Distributional Dynamics in a Stochastic Environment with Tradable Assets: Medieval English Land Markets[1]

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Abstract

Between the eleventh and thirteenth 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.

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1. INTRODUCTION

Inequality has become an important focus in recent literatures in development economics[2] and globalization.[3] A subset of these literatures seeks to explain changes in inequality by analyzing the role played by incomplete markets[4] and the interaction of market and non-market activities.[5] Fafchamps (2005), for example, provides theory and examples supporting the idea that risk, asset trading, and inequality are positively related. But how big are these interactions? The changing distribution of land in Medieval England offers an exceptional opportunity to explore the empirical relationship between the emergence of a tradable asset market in land and increasing inequality.

The Domesday survey of 1086 indicates that roughly 55 percent of peasant households held enough land to produce subsistence incomes (or better) working their own holdings exclusively. In contrast, the Hundred Rolls survey of 1279-80 indicates that, depending on the estimates for landless peasants, 60 to 80 percent of peasant households held plots so small that achieving subsistence relied on income from wage labor.[6]

Our hypothesis is that the root cause of the observed increase in inequality was peasant demand for insurance through land market transactions. Twelfth century land market reforms (Campbell, 2005a) allowed free peasants to more easily trade land in

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[2] Dercon (2005), Mookherjee and Ray (2001).
[3] Goldberg and Pavcnik (2007).
[4] On the impact of incomplete markets see Heaton and Lucas (1996) and Fafchamps (1999).
[5] Croix and Doepke (2003) and Piketty (1997).
[6] We use 15 acres as the demarcation between subsistence farmers and smallholders (i.e., peasants who needed to supplement their agricultural earnings with wage labour). This is the figure used by Britnell (2004, p. 172), but there are other estimates. For example, Kitsikopoulos (2000) calculates the cutoff at 18 acres while Dyer (1989, p. 117) calculates 12 acres.

response to declining harvest conditions, creating a path dependent sequence of land holdings leading to increased inequality. But the land market reforms were not extended to holders of customary land (i.e., land held by peasants of unfree status). For unfree peasants, land transactions continued to be confounded with rights over personal obligations.

We use simulation analysis to generate estimates of the quantitative impact of land trades (motivated by behavior towards risk) on the distribution of landholdings. We first demonstrate that, in the context of the medieval economy, land transactions were capable of generating significant increases in inequality over time. Then, starting from the distribution of peasant holdings at the time of the Domesday survey, we test the ability of our simulations to replicate the distribution of holdings documented in the Hundred Rolls survey of 1279-80. Using reasonable parameter values, the predicted distribution of land for free peasants conforms closely with reality. But given the asymmetry in transferable property rights over freehold land and customary land, our simulations, as expected, significantly overestimate the degree of inequality produced amongst of unfree peasants when we allow their (counterfactual) participation in the land market.

Our simulations also allow us to perform counterfactual calculations on the differential impacts of population change, differential fertility, and inheritance rules in determining the observed changes in inequality. We find, contrary to traditional analysis, that the effects of population change and partible inheritance were minor relative to the impact of the land market.

In section 2 we summarize the estimates of the changing distribution of land between Domesday and the Hundred Rolls of 1279-80. In section 3 we review previous explanations and develop our own. In section 4 we reference relevant details of medieval English land markets. In section 5 we present our simulation results. Section 6 summarizes our findings and offers concluding remarks.

2. THE DISTRIBUTION OF PEASANT LAND, 1086 TO 1300

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 Baily (2001), and Britnell (2004). All comment on the increasing inequality and fragmentation[7] of holdings between the eleventh century and the end of the thirteenth century.[8]

For our purposes, we require data on the distribution of land holding over time. Three sets of observations fit this requirement: the Domesday[9] survey of 1086, Postan's (1966) random sample of 104 manors[10] drawn from the late twelfth and thirteenth

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[7] Inequality refers to an increase in the variance of landholdings around the mean. Fragmentation refers to the breakup of standard holdings. When all peasants possess a multiple of a standard holding there is no fragmentation; fragmentation is maximized when no peasant possesses a multiple of a standard holding.

[8] Note that the increasing inequality in landholding is also reflected in other aspects of peasant wealth: archaeological findings show increasing inequality in peasant housing (Britnell 2004, p. 175).

[9] 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).

[10] Postan (p. 618) presents data from a "random" sample of 104 manors showing the distribution of "customary" holdings.

centuries, and Kanzaka's (2002) analysis of the Hundred Rolls of 1279-80.[11]

The least problematic comparison is between customary holdings (land held by unfree peasants, also referred to as villeins) at the time of Domesday and the Hundred Rolls. Table 1 shows only a slight increase in inequality over the period.

Table 1: *Distribution of land among villein tenants*

Source (Date)	More than a virgate[12]	Between one and one-half virgate	Smallholder[13]
Domesday survey (1086)[14]	19%	37%	44%
Postan's survey (Late 12th and 13th century manors)[15]	22%	33%	45%
Hundred Rolls (1279-80)	22%	31%	47%[16]

Measuring the change in landholdings among free tenants is more difficult. Postan's sample includes only customary holdings and therefore is not relevant. While the Hundred Rolls reveals a detailed distribution for freehold land, the Domesday survey

[11] 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 Kosminsky (1956).

[12] The standard translation is one virgate = 30 acres. The size of a virgate varied with population density, land quality, proximity to market towns, etc. Kanzaka (2002, p. 596) reports a range of 40 to 15 acres across vills.

[13] "Smallholder" refers to households holding less than the minimum amount of land required to achieve subsistence in a normal year without resorting to the labor market (i.e., less than ½ a virgate).

[14] The Domesday results follow from a two-step process. The first step is to 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 hominess 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). The second step is to 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).

[15] 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.

[16] Kanzaka's allocation of unfree smallholders: 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.

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) states that there were perhaps more freemen than unfree in "the topmost layer of village society, i.e. among the few villagers with holdings of two or more virgates."

It appears reasonable, therefore, to infer that the distribution of land among free peasants was similar to that of *villani* (see footnote 14), but with more largeholders and a few smallholders. We propose the following distribution of land among free peasants at the time of Domesday: 50% greater than 1 virgate, 40% between ½ and 1 virgate, and 10% less than ½ virgate.[17]

Table 2: *Distribution of land among free tenants*

Date/source	More than a virgate	Between one and one-half virgate	Smallholder
Domesday survey 1086	50%	40%	10%
Hundred Rolls of 1279-80	18.4%	11.6%	70%

[17] In section 5 of the paper we show that our simulation results are robust to alternative distributions.

Finally, we need to consider the issue of landless peasants. 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 were 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.[18] At the time of the Hundred Rolls, however, many peasants had become landless. How many? Estimating the number of landless in 1279-80 with precision is not possible since the Hundred Rolls only reports peasants with positive landholdings. We know 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." For a later period, Razi (1981, p. 5) identifies 174 landholding families in the court rolls for Halesowen over the period 1270 to 1282. At the arrival of the Black Death 70 to 80 years later he finds that 100 percent of the rich families (23% of population) still held land, 90 percent of the middling families (37% of population) still held land, but only 35 percent of the poor families (40% of population) still held land. Applying these estimates for the rapidity with which peasants lost their land at each wealth level to our distribution of wealth implies that between 40% to 50% of peasants would have become landless between

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

Domesday and Hundred Rolls. We use an estimate of 50% landless, consistent with Miller and Hatcher's example.

Table 3 provides a combined distribution of landholdings for free peasants alone and includes the target of our simulation: 9.3% of peasants with more than a virgate, 5.7% with between ½ and one virgate, and 85% with less than ½ virgate.

Table 3: *Distribution of land among free tenants*

Date/source	More than a virgate	Between one and one-half virgate	Smallholder
Domesday survey 1086	50%	40%	10%
Hundred Rolls of 1279-80			
0% Landless	18.4%	11.6%	70%
10% Landless	16.5%	10.4%	73.1%
20% Landless	14.4%	9.3%	76.1%
50% Landless	***9.3%***	***5.7%***	***85%***

Table 4 provides a combined distribution of landholdings for all peasants with alternative assumptions about the number of landless peasants.

Table 4: *Combined distribution of holdings*

Date/source	More than a virgate	Between one and one-half virgate	Smallholder	Landless
Domesday survey 1086	16.2%	31.1%	32.4%	12.5%
Hundred Rolls of 1279-80	19.9%	20.7%	59.5%	0%
	17.9%	18.6%	53.5%	10%
	15.9%	16.5%	47.6%	20%
	10%	10.3%	29.7%	50%

3. THEORIES OF MEDIEVAL LAND DISTRIBUTION

The dominant explanation for increasing inequality in landholdings is the increasing size of the English population.[19] Supplemental explanations derive from the following correlations: (i) the percentage of smallholdings was highest in areas characterized by partible inheritance rules, commercial development, freehold tenure, and

[19] See Britnell (2004, p. 81) for estimates of population growth.

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). The role of the land market is frequently mentioned, but more so in association with population growth as an explanation for increased fragmentation of holdings. General problems with this literature are that the theoretical connections to inequality are not fully specified and that quantitative estimates of the relative importance the proposed causal variables are lacking.[20]

The causal link between the combined effects of population growth and partible inheritance on inequality is encumbered with specific empirical difficulties. First, since every surviving heir inherits land, partible inheritance cannot easily explain an increase in landlessness. Second, as a group, smallholder peasants were not able to produce enough surviving children to replace themselves (Clark and Hamilton, 2006). Population growth was mainly due to wealthy families having large numbers of surviving children. Partible inheritance might be able to explain why there were so few families farming very large holdings, but it has difficulty explaining the rate of increase in the percentage of smallholders and the observed increase in skewness of landholdings at all sizes. Further, vills similar in all respects but inheritance rules produced similar levels of inequality.[21] Medieval peasants could and did distribute bequests of land to their children while alive as well as at the time of death. It would seem that preferences for egalitarian bequests were not overly constrained by what the legal environment dictated with regard to

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[20] For summaries of the alternative explanations see Miller and Hatcher (1978), Dyer (1989, 2002), Hatcher and Baily (2001), Britnell (2004).

[21] In her analysis of Norfolk manors Williamson (1984) finds that land in Sedgeford, which practiced impartible inheritance, showed no less fragmentation then Gressenhall and Martham.

inheritance at the time of death.[22] Finally, little progress has been made in apportioning relative weights to the quantitative impact of population growth and/or partible inheritance.[23]

Our explanation for the increased inequality in holdings centers on the role of land transactions motivated by consumption shocks. In previous work (Reed and Bekar, 2003; Bekar and Reed, 2003) we have argued that peasant survival depended on their ability to avoid consumption realizations below subsistence, and that buying and selling land was an efficient method of accomplishing this task. The link to inequality in landholdings is straightforward. Those who sell land in any period t (the unlucky) are more likely to be sellers in period $t+n$ since their diminished land position increases the probability their income draw in $t+n$ will be low. For similar reasons, those who buy in t (the lucky) are more likely buyers in $t+n$. Thus consumption smoothing tended to create an unequal distribution of land as peasants bought and sold land to smooth exogenous idiosyncratic shocks to their income.

A question naturally arises of why landholdings were more equal at the time of Domesday, why was extreme inequality not always the case? The answer is related to the relative stability of the distribution of land among unfree tenants. One argument is that low transaction costs in the land market were not realized until the reforms of Henry II

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[22] In discussing the effects of partible inheritance on land fragmentation 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." Razi (1981) provides extensive evidence of land provided to non-inheriting heirs in 13th century Halesowen. Examples of egalitarian inheritances to daughters through dowries are documented and analyzed in Botticini (1999) and Botticini and Siow (2003).

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

(1160 to 1170) separated land title for freehold land from personal obligations. This also helps explain the greater increase in inequality over time for freehold land compared to customary land (over which land title continued to be insecure and therefore involved higher transaction costs in the land market). Another argument focuses on static efficiency considerations, where static efficiency refers to the maximization of current output for a given bundle of inputs and technology. Manorial lords resisted the fragmentation of holdings as a means of minimizing administration costs (Campbell, 2005a. p. 46). This implies that, other things equal, there should have been less fragmentation in traditional manorial regions, a fact observed in the data. We would add that another important aspect of static efficiency was the minimization of labor sharing across households. Labor sharing—either informal or formal (through labor markets)—involved high transactions costs due to induced shirking behavior.[24] By allocating land such that most households could be fully employed on their own holding, medieval agricultural organization pushed the distribution of wealth towards equality.[25]

Consider the application of these ideas to land allocation in the middle ages. Around 1100 exchanging land was expensive because land titles were confounded with personal obligations. Smoothing was largely accomplished through charity and reciprocal exchange (i.e., gift exchange, also called informal pooling) in what Dyer (1989, p. 257) refers to as "networks of neighbors and friends"—a method of smoothing distributionally

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[24] High transaction costs in the labor market are a central focus in Fenoaltea (1975). They are also central to 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.

[25] Allen and Lueck (2002) argue that expensive monitoring of labor effort, along with small gains from specialization in production still drives much of North American agricultural organization in the form of the "family farm."

neutral over time.[26] As a result static efficiency considerations dominated the distribution of peasant land and most households cultivated holdings between 15 to 30 acres. By 1170, the emergence of more efficient land markets made exchanging land much less expensive, at least for free peasants. At the same time population growth resulted in the cultivation of marginal land, thus increasing the size of output shocks relative to mean output, increasing the need for smoothing. Consumption smoothing through land transactions dominated the determination of land allocation and holdings become more unequal.

4. THE MEDIEVAL LAND MARKET

Our theory requires the existence of a land market that allowed peasants to effect marginal changes to their land position in times of crisis. As we have noted, transferable property rights in freehold land were in place by the second half of the 12th century (Campbell, 2005a). We argue (Bekar and Reed, 2003 section 6.a) that peasants, in fact, insured through land market transactions, that such insurance was efficient relative to other forms of self-insurance, and that these facts might explain why English peasants held their land in small, scattered strips distributed throughout the open fields.

We also document the following attributes of English medieval land markets (Bekar and Reed, 2003 section 6.b): (i) transactions were dominated by the exchange of small parcels of land, such transactions were frequent and extensive; (ii) bad harvest

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

years were correlated with high levels of land market activity; (iii) land transactions were dominated by sales between families, not among families; (iv) land transactions were dominated by transfers of arable land.

5. THE SIMULATED ECONOMY

Formally the peasant's problem is,

$$Max \sum_{t=0}^{T} \beta^t \mathrm{U}(\mathrm{c}_t)$$

subject to,

$$c_t \le H_t + k_t + \rho_t + \ell_t + w_t$$

$$H_t = F(L_t) + \varepsilon_t$$

$$k_t = sH_{t-1} + (1-\delta_s)k_{t-1} \qquad \text{with } c_t \ge d \text{ and 0 otherwise}$$

$$\rho_t = \left[\sum_{n=1}^{N} pH_t\right](1-\delta_p) \qquad \text{if, } c_t \ge d \text{ and 0 otherwise}$$

$$\ell_t = \left[p_l l_s\right](1-\delta_l) \qquad \text{with } \ell_t > 0 \text{ if seller, } \ell_t < 0 \text{ if buyer}$$

with the solution taking the form,

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

Where H is the peasant's income (harvest) as a function of their landholding (L), k their store of grain, ρ the contribution/transfer from pooling, ℓ income from land sales, and w wage income (all in the appropriate period t).[27] From the peasant's maximization problem it is clear that current landholdings are a function of past harvest realizations, which are in turn a function of past landholdings. The sequence of landholdings for any peasant is therefore a path dependent process with multiple equilibria. The complexity of the consumption smoothing environment renders analyzing closed form solutions

[27] Further, 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.

difficult. We therefore adopt a simulation strategy that captures the peasant's problem, tracking landholdings through time from a given starting distribution.

Agents are initially endowed with an exogenous landholding.[28] In each period peasants draw a harvest realization as a function of their landholding from a random normal distribution transformed by the requisite mean and variance.[29] Shocks are idiosyncratic.[30] Peasants pool and save out of current harvests.[31] Harvests are compared to a subsistence consumption bundle.[32] Smallholders work in the labor market; largeholders hire labor.[33] If an agent faces a deficit harvest, and has a positive land position, the agent offers a parcel of land for sale.[34] If, after selling all available land, the agent is still below subsistence the agent is counted as having experienced a subsistence crisis. Assuming a positive supply, an agent sufficiently above subsistence purchases a parcel of land. Population growth occurs once a 'generation.' Poor peasants produce heirs as a function

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[28] The poor are evenly distributed between 5 and 7.5 acres, one-quarter of middle holders get 10 acres three-quarters get 20 acres, all largeholders receive 30 acres.

[29] We use the production parameters from the literature on open fields (McCloskey 1975a, 1975b, 1976; Bekar 2001) to parameterize our simulation.

[30] Following McCloskey (1976, see pages 136-40) we ignore price uncertainty and shocks to labor. This abstracts from important components of the risks faced by peasant families. The assumption of no price risk greatly simplifies our simulations and makes them much easier to integrate into the existing literature.

[31] Consumption smoothing is rule based, agents pool and save fixed amounts of their harvests. They do not engage in intertemporal utility maximization. This assumption—that peasants are motivated by a safety first decision rule, that they are only concerned with minimizing the probability of disaster—means that competing risk coping alternatives are fully described by their Probability Of Disaster.

[32] We take our subsistence consumption bundle from Bekar (2001) and McCloskey (1976).

[33] When a peasant's holdings fall below 10 acres they a spend fraction of their time working as wage laborers. The amount of time is linear in their holdings below 10 acres. When a peasant's holdings exceed 25 acres we assume they hire wage laborers to help work the holding.

[34] Land sells at a 10 years purchase price (Harvey 1984), peasants 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 (Harvey 1984, Smith, 1984). When land is relatively indivisble peasants are forced to smooth consumption by selling off large portions of their stock of land. All else equal, the more divisible is land, the better able are small-scale farmers to hold on to their land.

of their landholdings, with largeholders producing more heirs than smallholders.[35] If no heir is produced the peasant's landholdings are added to the available land supply. If more than one heir is produced that peasant's landholding is divided equally between all heirs.

5.1 Potential impact of the land market, population growth, and inheritance rules

We start by estimating the potential impact of the land market by simulating counterfactual estimates of how much inequality increases as a result of land market activity alone. The simulation is seeded with an equal distribution of landholdings and run for 120 years with zero population growth (i.e., all agents live for 120 years and are childless). The calculated Gini coefficient on the distribution of land goes from 0 to .789.

Next we simulate the effect of population growth and partible inheritance in the absence of a land market, the calculated Gini coefficient goes from 0 to 0.049. Finally we simulate the effect of population growth and primogenitor in the absence of a land market, the calculated Gini coefficient goes from 0 to .167. Population growth does cause some degree of fragmentation, and some inequality, but ultimately the main impact of population growth is to simply lower the size of the mean holding. When combined with primogeniture population growth produces some small amount of inequality, when combined with partible inheritance it produces even less.

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[35] 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 their father) and number of children. Combining these estimates suggest that the probability a Poor to Middling peasant produced two male heirs is quite low. Wealthy peasants could be expected to produce two male heirs with some regularity. This is equivalent to egalitarian bequests followed by marriage between peasants in the same landholding category.

Allowing for both population growth and land market activity, but again starting with an equal distribution of land predicts a Gini of .764. While population growth all else equal increases inequality on the margin, when combined with the land market it offsets inequality in a small way. It does so by breaking up largeholdings at a relatively faster rate then smallholdings and middleholdings.

5.2 Empirical impact of land market

We now turn to simulating the historical period between the land reforms of 1170 and the Hundred Rolls of 1289. We start with the distribution of free tenants from Table 2 and run the simulation for 120 iterations. The results are presented in Tables 5 and 6 below.

Table 5: *Simulating Hundred Rolls (Free peasants, 50% Landless)*

Land	Kanzaka [50% landless]	Sim [50, 40, 10]
0-1 acres	66.4%	68.3%*
1- 6 acres	16.2%	4.9%
6 – 10 acres	5.4%	5.1%*
10 – 15 acres	3.3%	4.1%*
15 – 20 acres	4.4%	3.7%*
20 – 30 acres	1.3%	5.8%*
30 – 40 acres	4.2%	1.9%*
40 + acres	5.1%	6.2%*

* indicates simulated value with 1 standard deviation of measured value

Collapsing the distribution from Table 5 into our broader categories yields table 6.

Table 6: *Distribution of land among free tenants*

Date/source	More than a virgate	Between one and one-half virgate	Smallholder
Domesday survey 1086	50%	40%	10%
Hundred Rolls of 1279-80			
0% landless	21%	13%	66%
10% landless	16.5%	10.4%	73.1%
20% landless	14.4%	9.3%	76.1%
50% landless	***9.3%***	***5.7%***	***85%***

Simulated with alternative Domesday distributions

Sim [50% rich, 40% middle, 10% poor]	***13.9%***	***7.8%***	***78.3%***
Sim [60% rich, 30% middle, 10% poor]	13.4%	8.1%	78.5%
Sim [40% rich, 50% middle, 10% poor]	15.4%	7.7%	76.9%
Sim [50% rich, 30% middle, 20% poor]	14.6%	7.2%	78.2%

The simulation tracks an increased fragmentation of landholdings and a dramatic increase in the poor (especially in landholdings between 0 – 1 acres). Specifically, the simulation tracks declines in largeholdings and middle holdings with a sharp increase in smallholders. Over the 120 years median holding size falls to roughly 10 acres less than one-half a standard virgate. Fragmentation is very high with less than 5% of agents holding a multiple of a standard holding. The simulation tracks the distribution of landholdings reasonably well, and is robust to alternative starting values. From table 6 above we get 13.9% simulated rich versus 9.3% measured; 7.8% simulated middle versus 5.7% measured, and 78.3% poor simulated versus 85% measured.[36] The simulation predicts 45% population growth over the 120 years.

We report Gini coefficients for our simulated populations since an increase in smallholders is potentially consistent with increased equality. The initial seeding of our simulation corresponds to a Gini coefficient on land ownership of .151, after 120 years the Gini coefficient is .835.[37] This corresponds to a 553% increase in inequality. The simulation confirms the role of population growth in creating fragmentation and inequality. Without population growth, and therefore no bequest mechanism, the change in the broad categories is similar, but the calculated Gini coefficient is roughly 38%

[36] The simulation indicates that if the unfree had access to the land market they would have ended up looking much more like free tenants. After 120 years the simulation predicts an unfree distribution of 17% with more than a virgate, 10.5% between ½ and a full virgate, and 72.5% smallholders.

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

lower (.514). The reasoning is straightforward: while population growth tends to break down standard holdings (with population growth operating through the land market roughly 7% of peasants hold between 1 and 1.5 virgates, the number is 43% without population growth) it simultaneously breaks down the largest of holdings at a faster rate (without population growth roughly 25% of peasants hold more than 1.5 virgates, with population growth only 11% do). So population growth tends to increase inequality by breaking up the standard holding while simultaneously reducing inequality by working against the spread between the richest and poorest.

6. CONCLUDING REMARKS

Rural England experienced a dramatic increase in the inequality of peasant landholdings between the late 11th century and the late 13th century. Our explanation focuses on the role of risk reduction through land transactions. 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 created fragmentation (i.e., broke up the standard holding), and it created inequality (i.e., producing a large class of smallholders and landless peasants).

We test our explanation by simulating the dynamics of the land market, including differential reproductive success (largeholders had large families, smallholders small

families), inheritance rules, 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 produce levels of inequality consistent with those observed in the data. Population growth alone, regardless of the legal environment with respect to bequesting, helps explain only a small portion of the observed fragmentation and little of the inequality.

6.1 A larger perspective

Our analysis answers an historical question, but our findings have a broader relevance. Fafchamps (2005) notes a 'novel result' of the literature exploring incomplete markets and risk: asset markets in which the asset is in finite supply naturally generate inequality. He notes (101-02) that, "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 novel result. While very small scale land sales constituted one of the most effective risk coping mechanisms available to the medieval peasantry, those same land sales contributed more than any other factor to the increased downward mobility of middle holders.

Examining the evidence relating to globalization and inequality Goldberg and Pavcnik (2007) find that there is little to suggest that "trade openness" benefits the poor. This constitutes a potential puzzle for traditional trade theory. They go on to note that

recent work on liberalization and increased inequality highlight new channels of effect. They detail the role of improved capital markets, increased volatility of labor 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 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 is 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 innovations is small and transitory this focus on efficiency would come at little cost to our understanding of long run growth. Our analysis offers a potential alternative view. Improved property rights in land created large and permanent increases in inequality. That inequality contributed to the eventual development of a commercialized English agriculture that fed the Industrial Revolution. It may have also helped create the large population of landless laborers generally considered to be a precondition for the decline of serfdom.

Finally consider a novel implication of our work to a very recent argument concerning the use of evolutionary biology to explain long run growth in Europe. Greg 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, work hard, 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 being more productive, the offspring of rich peasants were simply lucky, that previous generations, granted high income draws, had accumulated land from less fortunate peasants thereby creating larger families. The yeoman farmers of the Industrial Revoution descended from the lucky, not the diligent. In this view genetic make-up had very little to do with the where and when of the Industrial Revolution.

Appendix

Table 8: *Value of simulation parameters and their source*

Parameter	Value	Source
Mean output (μ)	100	Open field literature, McCloseky (1976), Bekar (2001)
Variance (σ)	45	As above
Rate of pooling (p)	7.5%	Bekar and Reed (2003)
Price of land (p_l)	10 units output per acre	10 years purchase price, Smith (1984).
Land sales/purchases (l_s)	Endogenous	
Rate of storage (s)	7.5%	Bekar and Reed (2003)
Wage rate (w)	2 units output per unit labor	Dyer (1989)
Cost of storage (δ_s)	20%	Bekar and Reed (2003)
Cost of pooling (δ_p)	20%	Bekar and Reed (2003)

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