposed to an

increased variance in their income (from globalized trade) at the same time that informal economic institutions that help provide economic security are under pressure, they may be induced to enter newly efficient capital markets to smooth consumption. The end result could be increased inequality similar to that created by newly efficient land markets in the Middle Ages.

Economic historians interested in economic growth over the very long run have tended to stress the benefits of liberalizing markets and improving property rights. From North and Thomas (1973) to Greif (2006) there is little discussion of the dark side of the market and its impact on inequality. If the inequality produced by institutional innovation was small and transitory, this focus on efficiency would come at little cost to our understanding of long run growth. Our analysis suggests an alternative view. Improved property rights in land created large and permanent increases in inequality. This inequality contributed to the eventual development of a commercialized English agriculture that fed the Industrial Revolution. It also helped to create the large population of landless wage labourers generally considered to be a precondition for the decline of serfdom.

Finally consider the implication of our work for a recent argument concerning the role of evolutionary biology in explaining long run growth in Europe. Clark (2007) argues that higher fertility among rich peasants and merchants largely determined the genetic make-up of the English population by the eve of the Industrial Revolution. In Clark's view, this genetic heritage included propensities to save and strive for material success in a manner conducive to growth. According to this argument the descendents of the wealthy were able to avoid violent rent seeking and instead improve their standard of living through the slow accumulation of productive assets. Our analysis suggests that, rather than being more productive, the offspring of rich peasants were simply lucky. Their ancestors had fortuitously experienced large harvest draws, had accumulated land from less fortunate peasants, and thereby had a larger number of surviving children. The English population of the Industrial Revolution were perhaps the descendants of the lucky rather than the diligent.

Appendix

Simulation parameter values

Table 6: Value of simulation parameters and their source

Parameter	Value	Source
Mean output (μ)	110	Open Field Literature, McCloskey (1976), Bekar (2001)
Variance (σ^2)	48.4	Open Field Literature, McCloskey (1976), Bekar (2001)
Subsistence income	60	Bekar (2001)
Rate of pooling (ρ)	2.5%	Bekar and Reed (2003)
Price of land (p_l)	9.16 units of output per 1/4 acre	10 year purchase price, Smith (1984)
Rate of storage (s)	2.5%	Bekar and Reed (2003)
Wage rate	1.2 units of output per unit of labour	Dyer (1989)
Cost of storage (δ_s)	20%	Bekar and Reed (2003)
Cost of pooling (δ_p)	20%	Bekar and Reed (2003)

Robustness test: alternative rules for agent behavior

Table 7 presents simulated results for different economic environments. Specifically: (i) reducing the amount of income agents use to purchase land from 50% of income above subsistence to 25%; (ii) correlating income shocks across agent households such that shocks are no longer independent.

Table 7: Robustness test for simulation results

Date (source)	More than a virgate	One to one-half virgate	Smallholder
Hundred Rolls (1279-80, assuming 30% landless)	12.8%	8.2%	79.0%
Simulated, benchmark assumptions	9.5%	11.0%	79.5%
Simualted, assume reduced budget for land purchases	10.2%	10.7%	79.1%
Simulated, assume aggregate shocks	10.7%	8.6%	81.7%

Robustness test: alternative estimates for landless peasants

Table 8 presents simulated estimates for alternative assumptions about the percentage of peasants that were landless. Different numbers of landless peasants requires running the simulation with different seeds.

Table 8: Distribution of land among free tenants, alternative seedings

Date (source)	More than a virgate	One to one-half virgate	Smallholder
Domesday survey (1086)	50.0%	40.0%	10.0%
Hundred Rolls (1279-80)			
0% landless	21.0%	13.0%	66.0%
10% landless	16.5%	10.4%	73.1%
20% landless	14.4%	9.3%	76.1%
30% landless	*12.8%*	*8.2%*	*79.0%*
40% landless	11.1%	6.9%	82.0%
50% landless	9.3%	11.3%	79.5%
Simulated with alternative Domesday distributions			
Sim [50%, 40%, 10%]	9.5%	11.0%	79.5%
Sim [60%, 30%, 10%]	8.4%	10.6%	81.0%
Sim [40%, 50%, 10%]	10.00%	15.5%	74.5%
Sim [50%, 30%, 20%]	10.5%	10.0%	79.5%

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