Risk, Institutions and Growth: Why England and Not China?

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March 1, 2009

Abstract

We analyze the role of risk-sharing institutions in transitions to modern economies. A transition requires new, productivity enhancing knowledge which is under-provided due to individual-level risk in developing such knowledge. Distinct risk-sharing institutions can therefore lead to different growth trajectories. But *functionally identical* institutions (providing identical risk-sharing) can also differentially impact growth becuase *institutional forms* matter to whether risk-sharing motivates risk-taking. Forms, however. are often determined by their cultural and institutional compatibility and not their unforseen economic consequences.

A simulation of England's and China's growth trajectories that incorporates their pre-modern risk-sharing institutions predicts a transition only in England. The distinction in institutional forms, and not function, was crucial. Focusing on institutions and endogenous new knowledge, our model is the first 'pure' choice-based model of transition in the sense that it neither depends on an exogenous shock nor on time-dependent state variables.

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Greif: Stanford University. Sasson: Credit Swiss. This paper benefitted from comments by Murat Iyigun, Karen Clay, Pete Klenow, Joel Mokyr, and participants in seminars at Stanford, Berkeley and Universidad Torcuato di Tella. Avner Greif thanks the Canadian Institute for Advanced Research (CIFAR) for support.

"The transition from stagnation to growth is largely an inevitable outcome of the process of development."
Oded Galor, 2007, p. 472.

"Theories of economic growth have failed. These theories are built around a positive rate of technological change, either simply assumed or generated ... by ... assumption."
Robert E. Lucas Jr. 2002, p. 110.."

1 Introduction

While it is widely accepted that institutions influence economic outcomes, their origins and channels of causal influence are still debated. Particularly controversial are institutions' inter-dependence with culture and whether institutional forms (e.g, how rights are secured) influence outcomes beyond the impact of institutional functions (e.g., securing rights).[1] This paper demonstrates that culture and social organization impact institutional forms and different forms have an independent and unintended influences on economic outcomes.[2] These results are established by examining theoretically and historically the important question of the transition to the modern economy.

Growth-theoretic models identified two important causes for the transitions from pre-modern economies to modern economies. In multiple-equilibria growth models, a low-growth economy is a stable equilibrium because decreasing relative risk aversion implies that agents are too risk-averse to choose the modern, high-risk, high-return technology. A transition to a high-growth economy requires exogeous "accidents and good fortune" (Becker, et. al., 1990, p. s14) that breaks the low-growth equilibrium. In endogenous-transition models, low-growth equilibria are unstable and a "transition from stagnation to growth is largely an inevitable outcome of the process of de-

[1] E.g., Greif 1994, 2006; Lal 1998; Zak and Knack 2001; Acemoglu et. al. 2001; Rodrik, et. al. 2004; Helpman 2004; North 2005; Tabellini 2005; Guiso, Sapienza and Zingales. 2006.

[2] The unintended consequences of institutions and technologies and the unintended technological and institutional consequences of individual actions have recently been emphasized by, for example, North (1990), Mokyr (1990, 2007), Lal (1998), Greif (1994, 2006), Galor (2005)

velopment" (Galor, 2007, p. 472).[3] In particular, time-dependent changes in relative prices, technology, or wealth trigger a transition.

Both the mulitiple equilibria and the endogenous transition models have been criticized for failing to explain transitions. Multiple-equilibria models invoke accidents (Galor 2005, pp. 176-7) while endogenous-transition models "are built around a positive rate of technological change, either simply assumed or generated as an equilibrium outcome by the assumption of [for example] constant or increasing returns to the accumulation of knowledge" (Lucas 2002, p. 110).

This paper theoretically analyzes and historically evaluates endogenous transitions in the absence of accidental changes in wealth or productivity, time-dependent variables, efficient markets, or knowledge of modern technology. It focuses on incentives to create new, productivity-enhancing knowledge because such knowledge can directly initiate a transition. The creation and implementation of such knowledge, however, requires cultivators, producers, and traders to conduct risky experiments.[4] Such risky experimentation was particularly important in the past because the epistemological basis of technology was narrow (Mokyr 2002). Yet, low level of wealth and decreasing relative risk aversion imply that socially beneficial risk-taking is not likely to be individually rational prior to a transition. Risk-sharing institutions that make risk-taking individually rational, can lead to new knowledge, higher productivity and a transition.[5] Whether a transition transpires directly depends only on choices on the social and individual levels.

We model this argument using an OLG, 'technology transition' framework (Hansen and Prescott 2002) in which economic agents choose how to employ their capital.[6] An agent's choice determines the probability that new knowledge is generated. Choosing the 'traditional,' technology is less likely to generate new knowledge but is also less risky. Experimenting is more risky

[3] Kremer 1990; Jones 1999; Galor and Weil 2000; Gollin, Parente and Rogerson 2002; Galor 2005.

[4] Acemoglu and Zilibotti (1997) examine the relations between the indivisibility of risky projects, diversification, and growth.

[5] There was, of course, some risk-taking in pre-modern economies. Some risky activities such as warfare and explorations were taken by those who could pay others to bear the personal cost of failure. Necessity and various means to mitigate risk (particularly in commerce) motivated others to pursue risky ventures. Our model allows and simulation reveals some risk taking prior to the transition.

[6] Analytically, we focus, without loss of generality, on capital productivity rather than human capital to capture choices with positive externalities (e.g., cultivation techniques).

but is more likely to generate new knowledge. This knowledge increases the capital productivity of the agent who discovers it and, once this knowlege spreads, it increases capital productivity more generally. A pre-modern economy is one in which most agents choose the 'traditional' technology and the rate of productivity growth is correspondingly low. In a modern economy, all agents experiment and choose the 'risky' technology leading to a high rate of productivity growth. In a transition, the number of agents choosing the risky technology increases over time causing an increase in the rate of productivity growth.

Positive externalities imply that agents will employ less capital than socially optimal in the risky technology. Moreover, decreasing relative risk aversion implies that poor agent select the traditional technology. If sufficiently many agents are poor, a transition will therefore not transpire and the economy stagnates. A risk-sharing institution can mitigate the impact of low wealth and risk aversion on some agent's technological choices and initiate an endogenous transition. More specifically, a risk-sharing institution that sufficiently increases risk-taking, causes a transition. For reasons discussed below, two institutions that provide the same risk-sharing, can nevertheless have different risk-taking implications. Risk-sharing institutions – their effectiveness and forms – can determine if and when a transition to a modern economy transpires.

This causal relation between new knowledge, non-market institutions, and transitions is intuitively appealing for two reasons. This relation does not assume that the 'modern' technology is known prior to a transition. It captures that modernization involves discovering this technology. The economic agents only know the traditional technology but recognize that risky deviations might lead to new productive knowledge. Similarly gratifying is the observation that transition does not depend on incentives provided by changes in market prices. An integral part of a transition is the development of the knowledge required for improving markets.

We evaluate the historical relevance of transitions' institutional conditionality by modeling China's and England's pre-modern institutions, simulate their implications and qualitatively evaluate their time-series and cross-section implications. In both economies, compassion and concern with social order led to effective, yet distinct, risk-sharing institutions. In China, poor relief was predominantly provided by lineages (clans) headed by their elders. In England, the state gradually displaced the Church and voluntary associations as the main provider of poor relief. The Old Poor Law of 1601 formalized the system which, with some modification, prevailed until 1834.[7] Similar transitions transpired elsewhere in Europe but England's system was particularly effective (Solar 1995).

In each state, these institutions were not selected by their (unforseen) growth implications. These institutional forms were selected, by the state, based on their competability with the prevailing culture and institutions.[8] A clan-based risk-sharing institution indeed evolved in the collectivist, lineage-based Chinese society while a state-based risk-sharing institution evolved in the individualistic, nuclear-family based English society. It is therefore appropriate to consider these risk-sharing institutions as exogenous in examining their growth implications.[9]

The evolution of different risk-sharing institutions highlights an interpretation of our analysis as bridging the view that transitions are due to luck and the view that transitions are inevitable. Transitions transpire when 'luck' creates the conditions under which economic agents find it beneficial to make the choices leading to a positive rate of technological changes.[10] Luck did not come in the form of a random draw of knowledge or wealth but in the form of historical processes leading to *risk-sharing* institutions whose unintended consequences encouraged productivity-enhancing *risk-taking*. Transitions were conditional on having risk-sharing institutions that increased the rate of productivity growth.[11]

Our simulation and historical analysis confirm the importance of risk-sharing institutions in transitions to a modern economy. China's lineage-based institution implied more *risk-sharing* prior to the introduction of the Old Poor Law. Yet, it was relatively ineffective in promoting *risk-taking* because lineages' elders had, by law and custom, strong influence on techno-

[7] Voigtländer and Voth (2006) found that the Old Poor Law did not influence England's industrialization by increasing wages.

[8] For one perspective on why institutional dynamic is a historical process in which past cultural and institutional elements influence subsequent institutions, see Greif 1994, 2006, chapter 7.

[9] Institutions governing one transaction (i.e., poor relief and social order) tend to have unintended consequences on behavior in other transactions (i.e., risk-taking). Greif (2006).

[10] Previous works in economic history have focused on an endowment windfall due to the discoveries (e.g., Pomeranz 2000), better informal contract enforcement institutions and the enlightenment (Mokyr 2005, 2006), and higher mortality rates which increases per-capita income (Voigtländer and Voth 2006).

[11] On the role of risk taking in economic growth, see, for example Hausmann and Rodrik 2003; Iyigun and Rodrik 2005.

logical choices made by their lineages' young members. Because older people tend to be more risk averse than younger ones, the lineage-based institution led to less risk taking than if the young were in charge.[12] Our simulation reveals that if the Chinese and the English institutions implied the same level of risk-sharing, an eight percent initial difference between the risk aversion of young and old was sufficient to prevent China from embarking on a transition to a modern economy. To initiate a transition, the Chinese institutions would have had to provide, roughly speaking, about three times better risk sharing than the English one.

Prior to the introduction of the Old Poor Law, England's risk-sharing institutions were not conducive to a transition either. The early seventeenth century transformation of England's risk-sharing institutions, however, fostered both risk-sharing and risk-taking. More specifically, the Old Poor Law directly insured the poor from the economic risk associated with the structural transformation associated with the transition. Insuring the poor reduced the risk to the wealthy from investing, discovering, and implementing new useful knowledge.[13] By the middle of that century, as discussed below, England began the expansion leading to a modern economy.[14]

This analysis demonstrates the historical relevance of the causal relations between risk-sharing institutions, knowledge, and transitions. It is also reassuring to note the empirical confirmation of the model's qualitative time-series and cross-section predictions. Our analysis accounts for observations that are difficult to reconcile when viewing transitions as either accidental or inevitable. Among these are the surge in China's contributions to new knowledge under the Song Dynasty (960-1279), their subsequent decline, England's

[12] Contemporary empirical analyses found that the elders are more risk averse. Einav and Cohen (2007) found that risk aversion declines after the age of 18 and increases after the age of 48. See also Graham, Harvey, and Puri. 2008; Halek and Eisenhauer, 2001; Riley and Chow, 1992. Early twentieth-century decisions by Chinese peasants regarding crops and labor were influenced by risk aversion (Wiens 1976), while in the modern economy, low risk-aversion fosters entrepreneurship (van Praag and Cramer, 2001).

[13] Private-order institutions that mitigated the economic risk the investors faced (e.g., Mokyr 2007) did not insure aganist violent responses by the poor

[14] The Industrial Revolution is usually dated to the second half of the 18th century, after James Watt introduced a steam engine with separate condenser. The transition itself – the increase in risk taking and innovations – began in the 17th century. It is epitomized by the shift in developing the steam engine to England from as early as 1680 when Denis Papin's moved there from Paris and, among other contributions invented the reciprocating steam engine conceptually.

leadership in innovations rather than inventions during the Industrial Revolution, and the capacity of European states to rapidly imitate England. Our analysis reveals that risk-sharing institutions may have been important in rendering England, rather than China, the first modern economy.

Our theoretical analysis assumes that China and England differed only by their risk-sharing institutions. Historically, however, these two societies differed in many ways. Some of these distinctions, such as differences in cultural attitudes toward risks and inventions (e.g., Mokyr 2002, 2006) and the institutional foundations of the market (Greif 2005) might be endogenous to the institutional distinctions we focus on. Other distinctions such as political institutions or access to natural resources (Pomeranz 2000) were not. The possible importance of such distinctions notwithstanding, it is important to note that China was economically ahead, or not far behind, England prior to the 16th or 17th century. Urbanization rate suggests that around 1000 AD, China was more economically developed than Europe. Grain-equivalent wages in China, for example, were 87% of the English ones in 1550-1649 (Broadberry and Gupta 2006) and only during the 19th century, European markets were better integrated than China (Shiue and Keller 2007).

The rest of the paper is as follows. Section 2 provides historical background on risk-sharing institutions and elders' authority in England and China. Section 3 describes the model. Section 4 provides the numerical results of our model and Section 5 concludes.

2 Social structures, Risk-Sharing Institutions and Knowledge

Over the last millennium, institutions insuring against idiosyncratic individual-level risks evolved in differently in China and England. Three observations about these non-market institutions are presented in this section. First, lineages, dominated by their elders, prevailed in pre-modern China, but not England. More economic choices involving risk-taking were made by elders. Second, after 1601 the main risk-sharing institutions in these countries were state-based in England and lineage-based in China. Third, risk-sharing institutions influenced risk-taking and hence the creation of new knowledge. These observations underpin the assumptions we later make in modeling these risk-sharing institutions.

2.1 Social structures

By 1000 AD, social structures in England and China had already evolved differently. In England, generally speaking, there were no large, kin-based social structures such as lineages and tribes. The nuclear family structure predominated. In China, however, lineages (clans) have been important economic, social and cultural units to the modern period.

The elimination of large, kin-based social structures in Europe was due to the dogma adopted by the Church regarding marriage. (Goody 1983; Greif 2006). This dogma discouraged practices that enlarged the family, such as adoption, polygamy, concubinage, divorce, and remarriage. The Church also restricted marriages among kin (consanguineous marriages), often up to the seventh degree, and prohibited unions without the bride's explicit consent.[15] Kin marriages and parents' ability to retain kinship ties through arranged marriages were historically important means of maintaining kinship groups.

The European family structures did not evolve monotonically toward the nuclear family, nor was their evolution geographically and socially uniform. Yet, by the late medieval period the nuclear family became the norm in Western Europe (e.g., Mitterauer et. al. 1982; Goody 1983; Ekelund et. al. 1996; Herlihy, 1985; Greif 2006, chapter 8). The (Germanic) Salic law of the sixth century denied legal rights to anyone not affiliated with a large kinship group. By the 10th century, the English King Edward issued a law mandating that every male join a group that would guarantee his appearance in court, suggesting that kinship groups could no longer be held accountable as was the case when the Salic law was specified. Indeed, already by the eighth century the term family among the Germanic tribes denoted one's immediate family. Tribes and lineages, by and large, were no longer institutionally relevant (Guichard and Cuvillier 1996).

Quantitative evidence from later centuries also reveals a decline of large kinship groups. English court rolls from the thirteenth century reflect that cousins were not more likely than non-kin to be in each other's presence (Razi 1993). The English poll-tax records of 1377 indicate that there were approximately 2.3 individuals over the age of thirteen per-household (Schofield 2003, p. 83). The mean household size in five English parishes in the 16th century ranged from 4.05 to 6.05 and that of 100 parishes from the 16th to the

[15] In the late Roman period, the law prohibited marriage among relatives to the 3rd degree, implying that first cousins could marry. The Roman law also required consent to these marriages. Herlihy (1985), pp. 7-8.

19th century was 4.788. Only about 10 percent of the households had a resident kin (Laslett 1969, pp. 204, 207, 218).[16] Large kinship groups remained important only among nobility and on the fringes of Europe (e.g., Scotland).

The nuclear family, was also a basic unit of social organization in premodern China. But larger, kin-based social structures were common and remained culturally, socially, politically and economically prominent to the modern period.[17] Indeed, the ideology and practice of patrilineal descent, filial pity, and ancestor worship was the hallmark of Chinese society and culture (e.g., Freedman 1958). Furthermore, social and economic relations were commonly kinship-based and lineages provided members with local public goods such as protection and education (e.g., Hamilton 1990). The state, whose magistrates were positioned at the county level and above, used kin-based organizations for tax collection and considered male descendants of a household a jointly liable tax unit.

The structure of Chinese kin-based social structures evolved over time and was not uniform over space. In particular, there was a gradual shift from communal families to lineage organizations. The communal family are the kinship group referred to the most during the Tang (618-690, 705-907) and the Song (960-1279) dynasties. These were domestic units that had not divided – in terms of property or membership – for five, six, or even ten generations. Some communal families included hundreds and even thousands of members. The state praised communal families as an ideal form of organization and supported exceptional ones through tax exemptions. Communal families are still often reflected in the historical records of later dynasties but we have no quantitative measure of how many communal families existed at any point in time. Given the complexity of supporting, organizing and maintaining the coherence of such large groups, really large communal families must have been relatively rare and it seemed that they gradually vanished.[18]

After the Song dynasty (960-1279), lineage organizations became common. These looser associations of relatively large numbers of kin "were the

[16] The mean household size of those receiving poor relief in Strasbourg in 1523 was similar (Jutte 1996, p. 382).

[17] The discussion particularly draws on Smith 1987; Ebrey and Watson 1986; Szonyi 2002; Freedman 1958; Watson 1982; Liu 1959.

[18] By tracing clans' life-cycle, Fei and Liu (1982, p. 399) concluded that the critical maximum size (CMV) of a lineage is about I,400 males and females which is about 300 families. Abramitzky (2008) presents an empirical analysis of contractual problems in large, risk-sharing organizations.

predominant form of kinship organizations in late imperial China" (Ebrey and Watson, 1986, pp. 1, 6; Watson 1982). Detailed information on the share of the population with lineage affiliation is not available but lineages were common in the south of China, were less common at the center and least common in the north of China.

In addition, those with sufficient means often maintained large households, either in the form of a 'stem' or an extended family. A stem family included parents and at least one married son and his family and averaged ten people (Fei and Liu 1982). The extended family encompassed members of several families related through the male line. Members often lived in a family compound, had common property and an internal dispute-resolution mechanism. Such larger households were culturally esteemed and economically beneficial to their members, practically because they consolidated assets and local political power under family control.

In all these social structures fathers, and elders more generally, exerted various degrees of authority even over their adult children and control over the family's assets. In Imperial China, "the father had paternal authority over his children, while the children had the duty to practice filial behavior and to support their parents in old age. The family head had absolute authority and discretion. This kind of power was not only confirmed by the rule of propriety (*li*) ... but was also protected by state and customary law. These rules provided him with arbitrary power over family property ... [and] in making decisions concerning all aspects of family matters... all earning of family members had to be handed to him.... Even members who settled somewhere else or were temporarily absent, sent their surplus earnings to him" (Chen 1999, pp. 250-1).

In China, the preferences of the elders had a large and institutionalized influence on the economic actions by young adults. In sharp contrast, long before the 17th century under English law and customs, adult sons were not under their fathers' authority.

2.2 Risk-sharing institutions

Throughout history risk-sharing non-market institutions have been created to maintain social order and help those in need. These details – institutional forms – were endogenous to these societies' pre-existing cultural and institutional elements. In particular, the absence and presence of large kinship groups deremined the cost to rulers of establishing different risk-sharing institutions. In England, risk-sharing institutions based on large kin groups were a costly proposition given the absence of such groups. This was not the case in China. Indeed, the English (and more broadly, the European) institutions were not kin-based while in China they were.

Specifically, in Europe prior to the 16th century, secular and religious organizations – monasteries, fraternities, mutual-insurance guilds, and communes – assisted the poor or their members in times of need. They provided individuals with such services as poor relief and unemployment and disability assistance. In the late medieval period, the total capacity of England's monasteries for grain storage was more than was required to sustain the Kingdom's population for a year (Fenoaltea 1976). In the early 16th century, the majority of the commoners in England belonged to fraternities and guilds that provided social safety nets (Richardson 2005). The same pattern seems to have prevailed elsewhere in Europe (Reynolds 1984; Brenner 1987). Getting relief from these risk-sharing institutions was, however, uncertain as they were either voluntarily provided by charity organizations (e.g., by the Church) or cooperatively financed by working people without much wealth.

The Wars of Religion in the 16th and 17th centuries eliminated this system of poor relief. Many of the corporations through which insurance was provided were associated with the Catholic Church and Protestant rulers dismantled them. During the Counter-Reformation, Catholic rulers also confiscated the properties of these corporations to finance their wars against Protestantism. Europe lost its system of poor relief. In England, Henry VIII established the Anglican Church, dissolved the monasteries in 1536-40, and shut down all religious guilds, fraternities, almshouses, and hospitals in 1545-49. These actions "destroyed much of the institutional fabric which had provided charity for the poor in the past" (Slack 1990, p. 8).

Social order was undermined by the lack of an effective poor relief system and population growth pressured wages and increased poverty. States responded by creating alternative, state-based systems. Local administrative bodies within the European states, such as parishes and cities, were required by law to care for their poor. In England, the Poor Law Act of 1601 (the Old Poor Law) formalized the emerging alternative system which lasted, with some modifications, until 1834. Each parish was authorized and obliged to levy a property tax to care for the poor (Boyer 1990).

Shifting the responsibility for poor relief to the state (via local administrators) was a European phenomenon and poor relief systems similar to England's were established elsewhere (Geremek 1997; Jutte 1996; de Vries and de Woude 1997, pp. 654-664). Yet, the English Poor Law system was more reliable and more generous than the continental ones. In England, expenses were financed through a variable poor rate on the assessed rental value of local real estate property and most aid was given without forcing the recipient to move to the poor house.[19] Continental poor relief, by contrast, was financed from a variety of sources: voluntary donations, capital income, subsidies from local and national governments, and general tax revenues. Funding was therefore less reliable. Furthermore, in England the legal right to relief was well defined while on the continent rights were vaguely defined, less credibly assured, and generally at the discretion of local authorities.

Annual spending on poor relief in England were about 1 percent of the national income in the seventeenth century and about 2.5 percent at its peak during the 19th century. At that time, it supported about 11 percent of the population and may have boosted average income of the bottom 40 percent by 14 to 25 percent. Expenditure per-capita was 7.5 times higher than in France in 1780s, 2.5 times higher than in the Netherlands in 1820s, and 5 times higher than in Belgium in 1820s. (Boyer 1990; 1999; Mokyr 2002).[20] England's exceptionalism reflects distinct needs in the late 16th century when these systems were created. While peasantry and other 'customary' labor relations that insured the poor still dominated in other European states, in England the transition to wage laborer had already began.[21]

Imperial China also experienced great diversity and changes in poor relief institutions.[22] The state sporadically financed general or medical aid to the old, poor, sick, and disabled. Buddhist monasteries and temples provided medical service, fed the hungry and sheltered the aged and decrepit. Their support, however, was uncertain as they fed any poor including 'undeserving' ones. Benevolent societies were established after 1580, particularly by members of the mercantile elite and the gentry. Yet, their forms and functions were often rigid and did not adjust to various needs.

[19] Those who financed the Poor Law had no legal rights to influence risk taking. Moreover, farmers who took risk (by specializing in grains) had the political power to trasnfer the cost of insurance on others. Boyer (1986).

[20] An extensive network of private charity suggests the limit of the public relief but contribute to social order despite the economic transition.

[21] On these and other aspects of the system see, for example, Boyer 1986; Slack 1990; Solar 1995. Patriquin 2006 compares the English case with that of Scotland and Ireland.

[22] The discussion particularly draws on Smith 1987; Ebrey and Watson 1986; Szonyi 2002; Freedman 1958. We are not familiar with quantitative analysis of these kinship organizations' relative importance.

In China, the major source of aid to the poor, the sick, and the aged were kinship groups. The role of communal and extended families in providing insurance is transparent from their internal organization. In such families, all property was held in common and the "underlying principle was distribution of income to all members equally according to need, just as though they were members of small family" (Ebrey and Watson 1986, p. 33). The young provided labor while the elders controlled all assets and had the legal and customary rights to make communal decisions.

In many respects, the lineages were the functional successors of communal families. They similarly exerted considerable legal and customary control over their members, provided them with public goods such as education, held common property, and acted as social and political units. In pre-modern China a lineage "performs many functions related to education, ceremony, social security, and maintenance of law and order. Whereas now most of these functions are performed by the government, the clan was a primary social group (or organization) through which these functions were carried out before the art of government was perfected" (Fei and Liu 1982, p. 375).

After the eleventh century lineages were most common and reliable source of poor relief. The first lineage charitable estate was established by Fan Chung-yen (989-1052). Such estates were considered by the state and their members as the lineage's property. Yet, they were not commonly owned corporations but were controlled and managed by the elders of the lineage's prominent families. Income was used to finance lineage rituals and provide members with education, income, and support for weddings, burials and illness. Members in poverty received additional benefits such as free lodging. The state motivated lineages to care for its poor by considering it legally responsible for crimes committed by its members.

2.2.1 Risk-taking and knowledge

Risk-sharing institutions might theoretically foster risk taking, knowedge, and productivity. Indeed, increase in useful, productivity-enhancing knowledge characterized the productivity growth leading to the modern economy (Mokyr 1990, 2002). The putting-out system, turnpike trusts, drainage projects, the factory system, the steam engine, the New Husbandry, and the joint stock companies directly increased production and/or productivity. Behind these changes was new knowledge of, or correct belief in, their benefits. Gaining this new, productivity-increasing knowledges, however, is risky. It is risky for an individual to invest in *discovering* new, productivity-enhancing (technological, organizational, or commercial) knowledge. *Implementing* existing knowledge often implies risk as well (e.g., long-distance trade). Yet, a familiar risk is subjectively less intimidating than unfamiliar one.

We often consider the patent system as the main means to induce risky investment in discovering new useful knowlege. Yet, patent systems were rare and ineffective in pre-modern economies. Even in England, an acceleration in patenting began only by 1757 (Sullivan, 1989) while the transition to modern growth began in the seventeenth century (Clark 2005). By and large, the new knowledge that increased productivity in pre-modern economies reflected the input of many individuals who took personal risk in 'deviating' from the conventional ways of 'doing things' and discovered productivity-enhancing knowledge. Pursuit of risky innovations and inventions contributed to the knowledge base that others acquire through observation, imitation, and education.

The high personal risk associated with developing new knowledge during the English transition is suggested by the evidence about inheritances. The inheritances left by English entrepreneurs (from 1700 to 1850) are "consistent with the intuitively appealing hypothesis that entrepreneurs in the modern sector suffered a higher failure rate, but when they struck it big, they did so on a larger scale" (Mokyr 2006, p. 31). The risk was sufficiently high that even wealthy individuals sometime lost all their property and ended relying on poor relief. One wealthy individual who took risk and paid dearly was "William Radcliffe, a Derbyshire 'improver of cotton machinery,' who bought Samuel Oldknow's mill after the latter's bankruptcy, and apparently died poor after a roller-coaster career; another was Samuel Hall, a cotton-spinner and engineer who died in 'very reduced circumstances.' The cotton merchant Thomas Walker had to live his final years from a bequest. Perhaps the most spectacular example of a failed entrepreneur was the highly eccentric Archibald Cochrane, earl of Dundonald, who spent his family's fortune on his ill-fated chemical business. More than anything, however, Cochrane was unlucky. Somewhat comparable was the case of Henry Fourdrinier, a well to-do London stationer who gambled on the main innovation in paper-making of his age, spent £ 60,000 on the business and failed in 1810. Both Cochrane and Fourdrinier are thus examples of a significant negative private return on entrepreneurship" (Mokyr 2006, pp. 24-5).

Given the personal risk of perusing new, productivity-enhancing knowledge, it is reasonable that risk-sharing institutions mattered. Risk-sharing institutions can encourage risk-taking by individuals without the wealth required for self-insurance. Indeed, the number of individuals of modest means that took the risk of creating new knowledge during one of the most important part of the transition, the Industrial Revolution, was far from negligible. There were 333 great inventors who were active after 1790 and were born prior to 1845 in Britain and the USA (that also had a Poor Law system).[23] Some 38 percent of the great inventors were of modest means.[24]

Yet, in England and elsewhere, members of the elite who were engaged in risky activities rarely ended up on the poor roles. Recipients of poor relief were generally individuals who never had the means to take much risk (Boyer 1990). Risk-sharing institutions can nevertheless increase the expected return to the wealthy from investing in the creation of new knowledge. Poor relief reduces the likelihood that implementing new knowledge would elicit violent responses from those economically disadvantaged by the process of change. The cost to the wealthy of risk-taking activities leading to new technological, organizational and commercial methods decline when support to the poor secures those with meager means from the implied economic change.

The evidence reveals that the poor were better secured after the implementation of the Poor Law in the 1620s. The elasticity of mortality to real wages was negative and statistically significant from 1540 to 1640 but it was basically zero from 1640 to 1740.[25] The break-point in the trend occurred in 1625 and was due to a better poor relief, and not higher real wages, reduced variance of grain output, increased urbanization, or changing climate (Kelly and Ógrada 2008). Death rate actually declined in England during the first half of the eighteenth century (Razzell 1994) while in China it was stable (Lee and Feng 1999). The relative importance of better nutrition in change in death rate during this period is still debated but the evidence indicates that nutrition "should be regarded as one in a battery of factors, often interacting, which played a key rule in Britain's mortality transition" (Harris 2004, p. 380).[26]

[23] A great Inventor is an individual who was included in biographical dictionaries because of his or her contributions to technological progress.

[24] Judging by the fact that their fathers were farmers, low-skilled workers, or were neither members of the elite nor had a declared occupation.Calculated from Khan (2008), table 3. The table precludes calculating the percent for Britain separately.

[25] Nicolini 2007; information from Parish's registers is available from 1540. See Landers 1987 about London.

[26] The role of better nutrition in this decline has been particularly emphasized by McK-

A lower risk of starvation should also have reduced petty property crimes due to necessity. Indeed, rates of criminal persecutions declined in the hundred years following the introduction of poor relief (Hay 1980, p. 63). In contrast, there was a significant and high correlation between grain prices and the level of prosecutions for property crime during the late sixteenth and early seventeenth century (Lawson 1986). Similarly, food riots were relatively few following the Poor Law and the 'golden age' of English rioting was in the second half of the eighteenth century (Outhwaite 1991, p. 41). Changes in the marketing of grain and larger population were the main causes.

Changes in crops also provide evidence suggesting that the Poor Law reduced the risks associated with the economic transition. The labor demand for the highly profitable grain production was highly seasonal. The Poor Law protected the livelihood of the laborers during the down season and reduced their incentives to seek employment elsewhere. This lowered the risk of labor shortage to the farmers while, unlike higher seasonal wages, protected them during years of low output prices. Furthermore, the law subsidized grain production by shifting the cost of seasonal unemployment to non-farmers and might have motivated a shift toward more risky economic pursuits more generally (Boyer 1986). Indeed, the particularly good data from early 19th century New York reveals a positive correlation between poor law expenditures and shift to wage labor in industry and agriculture (Hannon 1984).

Indeed, despite the major transformation that England experienced during its transition, it was surprisingly peaceful.[27] The system supported between the 5 to 15 percent of the population at any time (Solar 1995, p. 8) and transfer of such magnitude probably contributed a great deal to a relatively peaceful economic transition. "While there was some resistance to enclosure, the English were, by continental or Irish standards, quite easily separated from the land in the seventeenth and eighteenth centuries" (Solar

eown and his co-author and surveyed in Harris 2004. Smith 2008 emphasized the positive role of the Poor Law in reducing risk of labor migration.

[27] Charlesworth (1983) presents rural protest in Britain from 1548 to 1900. Protests were particularly likely when food price was high. He notes that In Lowland England "by the second decay of the seventeenth century ... lords were successful in ... sweeping away ... tenantry to make way for the large leasehold farm ... through the poor law, the attack on alehouses, the quarter session and the church court" (pp. 16-18). Patriquin (2006) notes that "it is striking that a profound recasting of class relations in England, one which left most people beret of property and control over their lives, occurred without inducing a protracted and violent revolution" (p. 223).

1995, p. 9). Similarly, there was relatively little popular resistance to other major transformations such as the decline in the putting-out system, the introduction of hourly wage or the New Husbandry. England was remarkably peaceful during a transition that destroyed numerous traditional occupations and shifted risk toward the poor by increasing wage labor and eliminating many of their small landholdings and communal rights.

Although the Chinese and English risk-sharing institutions emerged to fulfil the same functions, they had different forms due to distinct cultural and institutional elements. Specifically, the English society did not have large, kin-based units implying that a lineage-based institution was too costly, if not impossible for the state to create. The state turned to the pre-existing, self-governed parishes to provide poor relief. In China, however, lineages prevailed and the state's administration was designed to interact with large kin-based social structures and not their individual members. Creating a state-based poor relief system was too costly given the alternative of relying on lineages. Because their growth implications were unforseen, these risk-sharing institutions were not designed to promote growth. It is therefore appropriate to consider the forms of these risk-sharing institutions as exogenous while modeling their impact on growth.

3 Model

We model the rate of productivity growth as a function of risk-sharing institutions. After presenting the model's basic structure, this section models the bench-mark case of a market economy and continue by considering two risk-sharing institutions. The first is a state-based institution which complements the market through redistribution to the poor and the second is a lineage-based institution under which economic agents are insured by their lineages, employ the technology chosen by their elders and share the output.

3.1 The basic structure of the model

Consider the following OLG, full information model. There is a continuum of agents in $\left[0, \frac{1}{1-\lambda}\right]$ each of whom is young for two periods and is old for the rest of her life. An agent might die with probability 1-λ at the beginning of each period and an agent who dies is immediately replaced.[28] An agent is a 'newly born' in his first period, a 'young adult' in the second, and an 'elder' thereafter. Standard models let agents be young for only one period. Yet, the relevant choice in our model is next period's capital productivity, which is driven by next period utility function. If agents were to be young for only one period, we could not have captured age-depended risk preferences.[29]

Denote by u^y the utility function of a young agent (either newly born or young adult), by u^o the utility function of an old agent and by β the discount factor. The utility functions are defined over income and are increasing, concave, (twice) continuously differentiable, satisfy the Inada conditions and have decreasing relative risk aversion (DRRA).[30]

Only newly born agent can work and each of them is endowed with one undivisible unit of labor. Production requires labor and capital. The per-period production function is

$$y = (Ak)^{\alpha}$$

where A is capital productivity, k is capital units, Ak is the units of effective capital, and $\alpha < 1$ is the capital share. At the end of her first period,

[28]Our analysis abstracts from fertility issues to ease demonstrating that it does not depend on time-dependent variables and changes in relative prices. This implies, however, that we have to ignore facts regarding fertility. We agree that fertility issues are important, but our focus is on the effects of risk sharing institutions and we leave potential linkages between fertility and risk sharing for future work. Capping population growth in this manner biased the analysis against our argument.

[29]Alternatively, we could have changed the order of move and let agents to first make their technological choice, then have the productivity realizations and finally let agents produce. This would have implied that young agents had to make decisions before they were born, which did not sound appealing to us.

[30]The utility function for individual i is given by:

$$\begin{aligned} U\left(C_{\tau}^{i,\tau}\right) &= \sum_{t=\{0,1\}} \sum_{s_{\tau+t}\in S} \pi\left(s_{\tau+t} \middle| s_{\tau+t-1}\right)(\beta\lambda)^t u^y\left(c_{\tau+t}^{i,\tau}\left(s_{\tau+t}\right)\right) \\ &\quad + \sum_{t>1} \sum_{s_{\tau+t}\in S} \pi\left(s_{\tau+t} \middle| s_{\tau+t-1}\right)(\beta\lambda)^t u^o\left(c_{\tau+t}^{i,\tau}\left(s_{\tau+t}\right)\right) \end{aligned}$$

S is the space of states of the world, $s_{\tau+t}$ is the state of the world at time $\tau+t$, $\pi\left(s_{\tau+t} \middle| s_{\tau+t-1}\right)$ is the conditional markovian probability, $c_{\tau+t}^{i,\tau}$ is the consumption of agent i of generation τ in period $\tau+t$ and $C_{\tau}^{i,\tau} = \left(c_{\tau+t}^{i,\tau}\left(s_{\tau+t}\right)\right)_{t=0}^{\infty}$ represents every possible consumption value for each state of the world conditional on survival.

a newly born agent divides her income between consumption and saving in the form of capital. Young adults and elderly agents rent their capital, consume and save. Capital depreciates at rate δ per-period.[31] A newly born is endowed with the previous period's average capital productivity and depreciated average capital level.[32] This 'inheritance' creates inter-generational spillover effects in our fertility-free model.

Each agent i can use one of two technologies that affect her future idiosyncratic capital productivity, A^i_{t+1} These technologies differ in their expected impact on future productivity of capital rather than current output. The first technology is "low-risk, low-return" (LR) and the second is "high-risk, high-return" (HR). Formally, each technology j is defined by its expected return (in terms of new knowlege), μ_j, and its variance σ^2_j where

$$\begin{aligned} \mu_{LR} &< \mu_{HR} \\ \sigma_{LR} &< \sigma_{HR} \end{aligned}$$

The expected productivity of agent i's capital next period, A^i_{t+1}, depends on her current productivity, A^i_t, the return on the technology she chooses, μ_j, and an individual-level idiosyncratic shock, $\varepsilon^i_{t,j}$. Specifically,

$$A^i_{t+1} = A^i_t \left(1 + \mu_j\right) + \varepsilon^i_{t,j}$$

where the distribution of the idiosyncratic shock for technology j is:

$$\varepsilon^i_{t,j}\tilde{\ } F : \left\{F : F\tilde{\ } \left(0, \sigma^2_j\right)\right\} \text{ where } j = LR, HR$$

The main distinction between this set-up and the growth theoretical models on which we build is regarding the rate of productivity growth. In these models productivity growth is either exogenous, due to investment in acquring existing knowledge, or positively depends on a variables that are assumed to change over time, such as population. In the current model, productivity growth is endogenous reflecting technologically feasible choices on the social and individual levels.

[31] An alternative specification is that capital depreciates at rate one upon one's death and there is no intergenerational bequest. We simulated this model and our results remains qualitatively the same. This is because δ is already so large that the effect of the additional depreciation becomes of second order.

[32] The analysis is robust to reasonable alternative specifications such as that one's initial capital equals that of the one she replaces.

3.2 Risk-sharing: the Market, the State and the Lineage

The rest of this section considers the growth implications of different risk-sharing institutions through their impact on risk-taking. Consistent with the historical records, we assume that there is no insurance market and recognize that risk-sharing institutions influece bothe the allocation of both decision rights and income. Our specification enables comparing an individualistic economy with or without a state-based insurance with an economy with a lineage-based insurance.[33] In the individualist ssociety labor and capital are matched by the market, each agent chooses a technology for her capital, and have no insurance unless provided by the state. In the lineage-based society, labor and capital are matched within the lineage, elders choose a technology, and lineage members insure each others.

3.2.1 Individualistic, Market Economy

Consider a small open economy with a fixed, state independent rental rate of capital, r, and recall that a newly born agent produces by combining her labor with capital.[34] The profit-maximizing level of effective capital units is therefore $Ak = \left(\frac{\alpha}{r}\right)^{\frac{1}{1-\alpha}}$. Although all newly born agents have the same endowment denote, for ease of exposition, the capital productivity and capital of a newly born agent i born at time t by A_t^i and k_t^i, respectively. If a newly born is endowed with less than the optimal units of effective capital, $\left(\frac{\alpha}{r}\right)^{\frac{1}{1-\alpha}}$, she rents $A_t k_t$ units from the market and otherwise rents her excess capital in the market. The maximization problem for the newly born is $\max_{A_t k_t} \left(A_t k_t + A_t^i k_t^i\right)^{\alpha} - rA_t k_t$ implying the profit function of newly born agents in period t is $\pi_t\left(A_t^i, k_t^i, r\right) = (1-\alpha)\left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha}} + rA_t^i k_t^i$ which is continuous and linearly increasing with the agent's initial capital (k_t^i) and capital productivity (A_t^i).

We can now turn to the inter-temporal problem of saving and technological choices. After choosing technology in the beginning of a period, an agent observes, at the end of the period, the productivity of her capital in the next period and then allocates her income between consumption and saving. In

[33] Markets prevailed in pre-modern China, of course, but our focus is on the non-market relations among members of lineages.

[34] We keep the interest rate constant and exogenous to have a parsimonus model.

formally presenting this dynamic programing problem we denote by k_{t+1}^i an agent's i capital in period $t+1$ (which equals her saving in period t) and by $V_{k,t}^{i,}$, the value functions for an agent of cohort $k = 1,\ 2,\ 3$ (a newly born, young adult and elderly respectively) for a given a technological choice $(J_{k,t}^i)$ by agent i of cohort k at time t. Recall that the capital productivity of each of the young adults and elders differ due to individual-specific past outcomes. For simplicity, however, we present the optimization problem of an agent i of cohort k at time t.These problems are (using superscript m to denote a market economy):

$$\begin{aligned} V_{1,t}^{i,m}\left(A_t^i, k_t^i \middle|\ J_{1,t}^i\right) &= \max_{k_{t+1}} u^y\left(\pi_t\left(A_t^i, k_t^i, r\right) - \left(k_{t+1}^i - (1-\delta)\, k_t^i\right)\right) \\ &\quad + \beta\lambda E_{A_{t+1}|A_t} V_{2,t+1}^{i,m}\left(A_{t+1}^i, k_{t+1}^i \middle|\ J_{2,t+1}^i\right) \end{aligned}$$

$$\begin{aligned} V_{2,t}^{i,m}\left(A_t^i, k_t^i \middle|\ J_t^i\right) &= \max_{k_{t+1}} u^y\left(rA_t^i k_t^i - \left(k_{t+1}^i - (1-\delta)\, k_t^i\right)\right) \\ &\quad + \beta\lambda E_{A_{t+1}|A_t} V_{3,t+1}^{i,m}\left(A_{t+1}^i, k_{t+1}^i \middle|\ J_{3,t+1}^i\right) \end{aligned}$$

$$\begin{aligned} V_{3,t}^{i,m}\left(A_t^i, k_t^i \middle|\ J_t^i\right) &= \max_{k_{t+1}} u^o\left(rA_t^i k_t^i - \left(k_{t+1}^i - (1-\delta)\, k_t^i\right)\right) \\ &\quad + \beta\lambda E_{A_{t+1}|A_t} V_{3,t+1}^{i,m}\left(A_{t+1}^i, k_{t+1}^i \middle|\ J_{3,t+1}^i\right) \end{aligned}$$

Comparing the expected utility under various technological choices yields the optimal per-period technological choice for an agent of a given cohort and wealth which we denote by $J_{1,t}^{i,m}$, $J_{2,t}^{i,m}$, $J_{3,t}^{i,m}$ for a newly born, young adult and elderly respectively at time t.

$$\begin{aligned} J_{1,t}^{i,m}(A_t^i, k_t^i) &= \arg\max\left\{V_{1,t}^{i,m}\left(A_t^i, k_t^i \middle|\ LR\right), V_{1,t}^{i,m}\left(A_t^i, k_t^i \middle|\ HR\right)\right\} \\ J_{2,t}^{i,m}(A_t^i, k_t^i) &= \arg\max\left\{V_{2,t}^{i,m}\left(A_t^i, k_t^i \middle|\ LR\right), V_{2,t}^{i,m}\left(A_t^i, k_t^i \middle|\ HR\right)\right\} \\ J_{3,t}^{i,m}(A_t^i, k_t^i) &= \arg\max\left\{V_{3,t}^{i,m}\left(A_t^i, k_t^i \middle|\ LR\right), V_{3,t}^{i,m}\left(A_t^i, k_t^i \middle|\ HR\right)\right\} \end{aligned}$$

Decreasing relative risk aversion implies that sufficiently poor agents (those with low $A_t^i k_t^i$) adopt the LR technology while sufficiently wealthy agents adopt the HR technology. If there are initially sufficiently many poor agents, the average productivity of capital is low enough to make the LR technology optimal for subsequent generations as well. If, however, there are initially sufficiently many wealthy agents who adopt the HR technology, their choice has a positive inter-temporal spill-over effect; it increases the initial capital productivity of the newly born. This process of higher capital productivity reinforces itself and eventually every agent employs the risky technology. Our model thereby captures that technological choices have an external effect on productivity growth and either LR or HR technologies can perpetuate in equilibrium.[35]

The HR technology Pareto dominates the LR technology because shocks are agent's specific and there is no aggregate uncertainty.[36] It is Pareto optimal for all agents to use the HR technology and share the output thereby gaining from its positive inter-temporal spill-over effects. Risk-sharing institutions can therefore determine whether an economy remains in a LR technology equilibrium or exhibits a transition to HR technology equilibrium. In our model a society can remain trapped in a low-growth equilibrium in the absence of an appropriate risk-sharing institutions. If a risk-sharing institution is introduced, however, a larger fraction of the agents adopt the HR technology and the increase in wealth can reinforce the adoption of the risky technology, up to the point where every agent utilizes the HR technology.

3.2.2 State-based insurance: the Old Poor Law

In modeling the Old Poor Law one has to consider its fiscal implications. Relief to the poor has to be financed through taxation that can distort technological choices and the allocations of capital and labor. The Old Poor Law, however, was financed by a tax on land. Taxing a fixed factor acts as a quasi lump-sum tax and it is therefore reasonable that distortions were rel-

[35] Similarly, increasing returns to scale in the endogenous growth literature implies that higher income per capita leads to higher productivity levels, which itself increases income per capita and reinforces growth (e.g., Romer 1986).

[36] For a proof see Kocherlakota (1996) or Ligon, Tomas and Worral (2000). Since the endowment is state invariant in the economy and there is perfect risk sharing, agents will have constant consumption across states. Since total endowment is larger under the high risk-high return technology, agents will have a higher state-invariant consumption under the latter technology.

atively small. The evidence confirms that this was the case.[37] Accordingly, we ignore the issue of financing (and its distortionary effect) to more clearly capture the Poor Law's impact on risk-taking rather than wealth redistribution. Similarly, those who paid or administered the tax had neither legal nor customary rights to influence others' technological choices. Accordingly, we assume that the Poor Law reduces the variance of the individual-levek technological shocks.[38] Specifically, denote the standard deviation of the individual level idiosyncratic shock under the Poor Law by $\sigma^2_{j,PL}$, $j = LR, HR$ and assume that:

$$\varepsilon^{PL}_{t,j}\tilde{\ } F_{PL} \text{ with } \left\{F_{PL} : F_{PL}\tilde{\ } \left(0, \sigma^2_{j,PL}\right)\right\}$$

$$\text{with } \sigma^2_{j,PL} < \sigma^2_j$$

The Poor Law reduces risk and therefore the capital productivity levels above which agents adopt the risky technology. Formally, denote these thresholds of capital productivity levels in the market economy by $\left(\underline{A^m_y}, \underline{A^m_o}\right)$ for the newly born and the rest of the agents respectively before the Poor Law, and by $\left(\underline{A^{PL}_y}, \underline{A^{PL}_o}\right)$ after the Poor Law. The reduction in risk implies that $\underline{A^{PL}_y} < \underline{A^m_y}$, $\underline{A^{PL}_o} < \underline{A^m_o}$.[39] (See proof in the appendix.)

By reducing the threshold levels above which agents adopt the risky technology, a Poor Law can initiate a transition that otherwise would not have

[37] Clark (2008) estimated that the Old Poor Law was not distortive. Personal and commercial wealth was not taxed. To the extent that the Poor Law thereby led to allocating more resources toward commerce and industry, it had an additional favorable impact on industrialization.

[38] Another way to model the Poor Law is to truncate shocks below a certain threshold:

$$\varepsilon^{PL}_{t,j}\tilde{\ } F_{PL} \text{ with } \left\{F_{PL} : F_{PL}\tilde{\ } \left(0, \sigma^2_j\right) \text{ and } \sup_F \left[-\iota_{PL}, \iota\right]\right\}$$

$$\text{where } -\iota_{PL} > -\iota,\ F\left(-\iota_{PL}\right) > 0 \text{ and } F_{PL}\left(x\right) = F\left(x\right)\ \forall x > -\iota_{PL}$$

Because $E\left(\varepsilon^{PL}_{t,j}\right) > 0$ this modeling of the Poor Law implies both a change in the risk structure and wealth. To keep the introduction of the Poor Law wealth neutral, we prefer modelling as a reduction in the volatility of the shocks.

[39] It is sufficient to focus on the newly borns and the elders becuase the treshold for the young adult and the elderly are the same. The choice of the technological regime impacts next period utilty, where both the current young adults and elder agents have the same preferences.

happened. The simulation below lends support to the argument that the Old Poor Law had such impact. Before turning to the simulation, however, we address the comparative question: couldn't an equivalent lineage-based insurance be similarly effective in initiating a transition? We find that the lineage-based insurance, as practiced in China, was not similarly effective.

3.2.3 Social Insurance: The Lineage

Distinct assignment of decision rights were associated with the Chinese lineage-based institution and the English Poor Law. Under the lineage-based insurance, elders had more decision rights over technological choices than they had under the English Poor Law. The following extension of the model captures this distinction.

A lineage, Γ, is a finite group of agents of different generations that merge their endowments, share the output they produce and commonly decide which technology to use. Since each lineage has a finite number of agents, even initially identical lineages will subsequently differ in their per-period mortality and membership. We therefore model the dynamics of an average lineage, whose demographic are identical to that of the population as a whole. The average lineage is composed of one newly born, λ young adults and $\frac{\lambda^2}{1-\lambda}$ elderly agents implying an expected number of agents of $\frac{1}{1-\lambda}$.

Capital and labor are matched within the lineage and output is divided, without loss of generality, equally among members. There are $\frac{1}{1-\lambda}$ members in the average lineage and therefore each member obtains $(1-\lambda)$ of the total production. To maintain comparability with the individualistic society and to capture insurance provided by the lineage, we assume that the capital of each lineage's member is still subject to individual-level idiosyncratic shocks. The variance of the productivity shock that the lineage faces is $(1-\lambda)^2$ times smaller than the variance of any given technology. Lineages provide insurance.

Insurance provided by the lineage, everything else being equal, makes a transition more likely. Lineage-based insurance, similar to the Poor Law reduces risk and therefore the capital productivity levels above which agents adopt the risky technology. Formally, denote these threshold by $\left(\underline{A_{y,}^{\Gamma}}, \underline{A_o^{\Gamma}}\right)$ when there is insurance. Everything else being equal, the lineage-based insurance might be as effective in promoting risk taking as the Poor Law.

But not everything is equal and in the case of China, elders had more decision rights than other members. Accordingly, we assume that the elders determine the technological choice and the capital accumulation within each lineage. Formally, the evolution of the capital stock for the average lineage is $k_{t+1}^{\Gamma}=\lambda\left(k_t^{\Gamma}(1-\delta)+h_t^{\Gamma}\right)$ where $k_t^{\Gamma}=\sum_{i\in\Gamma}k_t^i$ and h_t^{Γ} is investment at time t. The elders' decision can be analyzed sequentially, as before, by first considering the optimal investment for a given the clan's technological regime at time t , $J_t^{\Gamma}=\{LR \text{ or } HR\}$, and then considering the choice of optimal technology. Note that the value functions for the newly born and the young adults are determined by the elders' investment choice and there is full insurance - equal consumption - within the clan.[40] Using the notations developed above, these value functions and choice are (for a given technology):

$$\begin{aligned} V_{1,t}^{i,\Gamma}\left(A_t^{\Gamma},k_t^{\Gamma}\middle|\ J_t^{\Gamma}\right) &= u^y\left((1-\lambda)\left(A_t^{\Gamma}k_t^{\Gamma}\right)^{\alpha}-\left(k_{t+1}^{\Gamma}/\lambda-k_t^{\Gamma}(1-\delta)\right)\right) \\ &\quad +\beta\lambda E_{A_{t+1}|A_t}V_{2,t+1}^{i,\Gamma}\left(A_{t+1}^{\Gamma},k_{t+1}^{\Gamma}\middle|\ J_{t+1}^{\Gamma}\right) \end{aligned}$$

$$\begin{aligned} V_{2,t}^{i,\Gamma}\left(A_t^{\Gamma},k_t^{\Gamma}\middle|\ J_t^{\Gamma}\right) &= u^y\left((1-\lambda)\left(\left(A_t^{\Gamma}k_t^{\Gamma}\right)^{\alpha}-\left(k_{t+1}^{\Gamma}/\lambda-k_t^{\Gamma}(1-\delta)\right)\right)\right) \\ &\quad +\beta\lambda E_{A_{t+1}|A_t}V_{3,t}^{i,\Gamma}\left(A_{t+1}^{\Gamma},k_{t+1}^{\Gamma}\middle|\ J_{t+1}^{\Gamma}\right) \end{aligned}$$

$$\begin{aligned} V_{3,t}^{i,\Gamma}\left(A_t^{\Gamma},k_t^{\Gamma}\middle|\ J_t^{\Gamma}\right) &= \max_{k_{t+1}} u^o\left((1-\lambda)\left(\left(A_t^{\Gamma}k_t^{\Gamma}\right)^{\alpha}-\left(k_{t+1}^{\Gamma}/\lambda-k_t^{\Gamma}(1-\delta)\right)\right)\right) \\ &\quad +\beta\lambda E_{A_{t+1}|A_t}V_{3,t}^{i,\Gamma}\left(A_{t+1}^{\Gamma},k_{t+1}^{\Gamma}\middle|\ J_{t+1}^{\Gamma}\right) \end{aligned}$$

The lineage's technology is the one optimal to the elders implying that the technological regime, $J_{3,t}^{i,\Gamma}$, is determined by:

$$J_{3,t}^{i,\Gamma}=\arg\max\left\{V_{3,t}^{i,\Gamma}\left(A_t^{\Gamma},k_t^{\Gamma}\middle|\ LR\right),V_{3,t}^{i,\Gamma}\left(A_t^{\Gamma},k_t^{\Gamma}\middle|\ HR\right)\right\}$$

Since the elders are more risk averse than the young, the elders would choose, *ceteris paribus*, the LR technology in situations in which the newly born agents would choose the HR technology. In particular, different choices are likely in 'intermediate' level of capital productivity. (See appendix.) Two

[40] All elders will make the same choice given that each considers the clan's total effective capital.

opposite forces emerge in the lineage-based society. On the one hand, insurance within the lineage fosters risk taking. On the other hand, the elders' higher risk aversion discourages risk taking. Which force would dominate and whether the lineage-based insurance promotes growth is an empirical matter.

4 Simulation[41]

In the absence of data to conduct to an empirical analysis, we resort to simulation. Was the reduction in risk-taking caused by differences in decision rights large? More generally, could differences in risk-taking account for England's transition and China's stagnation? Our simulation suggests a positive answer to both questions.

To make the simulation meaningful and consistent with the historical evidence, our choice of parameters is aimed at first simulating both economies in steady states where income per capita is relatively constant over time. This captures well the situation in China and England prior to 1600. The simulation then examines the impact of state-based tisk-sharing institution assuming that it provides the same level of risk-sharing as the clan-based insurance. The simulation thus cpatures the impact of insitutional forms and not function, namely, the difference in risk-taking enatiled by institutions that provide the same level of insurance. We can consider whether the Poor Law could have tiltled the balance of risk-taking to initiate a transition.

4.1 Parameters Choice

In the model there are parameters related to rental price of capital, preferences and technology. The main parameters that affect preferences includes risk aversion, σ, and discounting, $\lambda\beta$. The main parameters that affect technology are means, μ_{LR}, μ_{HR}, variances, ν_{LR}, ν_{HR}, capital share, α, and depreciation rate, δ. Table 2 summarizes the parameters chosen for the simulation and we explain our choices below.

We set the capital share to $\alpha = 1/3$, the depreciation rate $\delta = .543$, implying a 3% annual depreciation and a population size of 10000. Based on the

[41]This simulation is tentative and based on a slightly different specification of the newly born profit function. We are in the process of rerunning the simulation and expect the results to be qualitatively the same.

historical interest rates reported in Homer and Sylla (1998), we set the interest rate r to 4.5% a year (yielding a 141.17% return every twenty year period). We set the initial capital stock and capital productivity values to prevent A_t^i from becoming negative. These values generate a steady state where none of the agents' consumption goes below 0.01 when young and 0.05 when old. We use a CES utility function and to prevent uninsured agents from always preferring the risky technology, we set the common risk aversion parameter, σ, to 5 (which is within the range of risk aversion coefficients in macroeconomics). It is sufficient for the analysis to assume DRRA and higher risk aversion for the elders but to restrict arbitrarily choosing parameter values, we assume Stone-Geary preferences with a higher minimum consumption for the old. We thereby endogenize differences in risk preferences.[42] Specifically, the utility function of agent u^r, $r = y, o$ is:

$$u^r = \frac{(c - \overline{c}^r)^{1-\sigma} - 1}{1 - \sigma}$$

where $\overline{c}^y < \overline{c}^o$. The relative risk aversion coefficient R^r is:

$$R^r = \sigma \left(\frac{c}{c - \overline{c}^r} \right)$$

We assume that the consumption requirement for the young is the lower bounds in our simulation, namely, $\overline{c}^y = 0.01$ for the young and $\overline{c}^o = 0.05$ for the old. This specification leads to a reasonable difference in risk aversion between the young and the old when the steady state consumption per capita is the same across societies. (Namely, before the poor law is established.) In that steady state consumption per capita of almost 0.55, the risk aversion coefficient for the young is initially 5.09 and is only 8% higher for the elders, at 5.5.

Each period lasts for twenty years in our simulation. Agents are newly born in the 0-19 cohort, young adult in the 20-39 cohort and elderly for the rest of the cohorts. We set the discount factor, β, to .603, which implies an annual discount factor of .975. Agents die with a per-period probability, λ, of .5. This is consitent with the high rate of pre-modern mortailty before adulthood and implies that an agent's expected working life is thirty years which is reasonable given that as late as the early 19th century, life expectancy at

[42] This property still enables us to carry our argument that higher wealth induce agents to assume more risk in absolute value and in percentage change.

birth was about 40 years.[43] We assume that young agents are born with the average productivity of the previous period and the average capital level of the previous period minus depreciation.

We normalize the return to LR technology to be zero, $\mu_{LR} = 0$. To set the return to the HR tecnology, wee note that in the early stage of English Industrial Revolution (1780 to 1820), the annual income per capita growth rate was slightly less than 0.5% (Maddison 1991). Accordingly, we assume that the HR technology has a period return of $\mu_{HR} = 10.489\%$ which implies a 0.5% return a year.

To simplify the simulation we set the binomial shock, ε_t^i, to $\varepsilon_{t,LR} = \pm\nu_{LR}$ and $\varepsilon_{t,HR} = \pm\nu_{HR}$ for the low and high risk technology respectively. Table 1 shows the level of ν_{LR} and the relative value of ν_{HR} on the rows and columns respectively, given that the rate of return for the LR and HR technologies are 0 and 0.5% a year respectively. We set the absolute and relative size of the variances to replicate the initial conditions of zero or very low productivity growth. If the shocks are too small, the initial capital and productivity endowments determine whether all or none of the agents engage in risky activities. Larger values for ν_{LR} imply more technological transitions as positive productivity shocks shift the optimal technology from LR to HR. Under the Poor Law, large shocks cause agents to switch from low income levels to income levels that are high enough to adopt the HR technology although they might later transition back to the LR technology. However, given the higher mean, this transition is less likely to happen. If ν_{LR} is below 0.1, there is almost no transitions. On the other hand, if ν_{LR} is above 1/3, there is too much variation in the shocks and we have cases were productivity becomes negative for some agents. If ν_{HR} is twice ν_{LR}, too many people engage in risky activities. If it is three times as much, only some individuals engage in risky activities in the steady state before the Poor Law is introduced. If it is four times as much, almost no individuals engage in the risky technology. We let ν_{HR} be three times as high as ν_{LR} and set $\nu_{HR} = 1$ and $\nu_{LR} = 1/3$.

Under our assumptions, average lineage shocks are half those an individual face: $\varepsilon_{t,j}^{\Gamma} = \frac{\varepsilon_{t,j}}{2}$ for $j = LR, HR$. For the Poor Law to imply the same level of risk-sharing, we reduce the shocks to those of the lineage, $\sigma_{j,PL}^2 = \varepsilon_{t,j}^{\Gamma}$, for

[43] In the early nineteenth century China (the Yangzi Delta), male life expectancy at 15 was between 30 to 54 years (Liu, Cuirong, 1992 cited by Brenner and Isett, 2002). In our model the probability of being older than 100 years is 3.125%. This is clearly unrealistic, but keeping an unconditional death probability simplifies the model and keeps the fertility issue as silent as possible.

$j = LR, HR$.[44] Since ν is fixed, the wealthier the individuals are, the more they are inclined to engage in the risky technology. We have also modeled the case where the shock is heteroskedastic and takes the form: $\varepsilon_t = \pm\nu * A_t$. Since preferences are DRRA, as agents become wealthier the same effect emerges as when ν is fixed and the results are qualitatively the same.

4.2 Results

The simulation supports the conjecture that risk-sharing institutions were important in England's transition and China's relative lack of economic growth. In the lineage economy, risk-sharing motivate some of the relatively more risk-averse elders to chose the HR technology but their number is too low to initiate a transition. There is no major shift toward using the HR technology. In the market economy (without the Poor Law), there is no risk sharing or taking and the economy is literally stagnant. When a Poor Law is introduced in a market ecomomy, the thresholds to engage in riskier activities decline and there is an instantaneous spike in the fraction of the population that chose the HR technology. This generates income per capita growth that fosters further risk taking. A transition transpires until every agent uses the HR technology and consumption per capita growth becomes positive.

More specifically, initially, all elders in a market economy prefer the low return technology while sufficiently wealthy young adults choose the risky technology. Once the Poor Law is introduced, elderly agents engage in risky activities if their productivity and capital stocks are sufficiently high, and young adult do so for a larger state space than before. Figure 1 and 2 show the regions of A_t and k_t for which the newly born and elderly respectively choose the different technologies. The black area represents the adoption of the LR technology while the shaded area represents the adoption of the HR technology.

Prior to the introduction of the Poor Law, the young adults in the market economy are less risk takers than the elders in the clan-based economy. In other words, clan elders have a lower productivity threshold above which they take risk than the market economy's young adult. The effect of the risk-sharing provided by the lineage is stronger than the effect of the elders'

[44] We have performed a comparative statics analysis where we increase the number of agents per lineage. The more agents present in the lineage, the more inclined the lineage is to engage in the risky technology. This matches the anecdotal evidence of the Tong and Song dinasties, where lineages were widely extended as well as economic prosperity.

higher risk aversion. Once the Poor Law is passed, the thresholds for the young adult and elders in the market economy are lower than those of the elders in the clan-based economy. Figure 3 shows the regions of A_t and k_t for which a lineage's elders choose each technological regime. Again, the black area represents the LR technology while the shaded area represents the HR one.

Figure 4 shows the evolution of consumption per capita over time under the two social arrangements. The grey vertical line represents the introduction of the Poor Law, which we denote as period 0. Consumption per capita is immediately reduced after the Poor Law is introduced, as agents decide to engage in riskier activities and increase their precautionary savings (capital) in case they receive a large negative shock. Afterwards, consumption per capita grows at a positive rate forever, eventually surpassing the Chinese levels.

The fraction of the population that engages in risky activities is relatively constant in the clan-based economy at around 18%. The market economy has no population engaging in such activities but once the Poor Law is established, about 30% of the population immediately adopt the HR technology. The increase in the income per capita reinforces this process, up to the point where every agent in the population chooses the HR technology. During this process and in the clan-based economy, idiosyncratic shocks cause substantial reallocations of agents between the LR and the HR technologies. Depending on the state variables, agents shuffle from one technology to the other. Figure 5 shows the evolution of the fraction that engages in risky activities over time.[45]

The accumulation of capital is constant in the clan-based economy throughout time and in the market economy prior to the Poor Law. After the Poor Law, there is a rapid capital accumulation that is partly (although definitely not fully) reversed immediately after. This spike reflects two effects: a larger expected capital productivity value for next period and precautionary savings. Initially, agents are still poor and hence relatively more risk averse. They accumulate extra capital to mitigate the increase in risk.Gradually, agents become wealthier, the second motive vanishes and capital accumulation decreases slightly.

[45] After the Poor Law is established, many agents are left very close to the technology choice thresholds and therefore idiosyncratic shocks do alter their choices. Even with a 10000 agents simulation we still obtain a slightly volatile series which trends upwards after the poor law is established.

We have also evaluated whether the simulation captures the essence of our model by simulating the introduction of a Poor Law in the clan-based economy and the impact of larger clans. Our theory predicts either Poor Law or larger clans could have led the clan-based economy to transition and the simulation confirms these predictions. Once a Poor Law is introduced in a lineage society, agents adopt the risky activities and the growth rate of consumption per capita becomes positive. Similarly, increasing clans' size by more than three times, leads all agents to adopt the HR technology.

Evaluating why a Poor Law was not introduced or clans did not increase in size is beyond the scope of this paper. Yet, the Poor Law may not have been introduced because a universal, compulsory law would have undermined the lineage system through which the state was administered. Similarly, the decline in communal families indicates that moral hazard and adverse selection problems limited the size of clans.

5 Supporting Historical Observations

The comparative technological history of China and England is puzzling. China was ahead of England around 1000 AD but subsequntly fell behind. During the Song dynasty (960-1279), China was the world's technological leader. It "developed an amazing technological momentum, and moved, as far as these matters can be measured, at a rate as fast as or faster than Europe" (Mokyr 1990, p. 208). Yet, shortly after the fall of the Song, technological development slowed and China became, relatively speaking, technologically stagnant (ibid, p. 219). England became the leader. This reversal of fortune is inconsistent with existing endogenous growth models. Our conjecture is consistent with both.

Consider first China. We argue that two factors determined the impact of its lineage-based institutions on growth. Intra-lineage insurance encouraged risk-taking while control by the risk-averse elders discouraged risk-taking. This implies more (less) technological progress when lineages provides more (less) insurance, when elders are less (more) powerful, and when there is no state-provided insurance. Consistent with these predictions, the equal-sharing of output communal families that were common under the provided more insurance than provided under subsequent dynasties when lineages provided only poor relief (subsection 2.3). Elders also had less legal authority during the Song dynasty than later. Under the Song, a parent who killed an unfilial son was subject to a lower punishment compared to other murders. As severe this law may seem, it was mild compare to the law in later dynasties under which it was not a crime for a father to kill an unfilial son! (Hamilton 1990, p. 86). Clearly, disobeying one's father in post-Song China was a dangerous proposition.

Finally, the Song was the only post-1000 AD dynasty to have a substantial state-based, risk-sharing institutions. Wang Anshi, a prominent Song minister and reformer asserted that the state was responsible for providing the poor. Under his direction the state instituted pensions for the needy. (Ebrey, Walthall, and Palais 2005). Later dynasties did not follow this example although because clans were mainly rural, poor relief was sometimes provided in cities.

Prior to the seventeenth century, England was less innovative than China. Our analysis suggests the importance of China's effective risk-sharing institutions in causing this outcome. Following the introduction of the Poor Law in England during the seventeenth century, however, the intellectual and organizational basis of England's industrial revolution was formed (Mokyr 2005). There was, in particular, a rise in the distribution and creation of new agricultural knowledge as measured by patents and technical manuals. Between 1550 and 1600, the number of patents was zero and the number of published farming technical manuals was 16. In the next 50 years the numbers increased to 28 and 43 respectively (Sullivan 1984, table 1).[46] England's economic ascendancy had began in the seventeenth century (Nef 1940; Clark 2005). While real wage declined in the sixteenth century, it increased after 1601 and by the 1740s wages were 67 percent higher than would have been predicted by the pre-1600 relations between population and real wages.[47]

If the Poor Law reduced risk that innovators faced by lowering the likelihood of violent popular response, areas with better poor relief should have had a higher rate of innovations and growth. Although in principle this is a testable proposition, unobservable variations over time and space preclude doing so. These variations includes parish-level politics, the endognouse level of poor reliefs expenditures, local and weather related economic conditions, the sequentiality and randomness of innovations, the employment implications of different innovations (e.g., drainage, economies of scale, new agri-

[46] Sullivan conjectured that the increase reflects popolation growth. The rate of population growth, however was much lower.

[47] Clark 1995; Allen 2001.

cultural products and techniques, turnpike, and enclosure), and negative or positive inter-parish externalities.[48] A positive correlation between poor relief and growth is suggested, however, by a survey conducted by the Board of Trade in 1696. The survey reveals a "heavy expenditure [on poor relief], relative to population, in towns and industrial areas, suggesting that they had been first in the field" (Slack 1990, p. 18).

Another puzzling observation is that during the Industrial Revolution, England did not stand out as particularly inventive. It was particularly good in adopting, adapting, and commercializing inventions made elsewhere.[49] France, in contrast, was a particularly important source of inventions (Mokyr 1990). This observation is consistent with our conjecture. England's risk-sharing institutions did not specifically rewarded inventors and its patent system was not particularly rewarding either (e.g., Khan 2008). The Poor Law encouraged risk-taking in commercializing inventions by securing local landlords and industrialists from the social unrest that their innovative activities might have otherwise caused. France, which did not have a patent system during that period, was nevertheless inventive because inventors were rewarded by the Crown (Kremer 1998). France's Poor Law system, however, was not as effective as England's (e.g., Solar 1995, p. 7; Lindert 2004, p. 8) and innovations did not follow inventions.

Despite the differences in poor relief between England and the continent, the European states were in a better position to imitate England than Chinaa. They did not have lineages, elders had less power, and some state-based poor relief existed. As our analysis predicts, Europe's transition to the modern economy quickly followed England's while China did not. Notably, the continental industrialization transpired in the context of creating the modern, state-based welfare system. (Lindert 2004). At this point in the process of the rise of the modern economies, formal education became more important as a source of productivity growth (Easterlin 1981).

[48]Boyer 1986, for example, found that (in the early 19th century) the higher per-capita expenditures on poor relief in the agricultural counties, compared to industrial ones, reflects differences in the local political power of labor-hiring farmers.

[49]Mokyr (1990, 2002) highlighted the importance of complementary factors such as an advanced machine tool industry. These, however, also reflect the growth in useful knowledge.

6 Conclusion

In current growth-theoretic models, the initial increase in the rate of productivity growth that causes transitions to modern economy are due to either favorable realizations of random economic variables or a technological drift. This paper presents how institutional changes can initiate a transition by causing an endogenous technological drift. Analytically, our model considers the impact of distinct forms of risk-sharing institutions on risk-taking, new useful knowledge, and the rates of technological changes.

Historically, the paper focuses on risk-sharing institutions in pre-modern China and England. In both societies such institutions were introduced for similar moral and political reasons. The forms of these institutions, however, were determined by pre-existing cultural, social, and institutional features. Clans were a central component of China's social and cultural fabric and provided the state with such services as taxation and adjudication. It was optimal for the state to rely on clans also to provide social safety nets. The resulting clan-based, risk-sharing institutions contributed to the influence of the elders on economic decisions. The higher influence of the relatively more risk-averse elders had a negative effect on risk-taking, new knowledge, and growth. Societies in which risk-sharing was provided by elders-dominated kinship groups, were less likely to experience a transition to a modern economy.[50]

In England, during the same time, there were no large kinship groups and individualism prevailed. Non-kin based organizations, such as parishes provided the state with administrative services. It was optimal for the state to rely on parishes to provide insurance as made explicit in the Old Poor law of 1601. This risk-sharing institution did not shift decision power to the relatively more-risk averse elders. The Poor Law had the unintended consequence of fostering risk-taking, new useful knowledge, higher rate of productivity growth and the transition to the modern economy. It better insured the young thereby motivated risk-taking. Better insurance to the poor reduced the risk from social unrest that the wealthy faced when implementing new knowledge.[51]

[50] Risk-sharing institutions might still be relevant in determining the rate of productivity growth. In contemporary Africa, for example, parents did not adopt Pareto-improving technologies that would have reduced their control over their children and hence the likelihood of old-age support (e.g., Hoff and Sen, 2005).

[51] The positive mortality and real wage trends ended one hundred and fifty years after

The unintended consequences of the distinct forms of risk-sharing institutions in China and England suggests "why was England first?" and why Europe, being culturally and socially similar to England, was second. Ironically, Europe's success seems not have been due to foresight but an unintended consequence of its peculiar institutions. Our analysis supports the view that institutional distinctions – in function and forms – were central, rather than epiphenomenal, to transitions to modern economies.

Transitions' institutional conditionality is a contested issue in economic history and growth theory. Economic historians have traditionally emphasized England's growth-enhancing institutions, such as limited government, better labor markets, and a social environment conducive to innovations (e.g., North and Weingast 1989; Mokyr 1990, 1999, 2007; and Solar 1995). More recent literature, however, has down-played institutions' role, claiming that intra- and inter-European institutional distinctions were insignificant on the eve of the Industrial Revolution (e.g., Craft 1977; Pomeranz 2000; Clark 2005).

Growth theory has similarly downplayed the importance of institutional distinctions and emphasized the importance of accidents in determining the historical sequence of transitions. The "Industrial Revolution transpired due to an exogenous increase in research productivity" (Kremer 1990, p. 706). Institutions have been considered to impact, at most, the sequence of transitions but not the process leading to them. "Policy and institutions, by discouraging or preventing the invention and adoption of new ideas, might play an important role in determining when" industrialization transpires and "the fact that the industrial revolution happened first in England, ... rather than ... China ... is perhaps due to the institutions and policies in place in these two countries" (Hansen and Prescott 2002, p. 1215; and see Galor 2005, p. 178).

Our analysis suggests that institutions play a larger role in transitions determining whether transitions will or will not transpire by influencing risk taking, technological development, and thus the rate of productivity growth. More generally, this paper reaffirms that it is possible and rewarding to build on the pioneering recent works in growth theory to better capture the com-

the Old Poor Law was enacted. Real wage, for example, declined during the second half of the 18th century and rose again only in the 19th. The real world, unlike our model, exhibited urbanization, population growth, the Napoleonic war, and industrialization that changed workers' bargaining power. See Crafts 1985; Steckel and Floud 1997; Weir 1997; Cinnirella 2008.

plexity and diversity in of growth processes. The functions and forms of non-market institutions, and the political, social and cultural factors that influence institutional selection matter. Incorporating institutions in unified growth theory has the promise of enhancing our understanding of the "change in human condition that the industrial revolution represents" (Lucas 2002, p. 110).

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8 Appendix: Productivity Level and Optimal Technology

Remark 1 *For every state of the world and social arrangement ($r = m, PL,$ or Γ) there is a pair of productivity levels $\left\{\underline{A_y^r}, \underline{A_o^r}\right\}$ such that if $A_t < \underline{A_y^r}$, LR technology is optimal for all agents; if $A_t \in \left[\underline{A_y^r}, \underline{A_o^r}\right]$, the HR (LR) is optimal for the newly born (young adult and older agents); and if $A_t > \underline{A_o^r}$, HR technology is optimal for all agents.*

Proof. The preferences depend on the comparison between the two technological regimes, that can be viewed as two lotteries. The decision of the newly born agents depends on:

$$sign\ E_{A_{t+1}|A_t} V_2^r \left(A_{t+1}, k_{t+1} \middle| \ (A_t, k_t)\ ,\ HR\right) - E_{A_{t+1}|A_t} V_2^r \left(A_{t+1}, k_{t+1} \middle| \ (A_t, k_t)\ ,\ LR\right)$$

$$\text{for } r = m, PL, \text{ or } \Gamma$$

The young adult and the older agents always have the same optimal technology. The choice of technology impacts on next period utility, where both types of agents will have the same (elderly type) preferences. Their decision depends on:

$$sign\ E_{A_{t+1}|A_t} V_3^r \left(A_{t+1}, k_{t+1} \middle| \ (A_t, k_t)\ ,\ HR\right) - E_{A_{t+1}|A_t} V_3^r \left(A_{t+1}, k_{t+1} \middle| \ (A_t, k_t)\ ,\ LR\right)$$

$$\text{for } r = m, PL \text{ or } \Gamma$$

Since all the agents have DRRA utility functions, given the state variables (A_t, k_t), there is a threshold productivity value, $\left\{\underline{A_y^r}, \underline{A_o^r}\right\}$ for (**??**) and (**??**) respectively, such that for any value below that threshold agents choose the low risk regime and for any value above that threshold they choose the high risk regime in each of the social structure organizations. Since elderly agents are more risk averse than young agents (**??**) is always higher than (**??**) and therefore $\underline{A_y^r} < \underline{A_o^r}$. This determines three zones. Given (A_t, k_t), if $A_t < \underline{A_y^r}$, there is unanimity and all the agents favor the low risk-low return regime. If $A_t \in \left[\underline{A_y^r}, \underline{A_o^r}\right]$ newly born favor the high return regime while the rest of the agents the low return regime. If $A_t > \underline{A_o^r}$, all the preferences are realigned again and everybody favors the high return regime.

■

9 Tables and Figures

Figure 1. Technological Choice for the Newly Born Market Society

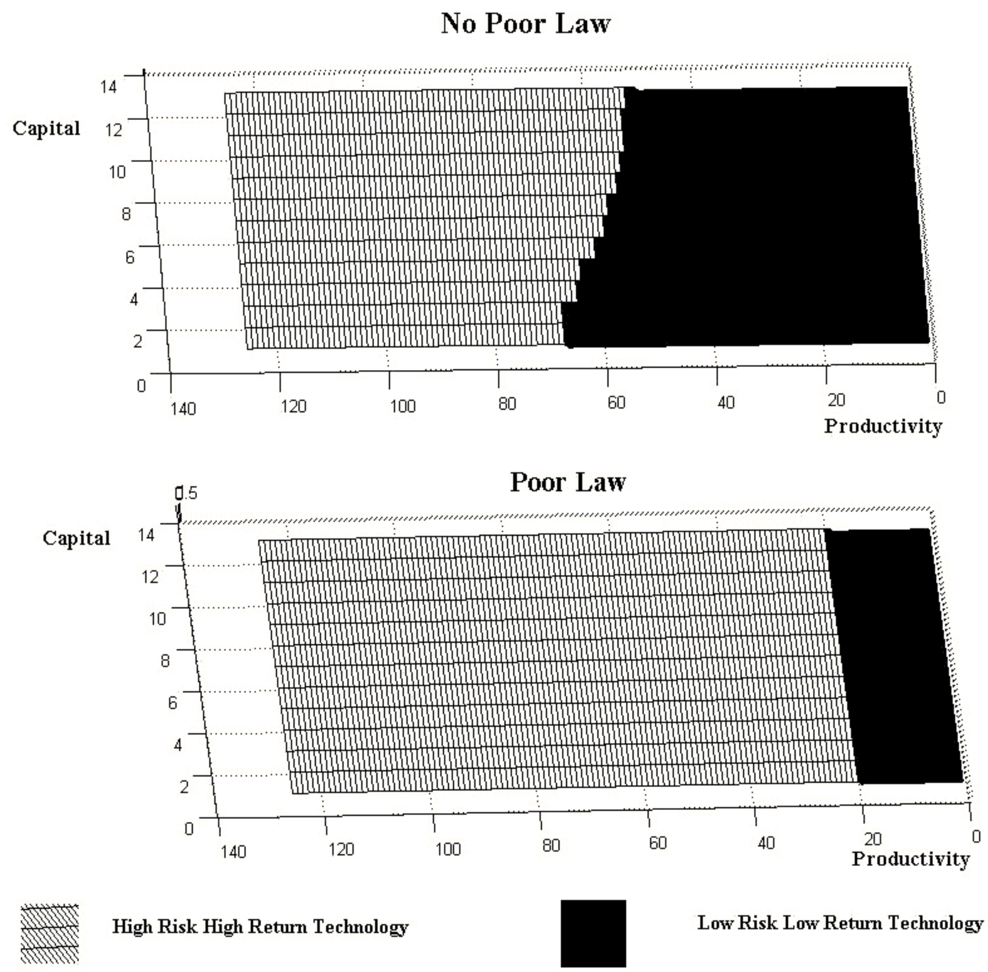

Figure 2. Technological Choice for the Elderly Individualistic Society

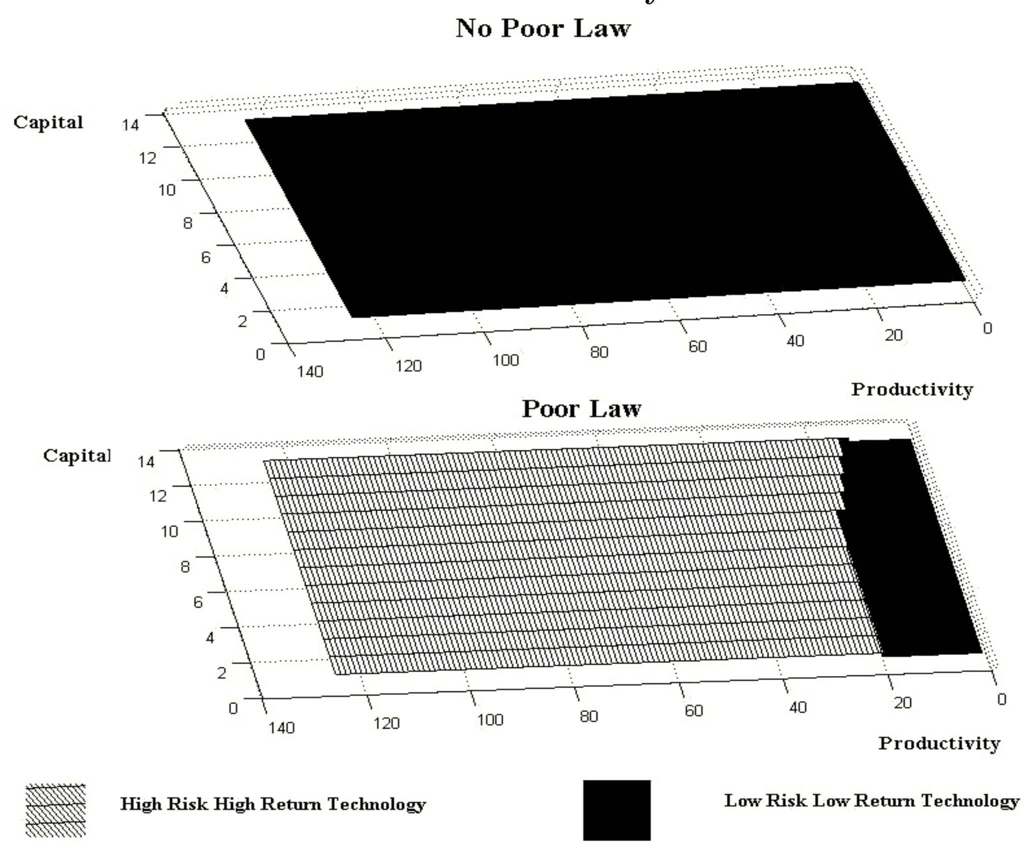

Figure 3. Technological Choice
Lineage Society

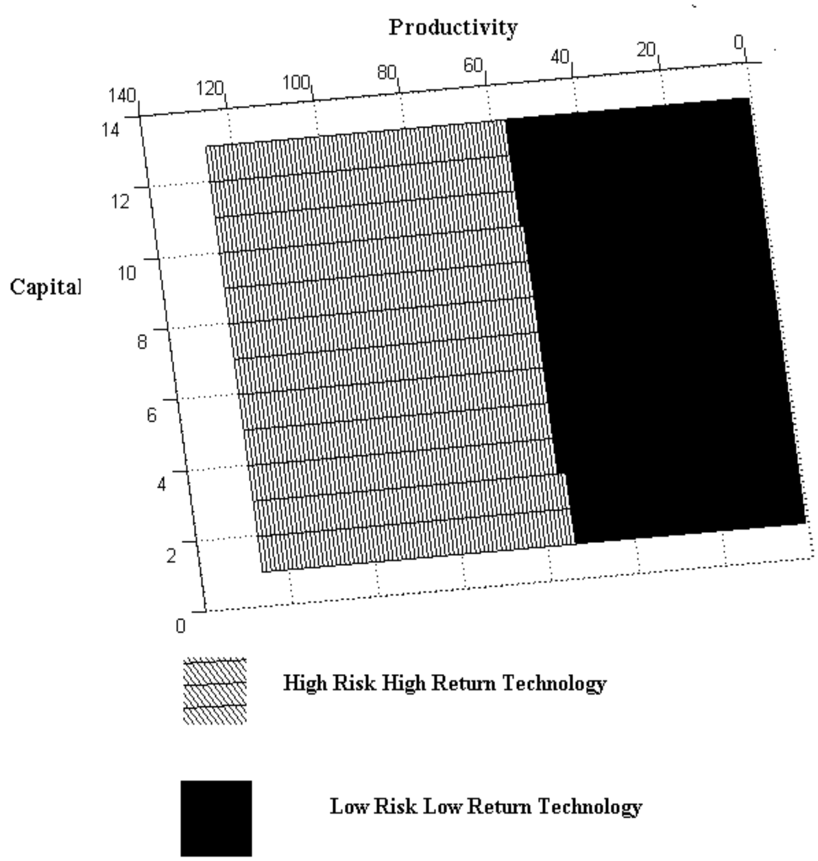

Figure 4. Consumption per Capita

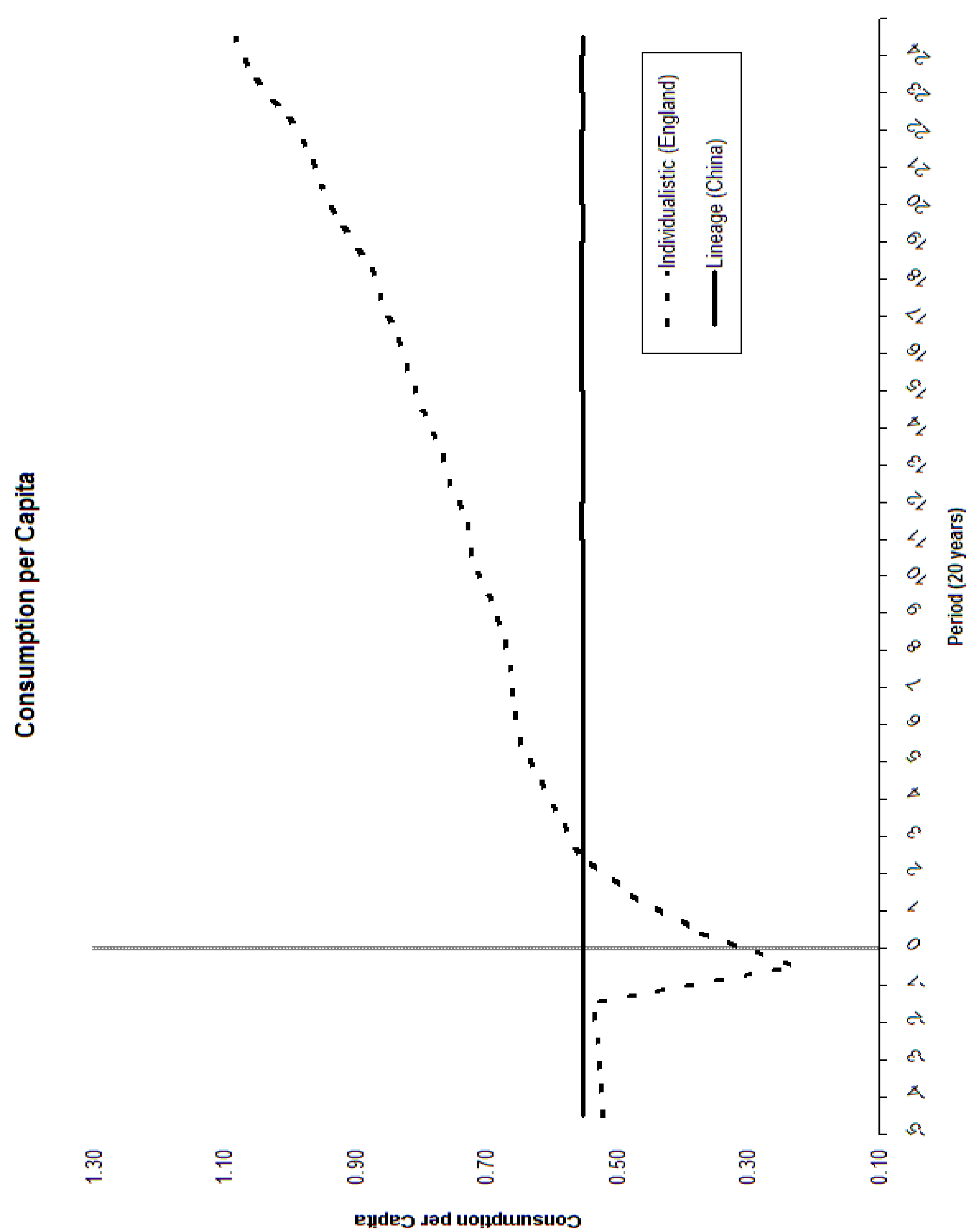

Figure 5. Fraction Engaging in Risky Activities

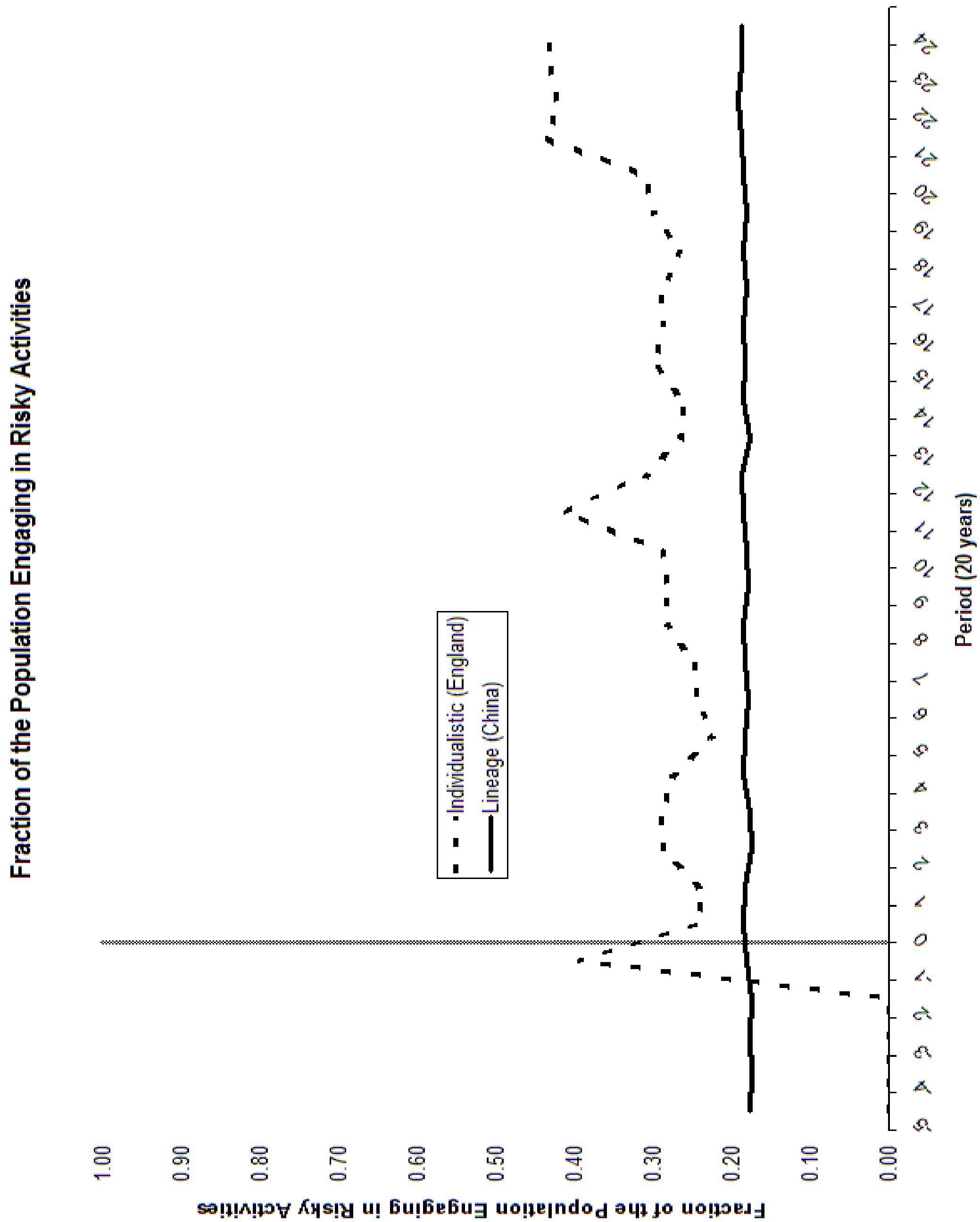

Figure 6. Capital Accumulation

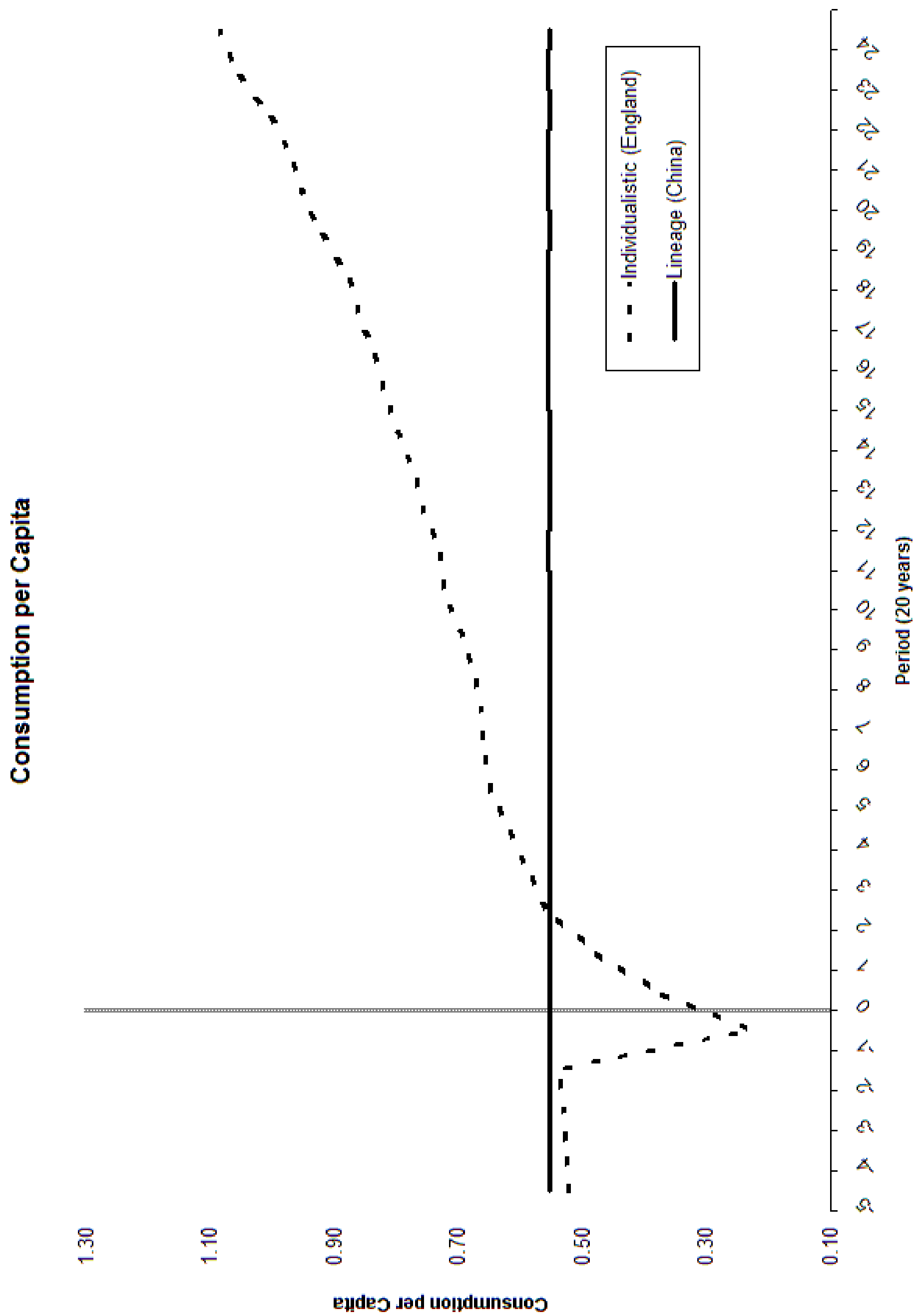

Table 1. Idiosyncratic Shocks

$v_{LR} \backslash v_{HR}$	$v_{HR} = 2 * v_{LR}$	$v_{HR} = 3 * v_{LR}$	$v_{HR} = 4 * v_{LR}$
$v_{LR} = 0.01$	HR, No Transition	HR-LW, No Transition	LR, No Transition
$v_{LR} = 0.05$	HR, No Transition	HR-LR, No Transition	LR, No Transition
$v_{LR} = 0.1$	HR, No Transition	HR-LR, No Transition	LR, No Transition
$v_{LR} = 0.33$	HR, Transition	HR-LR, Transition	LR, Transition
$v_{LR} = 0.5$	HR, Transition	HR-LR, Transition	LR, Transition

Table 2. Parameters

c_y	c_o	σ	β	λ	μ_1	μ_2	ν_{LR}	ν_{HR}	δ	r	α
.01	.05	5	$.975^{20}$	1/2	0	$1.005^{20} - 1$	1/3	1	$(1 - .03)^{20}$	$1.045^{20} - 1$	1/3