CULTURE AND ECONOMIC GROWTH

by

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DISSERTATION ABSTRACT

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The most fundamental question in economics is what causes some countries to prosper. An emerging literature has focused on the role of culture in determining growth. I interpret culture as "the collective programming of the mind which distinguishes the members of one group or category of people from those of another," following Hofstede. I focus on the role of culture in determining economic decision making and cooperation, with an emphasis on how cross-cultural differences in how strangers are viewed may influence economic activity by narrowing the scope of interaction.

I use modern econometric techniques and neoclassical economic models to formalize the role of culture in economic decision making and test the power of culture to explain cross-country differences in long run growth paths. Throughout my research I assume that agents behave rationally but that culture influences the expectations or beliefs they have about different activities.

Subject to the common elements above, each chapter answers a slightly different question. Chapter II focuses on how colonial history may influence decisions over risk-taking in certain countries, leading to a dearth of entrepreneurial activity. Chapter III focuses on how interactions across and between cultural groups may explain the decision of minority immigrant groups to assimilate or segregate over time and how public policy may influence this decision making. Chapter IV looks at the effect of culture through the media of trust and government. Using an instrumental variables strategy, I ask which is more important to economic development, contract quality or interpersonal trust, and find strong evidence that interpersonal trust is more important.

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For my parents, whose wisdom I come to appreciate more fully every day.

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CHAPTER I

INTRODUCTION

My research focuses on the role of culture in determining economic outcomes. An emerging literature has looked at the power of culture to explain cross national differences in economic outcomes and I contribute to that literature by formalizing cultural parameters inside of a choice theoretic framework and using modern econometric techniques to explore the power of these models to explain observed differences between countries. Culture can operate on economic outcomes by altering economic decision making in terms of private investments, by influencing the perceived or expected gains of an activity, or by altering the propensity to interact or cooperate with others.

Chapter II studies the cultural process through which a society inculcates an entrepreneurial spirit. People either work for a guaranteed wage or operate riskier businesses. Paternalistic parents prefer their offspring to choose occupations like theirs and accordingly indoctrinate them into their types. Specifically, having themselves developed business acumen, entrepreneurial parents try to endow their children with that human capital. Biological indoctrination may not be successful, in which case children take cultural cues from society at large. Cultural offspring may also choose an occupation different from the one they have been indoctrinated in. I examine the effect of family background on occupational choice and how society's appetite for risk-taking is shaped by culture and institution. A focus on safe occupations, possibly due to colonial and post-colonial policies, results in stagnation with entrepreneurs not upgrading technology because of their proficiency with existing methods. Sudden access to disruptive technologies, due to liberalization for instance, sees the emergence of new entrepreneurial lines who overtake established ones, spurring growth.

Chapter III looks at the relationship between cultural minorities and economic interaction. The economic effects of minority culture are examined using a coordination game to capture the simultaneous negative effect of culture on communication and the gains from trading with dissimilar agents. The model presumes there is some difference in production across cultures and difficulty communicating across cultures. From these basic assumptions, a stable, non-homogenous population distribution (one with some persistent minority culture) can be obtained even in the case of costless cultural choice by rational agents. The model can generate results in which an exogenous shift renders stable minority populations unstable as well as the result of minority populations being socially optimal and socially suboptimal depending on the gains from trade and the difficulty inherent in cross-cultural communication.

In chapter IV, I ask whether culture or government is more important to economic development. I construct a spatial model where people either prefer to trade with close neighbors, or with distant traders, with the possibility that they may cheat their trading partner in either case. These types evolve through imperfect parent-to-child transmission. Trades occur according to a repeated game featuring Prisoner's Dilemma type payoffs. I show that that increased value of trading at a distance can result in the joint cooperative outcome being maintained for all trades. I test this using climate instruments, specifically rainfall variance and absolute level. I find that rainfall variance is associated with higher levels of trust and that rainfall level is associated with stronger legal institutions. Using these as insturments, I find that trust explains a large amount of cross-regional variation in economic development, and that legal institutions don't. I conclude that culture, represented by trust, is important in determining economic development, and government quality is unimportant.

CHAPTER II

THE HISTORICAL ROOTS OF ENTREPRENEURIAL CULTURE

Introduction

Industrialization, which entails risk-taking on a large scale, is at the heart of economic prosperity. The incentives for economic development are consequently tied to the incentives for entrepreneurship. But innovating entrepreneurs do not emerge uniformly from all cultures or randomly from a society. History is replete with instances of small communities – the Huguenots in seventeenth and eighteenth century France, *Parsis* in western India, Chinese traders in south-east Asia – spearheading industry and trade far out of proportion to their numbers (Hagen, 1975, Bisin and Verdier, 2000). The empirical evidence shows a robust positive correlation between family background and occupational choice (Hout and Rosen, 2000, and Constant and Zimmermann, 2003, for example). Parental risk aversion and schooling have been found to affect children's risk attitudes (Hyrshko *et al*, 2011) and evidence from psychology shows that risk-taking differences across culture are associated with differences in the perception of its benefits (Weber *et al*, 2002). There is good reason to believe then that non-economic attributes of societies like cultural values can determine their appetite for risk-taking and economic progress.

This paper connects entrepreneurship with culture using a dynamic model where households are intergenerationally linked. People are of two types, workers or entrepreneurs. The former work for a guaranteed wage, the latter engage in riskier business activities. Individuals are neutral with respect to income risk but expected business earnings depend on their beliefs about the prevailing technology, a business expertise that can be accumulated over time (Jovanovic and Nyarko, 1996). Children are not born with skills for and subjective biases (preference) over the two occupations. These they acquire through upbringing, socialization and occupational experience (Bisin and Verdier, 2000). Parents prefer their offspring to choose occupations similar to theirs and, accordingly, try to imbue them with occupation-specific human capital. For example, entrepreneurial parents perceive entrepreneurship to be more rewarding and, having acquired expertise in their line of work, attempt to pass on that human capital to their children. Similarly wage-working parents may endow their children with human capital that predispose them toward low risk wage-work.

Within-family cultural indoctrination is, however, imperfect. When it fails, the child adopts the trait of a randomly chosen member of the active population. Either way, children's comparative advantage in the two occupations is determined by the time they become economically active. They then choose whether or not to engage in the occupation they have been indoctrinated in. The interplay of the cultural transmission of human capital and values, the accumulation of business expertise in entrepreneurial lines and the introduction of new technologies generate several possibilities.

We show that a focus on safe production results in stagnation where entrepreneurs do not upgrade technology because of their proficiency with existing ones. In this equilibrium, workers receive wages above what they can expect from entrepreneurship, entrepreneurs receive rewards greater than wages. Entrepreneurs do not upgrade their technology because they perceive it to be risker, dominated by their considerable expertise – accumulated over generations – in existing methods. This persistent, no-growth equilibrium is analogous to some colonial and post-colonial regimes in which wage-work or government employment was highly valued, the pursuit of profits frowned upon and businesses were too insular to be dynamic.

We consider this equilibrium as being shocked in one of two broad ways. In the first, the economy is shocked by an increase in overall productivity, causing existing entrepreneurial lines to start upgrading. The result is top-down growth without socio-economic mobility: existing businesses retain their dominant position, the growth of their businesses pulling up the rest of the economy. Alternatively, the stagnant equilibrium can be shocked by a sharp change in the human capital requirement of new technologies. Existing business lines find themselves ill-suited to adopt these new methods since their expertise does not transfer as easily. Some indoctrinated wage workers, on the other hand, become first generation entrepreneurs by adopting the new technologies as they are not invested in previous methods of production. Overtaking results, with the entrant lines becoming more productive than incumbents who eventually abandon entrepreneurship to become wage workers. In the long-run equilibrium, the newly emerged class of entrepreneurs keep upgrading their technologies leading to steady-state growth.

The notion that culture could matter for economic growth is not new of course. It goes back at least to Weber's (1930) thesis that cultural change, the Calvinist Reformation in particular, was critical in the development of capitalism and its institutions. Others have argued that individualism was instrumental in the rise of markets in the West (Lal, 1999, and references therein). Despite this historical interest and an emerging one in empirical development economics (recent examples are Tabellini, 2010, and Gorodnichenko and Roland, 2013), culture has received little formal treatment in modern growth theory. In large measure this reflects the widespread notion that development is only limited by the availability of opportunities and technologies: if incentives are strong enough, culture would change to accommodate economic interests.[1] While our work echoes this point of view, it also shows that culture can often amplify the effect of poor policies and institutions that are not obviously extractive.

Culture, in this paper, straddles several interpretations. Hofstede (1991, p. 5) defines it as "the collective programming of the mind which distinguishes the members of one group or category of people from those of another". In our model, this has the specific interpretation of a willingness to engage in high return-high risk occupations. This willingness evolves through cultural transmission, "transmission from one generation to the next, via teaching and imitation, of knowledge, values, and other factors that influence behavior" (North 1990, citing Boyd and Richerson, 1985). Besides economic incentives, parents are compelled by their own occupational biases in what they culturally transmit to their children.

We build on the literature that studies cultural transmission over time, including Boyd and Richerson (1985), Bisin and Verdier (2000, 2001) and Hauk and Saez-Marti (2002). In a departure from that literature, culture here is occupation-specific and tied to endogenous economic payoffs. We also extend the literature by introducing choice, that is, allowing agents to rationally discard their cultural "types" should it be in their economic interest. Our focus on occupation-specific cultural bias is related to Corneo and Jeanne's (2010) model where individuals value the social esteem some occupations: in our paper that perception is the product of one's own experience.

Less studied is the cultural development of entrepreneurship. Kumar and Matsusaka's (2009) model of culturally transmitted local and market capital can be related to entrepreneurship though that is not the authors' focus. More closely aligned are Hassler and Mora (2000) and Doepke and Zilibotti (2013). The former use Jovanovic and Nyarko's (1996) learning-by-doing technologies similar to us. Agents choose to be either entrepreneurs or workers and have two

[1] Also influential has been an earlier debate in the profession between those who proposed culture-based non-rationality as an explanation for agricultural backwardness in traditional societies and those who took the "poor but efficient" view of peasant agriculture, a debate that Schultz' *Transforming Traditional Agriculture* (1963) resolved convincingly in favor of the latter (Ruttan, 1988).

principal assets, parental knowledge about production and innate intelligence. There is no relationship between parental class and child intelligence, or parental and child intelligence. The choice to make larger technological improvements in their model leads to social information (passed from parents) being less important, resulting in intergenerational churning as the children of workers end up being new entrepreneurs if they are smart, and the children of old entrepreneurs end up being workers if they are not smart. There is, however, no scope for cultural indoctrination within or outside the family. Cultural inertia therefore plays no role in technological and economic change.

Doepke and Zilibotti (2013) relate patience and risk aversion to the Romer endogenous growth framework. Entrepreneurial work entails upfront human capital investment and risky rewards. Parents transmit an automatic level of their own social values to their children so that a child's risk aversion will be at least proportional to the parent's. Parents may also voluntarily invest in making their children less risk averse or more patient. This within-family cultural transmission is similar to ours, though there is no possibility of cultural versus purely biological transmission there or for social mobility or for entrepreneurs to be become less well suited to entrepreneurship. Notably, whereas the cultural transmission process in our paper is mainly about transferring human capital (business expertise) and individuals are risk neutral, it is risk aversion that is at the core of Doepke and Zilibotti's model.

A benchmark model of occupational choice and cultural transmission is developed in the next section under the assumption that entrepreneurs are locked into a particular technology. Technological upgrading is studied in section 3 and different types of dynamic equilibria are characterized. Section 4 discusses how culture explains entrepreneurship and development in some regions of the world. Section 5 concludes.

The Baseline Model

Childhood and adulthood are the two periods of life in an overlapping generations economy. In any period $t = 1, 2, \ldots, \infty$ a set $\mathcal{H}$ of agents of measure one are economically active in either of two occupations, wage-work and entrepreneurship. Each agent is endowed with a unit time and gives birth to one offspring during this period, dying at the end. An offspring born in t does not become economically active until $t + 1$.

Occupation and Production

Entrepreneurs engage in production through risky and imperfectly understood technologies while wage-work entails a steady risk-free income, for instance, supplying labor on a competitive market in the public sector.[2] People differ in how they subjectively value the two occupations and in their human capital. We treat this human capital as one dimensional – business expertise – that in the model takes the form of subjective beliefs about the riskiness of production technologies.

At the beginning of each period, an active agent must decide whether to become an entrepreneur or work for entrepreneurs at the market wage. Comparative advantage in entrepreneurship and the broader macroeconomic environment determine this choice.[3] We assume no unemployment or withdrawal from the labor force. Individuals care about their expected income y which is either profit income π or wage income w. In other words, individuals indivisibly supply their labor to wage-work or in managing their business. The latter is preferred as long as it yields a higher expected income.

Let $\mathcal{E}_t$ denote the subset of agents who become entrepreneurs at t and $\mathcal{H}\backslash\mathcal{E}_t$ the subset of individuals who work for a wage. Product and input markets are perfectly competitive. All workers are hired by entrepreneurs at the market wage rate w_t and all entrepreneurs produce the same homogeneous good $\{Y_k\}_{k\in\mathcal{E}}$ using a CRS technology.[4] Aggregate output is simply

$$Y_t = \sum_{k\in\mathcal{E}_t} Y_t^k.$$

[2]The alternative occupation can also be low-scale self-employment with lower risks. In other words, here entrepreneurship is not synonymous with self-employment. Rather, an entrepreneur is someone willing to take big risks and innovate.

[3]Implicitly the labor productivity of all individuals is being normalized to unity. It is easy to introduce heterogenous human capital specific to wage work and allow wage-working parents to transfer their skills to their offspring and build on them. As long as there is no market imperfection preventing the efficient level of such within-family investment and human capital accumulation is subject to diminishing returns, all wage-working families will eventually converge to the same skill level. What matters in that setup, as here, is an individual's comparative advantage in the two occupations. Hence cultural and occupational decisions would be analogous to those we analyze below.

[4]While k represents a particular entrepreneur, we later use b to tag variables for the entire set $\mathcal{E}_t$.

The price of each good is normalized to one. Entrepreneur (capitalist) k uses two inputs, labor L_t^k hired in the competitive market and his own input that we call business capital z_t^k:

$$Y_t^k = \left(z_t^k\right)^{1-\beta} \left(L_t^k\right)^{\beta}, \ \beta \in (0,1). \tag{2.1}$$

Business capital is *ex ante* uncertain. It depends on the technology used to produce it, the entrepreneur's understanding of it and entrepreneurial decisions ϕ taken before the business goes into production by hiring workers. The capital thus produced is an inalienable part of the entrepreneur's business venture, not transferable to other businesses nor easily verifiable by outsiders unless the entrepreneur chooses to impart his expertise. We solve for entrepreneur k's decision problem backwards. Given z_t^k, profit maximization leads to the labor demand

$$\beta \left(\frac{z_t^k}{L_t^k}\right)^{1-\beta} = w_t \tag{2.2}$$

with more productive entrepreneurs – those with higher business capital – hiring more. Using this in equation (**??**), the entrepreneur's expected profit at the beginning of t becomes

$$\pi_t^k = (1-\beta)\left(\frac{\beta}{w_t}\right)^{\beta/(1-\beta)} z_t^k \equiv \kappa_t z_t^k \tag{2.3}$$

which he maximizes by choosing z_t^k prior to going into production.

Denote the technology at the entrepreneur's disposal by some arbitrary n. Entrepreneur k takes a decision ϕ_t^k that determines his business capital according to a stochastic production function similar to Jovanovic and Nyarko (1996):

$$z_{nt}^k = a^n \left[1 - \left(q_{nt} - \phi_{nt}^k\right)^2\right], \ a > 1. \tag{2.4}$$

Here

$$q_{nt} = \theta_n + \nu_{nt} \tag{2.5}$$

is a random target that fluctuates around a grade-specific parameter θ_n and ν_{nt} is an *iid* shock drawn from a normal distribution with mean zero and variance σ_ν^2. The same technology is used by all entrepreneurs and for all $t \geq 1$. Later we allow them to choose from several grades of technology, indexed by $n \in [0, \infty)$, with a higher n corresponding to a riskier but higher return technology.

One way to interpret ϕ is as effort devoted towards fine-tuning some machinery that yields a stochastic output, based partly on how effectively it is employed in production. Alternatively, think of the entrepreneur as entering a market or innovating a product for which he needs to determine the optimal scale of operation ϕ without knowing for sure what the market conditions are. The entrepreneur knows a and the distribution of ν_{nt}. What he does not know is the mean target output θ_n about which he has some belief (prior).

Denote by $E_t^k(\theta_n)$ the conditional expectation and $x_{nt}^k \equiv V_t^k(\theta_n)$ the conditional variance for entrepreneur k. The cumulative distribution of priors over q_{nt} for the n-th grade technology in the population at t is denoted by $G_t(x_{nt})$. The population is endowed with $G_1(x_{n1})$ in the initial period; subsequently G_t is the outcome of cultural indoctrination and occupational choice. From (**??**), (**??**) and (**??**), maximizing expected business capital requires the optimal decision

$$\phi_{nt}^k = E_t^k(\theta_n) \tag{2.6}$$

which yields expected business capital

$$z_{nt}^k \equiv E_t\left(\tilde{z}_{nt}^k\right) = a^n \left[1 - \sigma_\nu^2 - x_{nt}^k\right]. \tag{2.7}$$

Equation (**??**) shows that the entrepreneur's belief about θ_n is a form of human capital or expertise. Agents with more informed beliefs – smaller x_{nt}^k – expect to earn a higher return from entrepreneurship. In observing q_{nt} during his lifetime running the business, the agent learns about the technology and updates his belief about θ_n. That is, he acquires additional expertise through learning-by-doing. He may then choose to impart this knowledge to his cultural offspring who, in turn, will be able to make a more informed decision $\phi_{n,t+1}^k$ should he become an entrepreneur. This means if entrepreneurial human capital is transmitted via cultural transmission and socialization, business expertise specific to an entrepreneurial line does not disappear.[5] As will be shown later, the learning process is bounded for a given technology: sticking with a grade

[5] There is no mean reversion in intergenerational ability unlike Caselli and Gennaioli's (2013) model of dynastic firms.

n along an entrepreneurial line allows agents to eventually learn θ_n completely. Consequently, expected business capital converges to $a^n(1-\sigma_\nu^2)$ in the limit, with expected business profit converging to

$$\pi_t^k = \kappa_t a^n \left[1-\sigma_\nu^2\right], \tag{2.8}$$

identical for all entrepreneurs since it is independent of initial beliefs.

Preferences

Children are not born with pre-determined preferences about or innate skills in the two occupations. These develop instead through cultural transmission at home (vertical transmission), socialization outside (oblique transmission) and work experience. Parents are paternalistic in that they believe they know better which occupation would best suit their children as in Bisin and Verdier (2000). Their altruism payoff V depends on their children's future well being which they evaluate through their own experience. Moreover, over their working lives parents acquire a subjective bias towards their own occupation and they dislike the prospect of their children going into an occupation different from theirs. In imparting values suitable to his occupation, a parent weighs the potential utility of his offspring by using his payoff matrix as if it were the child's.

Not all such vertical transmission is successful since children also socialize and absorb ideas outside of home. Higher parental effort $\tau \in (0,1)$ towards cultural education raises the likelihood of the offspring being similar to the parent. But due to socialization outside, such education may fail and the offspring picks up human capital from a randomly matched (cultural) parent who may well be in an occupation different from his biological parent's. We shall refer to this process of vertical and oblique transmission as *cultural indoctrination*.

The expected lifetime utility of an economically active individual at time t

$$U_t = y_t + V_t - \psi(\tau_t)$$

depends on his expected lifetime income, $y_t \in \{w_t, \pi_t\}$, the perceived welfare of his offspring, V_t, and socialization cost $\psi(\tau_t)$.

Socialization and Cultural Transmission

Even though socialization, whether through vertical or oblique transmission, imparts to the cultural offspring parental parental human capital in the two occupations, the offspring may choose not to follow his cultural parent's occupation. To keep track of this we denote the culturally indoctrinated fraction of wage workers in the population by m and their actually frequency by μ. We introduce two definitions.

Definition Cultural indoctrination is **persistent** if a cultural offspring does not choose an occupation different from that in which he has been indoctrinated.

Definition Cultural indoctrination is **dynamically persistent** if it is persistent for all agents and all $t \geq 1$.

In the remainder of this section we focus on an intertemporal equilibrium path that is dynamically persistent, that is, $m_t = \mu_t$ for all $t \geq 1$. Hence the dynamics of m is the same as that of μ.

A parent educates his naive biological child with the socialization effort τ. With probability equal to this effort, vertical transmission is successful and the child acquires the biological parent's type (Hauk and Saez-Marti, 2002). That is, the child of an entrepreneurial parent picks up the parent's posterior belief about technologies as his own prior and a child of a wage-working parent likewise acquires his parent's uninformed belief regarding how to operate businesses. If vertical transmission fails, the child remains naive and gets randomly matched with somebody else whose occupation-specific human capital he acquires. It is worth noting that, even if we assume costless and perfect vertical transmission of culture, our equilibrium results will be similar. However, the overtaking results (presented in the next section) are analyzed from the perspective of the possibility of oblique cultural transmission. This means that successful types will proliferate and unsuccessful types will diminish in population, and this drives our results. It is possible that the results would be similar with perfect cultural transmission, but we have not fully explored this as we wanted the model to allow social influence to work on agents as well as parental influence.

Let p_t^{ij} denote the probability that a child of a type i parent will be of type j where $i,j \in \{k, w\}$, k denoting an entrepreneurial and w a wage-working individual. We have

$$p_t^{ww} = \tau_t^w + (1 - \tau_t^w)\,\mu_t \tag{2.9}$$

$$p_t^{wk} = (1 - \tau_t^w)\,(1 - \mu_t) \tag{2.10}$$

where μ_t is the proportion of pro-wage agents at date t. Similarly, for an entrepreneurial parent we have

$$p_t^{kk} = \tau_t^k + \left(1 - \tau_t^k\right)(1 - \mu_t) \tag{2.11}$$

$$p_t^{kw} = \left(1 - \tau_t^k\right)\mu_t \tag{2.12}$$

where τ^k is the entrepreneurial parent's effort on social education. While all wage working parents are identical, entrepreneurial parents differ in their human capital. Consequently, the socialization effort chosen by entrepreneurial parents will differ depending on their perception of the benefits of that occupational choice.

The cost of socialization effort $\psi(\tau)$ satisfies $\psi' \geq 0$, $\psi'' > 0$, $\psi(0) = \psi'(0) = 0$ and $\psi \in [0, 1]$. Let V^{ij} denote the utility a type i parent derives from his child being type j. Parental altruism is paternalistic in the sense that the parent uses his own payoff matrix to evaluate this utility. Hence given the parent's expected returns y_t, each parent of type $i \in \{w, k\}$ chooses the social education effort τ to maximize

$$p_t^{ii} V^{ii}\left(y_t^i\right) + p_t^{ij} V^{ij}\left(y_t^i\right) - \psi(\tau_t)\,. \tag{2.13}$$

Substituting (**??**)–(**??**) into the first order condition for an interior optimum

$$\frac{\partial \psi(\tau_t)}{\partial \tau_t} = \frac{dp_t^{ii}}{d\tau_t} V^{ii}\left(y_t^i\right) + \frac{dp_t^{ij}}{d\tau_t} V^{ij}\left(y_t^i\right)$$

leads to

$$\frac{\partial \psi\left(\tau_t^w\right)}{\partial \tau_t^w} = \left[V^{ww}\left(y_t^i\right) - V^{wk}\left(y_t^i\right)\right](1-\mu_t), \tag{2.14}$$

$$\frac{\partial \psi\left(\tau_t^k\right)}{\partial \tau_t^k} = \left[V^{kk}\left(y_t^i\right) - V^{kw}\left(y_t^i\right)\right]\mu_t. \tag{2.15}$$

It follows that the optimal socialization effort is

$$\tau_t^i = \tau\left[\mu_t, V^{ii}\left(y_t^i\right) - V_t^{ij}\left(y_t^i\right)\right],\ i,j \in \{k,w\} \tag{2.16}$$

with $\partial\tau^w/\partial\mu < 0$ and $\partial\tau^k/\partial\mu > 0$. Parents have less incentive to educate their children the more frequent is their type in the population.

It remains to specify how parental utility depends on the offspring's occupation. As mentioned above paternalistic parents base this on their own payoffs. An entrepreneurial parent's human capital is his belief x_{nt}^k. Conversely, a wage-working parent lacks human capital specific to entrepreneurial activities which results in a more dispersed prior of $\overline{x}_n$ (see below). Based on these, we specify parental utilities as[6]

$$V_t^{ww} = \ln w_t, V_t^{wk} = \ln\left(\pi_t^k|\overline{x}_n\right) - \ln\delta_w = \ln\left[\kappa_t a^n(1-\sigma_\nu^2 - \overline{x}_n)\right] - \ln\delta_w, V_t^{kk} = \ln\left(\pi_t^k|x_{nt}\right) = \ln\left[\kappa_t a^n(1-\sigma_\nu^2 - x_{nt})\right] \tag{2.17}$$

The parameters δ_w and δ_b denote the subjective dissatisfaction that a type i parent feels when his child ends up in type j occupation. These biases do not affect a parent's choice of or utility from his own occupation, only his cultural indoctrination effort. It is useful to think of $(\mathbf{x}_n^i, \delta_b, \delta_w)$ as the "cultural endowments" of this economy (Hayami and Ruttan, 1985). These embody those aspects of preferences and skills that have an impact on the cultural transmission of attitudes. Importantly, cultural endowments have an economic significance here since they shape individuals' perception of the return from each type of activity (Weber *et al.*, 2002).

We assume parents have bounded rationality in that they project onto their children their own ability with a given activity to analyze the payoffs their children face by changing occupation between generations. We make this assumption to represent that our measure of the skill an agent

[6] The curvature is to ensure the existence of a balanced growth path when we later allow technology to be upgraded.

has with a given entrepreneurial technology, x, also encapsulates their beliefs about the quality of that technology. Because payoffs have a random element for entrepreneurs and there is no system for verifying the business aptitude of entrepreneurs, it is impossible for wage working parents to back out what the real expected value of their children being entrepeneurs will be. Therefore, they naively project their own skill level onto their children to analyze the expected returns.

Example 1

Suppose $\psi(\tau) = \tau^2/2 \in (0, 1/2)$. Then optimal socialization efforts are

$$\tau_t^w = (1 - \mu_t) \ln \left[\frac{\delta_w w_t^{1/(1-\beta)}}{(1-\beta)\beta^{\beta/(1-\beta)} a^n (1 - \sigma_\nu^2 - \overline{x}_n)} \right],$$
$$\tau_t^k = \mu_t \ln \left[\frac{\delta_b (1-\beta)\beta^{\beta/(1-\beta)} a^n (1 - \sigma_\nu^2 - x_{nt}^k)}{w_t^{1/(1-\beta)}} \right],$$

increasing in own occupational bias and payoff, decreasing in the frequency of and payoff from the alternative occupation. Occupational biases are absent if $\delta_b = \delta_w = 1$. If in addition occupational incomes are equalized, for example if business knowledge is alienable and easily acquired, neither wage-working nor entrepreneurial parents would indoctrinate their offspring, $\tau^w = \tau^b = 0$.

Occupational Income and Choice

An entrepreneur k who works with the technology n at t, starts with a belief about the distribution of θ_n which is, as specified above, normal with variance x_{nt}^k. During the course of his lifetime, the accumulated experience of observing q_{nt} leads him to update this belief. His posterior variance of θ_n becomes, as a result of Bayesian updating,

$$x_{nt+1}^k = \mathcal{F}(x_{nt}^k) = \frac{\sigma_\nu^2 x_{nt}^k}{\sigma_\nu^2 + x_{nt}^k}. \tag{2.18}$$

This posterior belief is then transferred, due to cultural indoctrination, as the cultural offspring's prior. Since $\mathcal{F}$ is increasing and concave with $\mathcal{F}(0) = 0 = \mathcal{F}'(0)$, it has a unique fixed point at $x_n^* = 0$. Hence the learning process along an entrepreneurial line – each generation of entrepreneur passing on his accumulated human capital to his cultural offspring – generates a sequence of variances $\{x_{nt}^k\}_{t=1}^\infty$ that converges monotonically to zero. In this sense, the entrepreneurial line eventually achieves full proficiency and maximal earnings if it were to stay with technology n forever.

From each entrepreneur's labor demand

$$w_t = \beta \left[\frac{z_{nt}^k}{L_{nt}^k} \right]^{1-\beta}$$

it follows that aggregate labor demand is $L_{nt}^D = \sum_k L_{nt}^k = \beta^{1/(1-\beta)} Z_{nt} / w_t^{1/(1-\beta)}$ where $Z_{nt} \equiv \sum_k z_{nt}^k$ is aggregate business capital. Since each worker supplies a unit time, aggregate labor supply is $L_t^S = \mu_t$, using which we get the market-clearing wage rate

$$w_t = \beta \left[\frac{Z_{nt}}{\mu_t} \right]^{1-\beta}. \tag{2.19}$$

The equilibrium wage is decreasing in μ_t because a higher μ lowers the supply of business capital and raises the supply of labor. As a result expected business profit π_n – see (**??**) – is increasing in μ. In other words, the culturally indoctrinated share of the population determines the relative attractiveness of the two occupations and, thus, occupational choice.

To study occupational allocations and the dynamics of cultural indoctrination we proceed in steps. First we restrict the parameter space, under the assumption that the dynamics exhibits monotonic convergence, such that indoctrination is dynamically persistent and offspring choose the occupation their cultural parent intended. We then establish that under that restriction, the dynamics is characterized by monotonic convergence to a steady state with an inefficiently low supply of entrepreneurs.

Begin by considering an individual at t who comes from the entrepreneurial line k, having been indoctrinated by his cultural/biological parent k at $t-1$. Given his human capital x_{nt}^k he will choose his parent's occupation as long as his expected business profit exceeds the wage rate

$$\pi_{nt}^k > w_t \Rightarrow (1-\beta)\beta^{\beta/(1-\beta)} z_{nt}^k > w_t^{1/(1-\beta)}. \tag{2.20}$$

We study conditions under which this is true for all entrepreneurial offsprings, that is, we solve for an equilibrium where no offspring indoctrinated into entrepreneurial activity abandons his cultural parent's occupation, choosing to become a wage worker instead. Using (**??**) in (**??**), this requires

$$\frac{z_{nt}^k}{Z_{nt}} > \frac{\beta}{1-\beta}\frac{1}{\mu_t} \quad \forall k \in \mathcal{E}_t. \tag{2.21}$$

To identify an equilibrium path along which indoctrination is persistent, we start with the plausible scenario that there is an initial scarcity of (culturally indoctrinated) entrepreneurs, that is,

$$\mu_1 > \mu^* \tag{2.22}$$

where μ^* is the steady-state share of wage-workers in the population (to be established). We anticipate that along the equilibrium path the economy monotonically converges to μ^* from above.

For analytical convenience we assume that the initial distribution of priors is discrete. Specifically it takes two values $x_{n1} \in \{\underline{x}_n, \overline{x}_n\}$ with $\overline{x}_n > \underline{x}_n$ and $\Pr\{x_{n1} = \underline{x}_n\} \equiv G_1(\underline{x}_n)$ and $\Pr\{x_{n1} = \overline{x}_n\} \equiv 1 - G_1(\overline{x}_n)$ fractions of the population with these priors respectively. When agents with the more diffuse prior $\overline{x}_n$ become wage workers and those with the prior $\underline{x}_n$ entrepreneurs in $t = 1$, we have $m_1 = \mu_1 = 1 - G_1(\overline{x}_n)$. For this, none of the potential workers should unilaterally want to become an entrepreneur, that is, $w_1 > \pi(\overline{x}_n)$. Using (**??**) and (**??**) this becomes

$$\frac{z(\overline{x}_n)}{z(\underline{x}_n)}\frac{1-G_1(\underline{x}_n)}{G_1(\underline{x}_n)} < \frac{\beta}{1-\beta}. \tag{2.23}$$

A similar restriction for the entrepreneurs, inequality (**??**), requires that

$$\mu_1 = 1 - G_1(\underline{x}_n) > \beta.$$

Combining the two inequalities we get a restriction on the initial distribution

$$\beta < 1 - G_1(\underline{x}_n) < \beta\left[\frac{1}{\beta + (1-\beta)\lambda_n}\right] \tag{A1}$$

where $\lambda_n \equiv (1 - \sigma_\nu^2 - \overline{x}_n)/(1 - \sigma_\nu^2 - \underline{x}_n) < 1$. We assume henceforth that (**??**) holds. It ensures that the initial share of wage workers exceeds the efficient allocation but the share is not so high that it depresses wages below expected business income even for informed agents, those with a prior of

$\underline{x}_n$. The latter requires that λ_n be small enough, that is, agents indoctrinated in entrepreneurship acquire a sufficiently strong comparative advantage in it.

Finally we need to ensure that cultural indoctrination is dynamically persistent for all t for which (**??**) is not sufficient. Since entrepreneurs are identical in their business expertise and learn at the same rate, $z^k_{nt}/Z_{nt} = 1/(1-\mu_t)$. Hence (**??**) simplifies to $\mu_t > \beta$ for which it is sufficient that

$$\mu^* > \beta \tag{A2}$$

if μ_t converges to μ^* from above as we have conjectured. Using an example later we illustrate what parametric restrictions ensure (**??**). Finally, note that in steady state, all entrepreneurial lines have asymptotically converged to the same level of business capital $a^n\left[1-\sigma^2_\nu\right]$ while aggregate business capital has converged to $(1-\mu^*)a^n\left[1-\sigma^2_\nu\right]$.

To summarize this discussion, Figure 1 illustrates occupational allocation at t using the relationship between expected business income and the wage rate from equation (**??**) above: entrepreneurial expected income is monotonically falling in how diffuse the prior x is. Since cultural indoctrination is persistent, the wage working prior stays stuck at $\overline{x}_n$ while the entrepreneurial prior converges asymptotically to zero. In other words, the distribution of priors in the population remains discrete at all points in time. As depicted in Fig 1, $\underline{x}_{nt}$ is the prior of all culturally indoctrinated entrepreneurs at t, less than their initial prior $\underline{x}_n$ due to learning-by-doing over time. For priors lower than $\hat{x}_{nt}$, entrepreneurs have sufficiently high expertise that they can expect a higher income than wage work. If the prior exceeds $\hat{x}_{nt}$, on the other hand, wage work dominates. This leads to the following Proposition.

Proposition 1

Under (**??**) and (**??**), at any t, agents with a prior lower than some $\hat{x}_{nt} \in (0, \overline{x}_n)$ become an entrepreneur and choose the socialization effort τ^k_t given by (**??**) for $i = k$. Conversely, any agent with prior higher than $\hat{x}_{nt}$ will choose to become a wage worker and the socialization effort τ^w_t given by (**??**) for $i = w$.

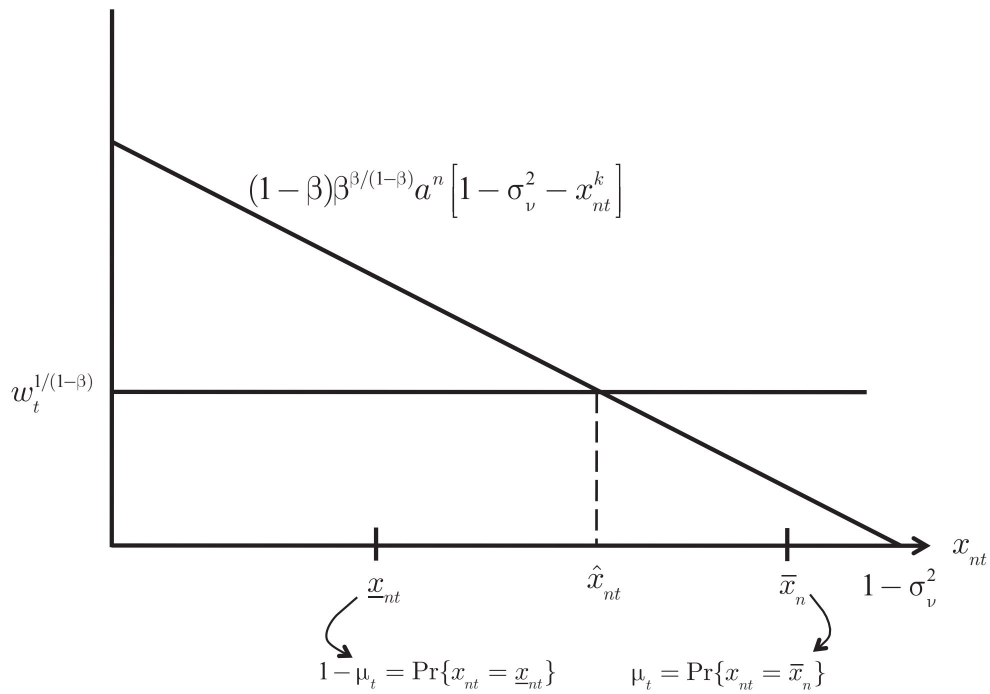


FIGURE 1. Occupational Allocation at t

Dynamics

We now characterize the dynamic behavior of $\mu_t \equiv 1 - G_t(\overline{x}_n)$. The proportion of wage workers in the $t+1$-th generation is comprised of three groups. First are the children of wage working parents from the t-th generation for whom the social education effort was successful,

$$\tau_t^w \Pr\{x_{nt} = \overline{x}_n\} = \tau_t^w \mu_t$$

The second group consists of those offspring for whom the socialization effort was unsuccessful but who were subsequently matched with a wage working cultural parent. The proportion of these agents is

$$\mu_t(1 - \tau_t^w) \Pr\{x_{nt} = \overline{x}_n\} = (1 - \tau_t^w)\mu_t^2.$$

Future wage-workers are also drawn from the children of entrepreneurial parents for whom the socialization effort was unsuccessful and who were subsequently matched with a wage working cultural parent:

$$\mu_t(1 - \bar{\tau}_t^b) \Pr\{x_{nt} = \underline{x}_{nt}\} = (1 - \bar{\tau}_t^b)\mu_t(1 - \mu_t)$$

where

$$\bar{\tau}_t^b \equiv \frac{\tau_t^k \Pr\{x_{nt} = \overline{x}_n\}}{1 - \mu_t} = \tau_t^k$$

is the average socialization effort among entrepreneurial families, the same for all k under the assumption x_{n0} takes only two values.

The evolution of μ is then governed by

$$\mu_{t+1} = \tau_t^w \mu_t + (1 - \tau_t^w)\mu_t^2 + (1 - \bar{\tau}_t^b)\mu_t(1 - \mu_t)$$

or,

$$\Delta\mu_t \equiv \mu_{t+1} - \mu_t = \left(\tau_t^w - \bar{\tau}_t^b\right) \mu_t \left(1 - \mu_t\right) \tag{2.24}$$

where the educational efforts depend on occupation- and belief-specific payoffs and μ from equations (**??**) and (**??**) above. In steady state, $V_t^{ww} - V_t^{wk} = V^{ww} - V^{wk}$ and $V_t^{kk} - V_t^{kw} = V^{kk} - V^{kw}$ for all t. Equation (**??**) has three steady states, zero, one and μ^* given by

$$\mu^* = \frac{V^{ww} - V^{wk}}{(V^{kk} - V^{kw}) + (V^{ww} - V^{wk})} \tag{2.25}$$

where both types of parents make the same socialization investment

$$\tau^w \left(\mu^*, V^{ww} - V^{wk}\right) = \tau^k \left(\mu^*, V^{kk} - V^{kw}\right).$$

The following proposition establishes the stability of this steady state and Figure 2 provides an intuitive justification (see Bisin and Verdier, 2000, for details).

Proposition 2

Under A1 and A2, μ_t monotonically converges to μ^* from above.

Aggregate output, given the technology n, is maximized when $\mu_t = \beta$ and entrepreneurs and workers earn the same expected income. This efficient outcome does not occur here even in steady state except when subjective occupational biases are absent and incomes are equalized (see example below). Typically we would expect $\mu^* > \beta$, that is, an undersupply of entrepreneurship and depressed aggregate output for three reasons. In the first place, entrepreneurship requires business-specific expertise that is private knowledge. This restricts entry into entrepreneurship.

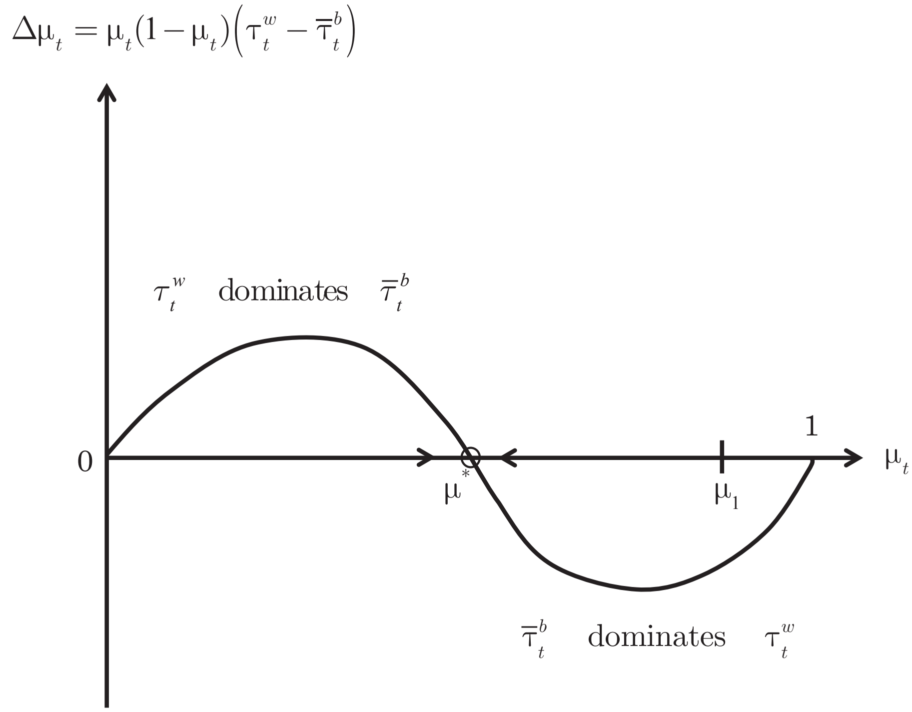


FIGURE 2. Dynamics of Occupational Type

On top of this are two distortions related to the cultural process. Parents prefer their children to be like them (occupationally) and impart those values through successful socialization. These take the form of business expertise and occupation-specific biases. Moreover, parental indoctrination is not always successful. Even if almost all parents were to be entrepreneurial, not all their biological offspring would be. If wage-working parents have a stronger bias ($\delta_w >> \delta_b$) and are relatively uninformed about running a business ($\overline{x}_n >> \underline{x}_n$), their indoctrination effort will strongly dominate those of entrepreneurial families. This would intensify the first distortion, restricting even more the supply of entrepreneurship. The following example and comparative statics highlight these margins.

<u>Example 2</u>

Under the functional form for $\psi(\tau)$ and the socialization efforts from the example above, and the equilibrium wage from (**??**), the steady-state supply of wage-workers μ^* implicitly solves:

$$\ln\left(\frac{1-\mu^*}{\mu^*}\right) = \ln\left(\frac{1-\beta}{\beta}\right) + \mu^* \ln\delta_b - (1-\mu^*)\ln\left[\delta_w\left(\frac{1-\sigma_\nu^2}{1-\sigma_\nu^2-\overline{x}_n}\right)\right].$$

Fig 3 shows, for $\beta = 0.5$, $\delta_w = 2$, $\delta_b = 2$, $\sigma_\nu = 0.1$, $\bar{x}_n = 0.2$, this is increasing in wage worker bias, decreasing in entrepreneurial bias and business expertise. If occupational biases were absent, that is $\delta_b = \delta_w = 1$, and business expertise were alienable, the efficient outcome $\mu^* = \beta$ obtains.

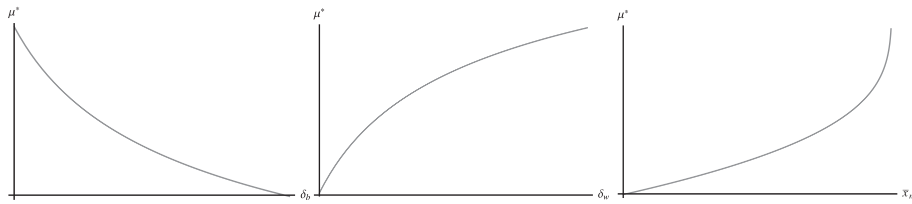


FIGURE 3. Comparative Statics for $\mu^* (\delta_b, \delta_w, \bar{x}_n)$

We contend in section 4 below that the resistance to large-scale risk-taking in developing countries often stemmed from colonial-era bureaucracies and education policies geared towards training the local workforce in the colonial mission. Public-sector employment was subsequently broadened, further luring people away from entrepreneurship.

Upgrading Technologies

The constant technology model from section 2 does not entertain growth in the long run or the possibility that newer entrepreneurs emerge from non-entrepreneurial families. We extend the previous environment to allow these.

First, potential entrepreneurs can choose from a menu of technologies (business activities) instead of a fixed and arbitrary n. In this we closely follow Jovanovic and Nyarko (1996). There is no direct cost of switching to a different technology and, as before, no cost to adjusting x. Each n is associated with the same technology as equations (**??**) and (**??**) and different technologies are imperfectly related. Specifically the parameters θ_n and θ_{n+s} for any n and $s \geq 0$ are linked by

$$\begin{aligned} \theta_{n+s} &= \alpha^{s/2}\theta_n + \eta_s, \qquad (2.26) \\ \text{where } \eta_s &\sim N(0, \sigma_\eta^2),\ \alpha \in (0,1), \end{aligned}$$

and θ_n and η_s are independent. Observe that if $\alpha = 1$ and $\sigma_\eta^2 = 0$, then $\theta_{n+s} = \theta_n\ \forall s$ which means any precision about θ_n can be transferred to θ_{n+s}, though even if an entrepreneur were to have learned θ_n entirely, he would still face uncertainty regarding θ_{n+s}. This suggests we can think of α

as a measure of the specificity of human capital – how well knowledge of one business venture or technology helps in the next. We assume that entrepreneurs cannot skip intermediate technologies when switching, that is, upgrading to $n+2$ is possible only via $n+1$ and not directly from n to $n+2$. Finally note that $a > 1$ ensures that, for the same level of business expertise on different technologies, a higher one yields higher expected profits.

The preference side is similar to the benchmark model. We maintain the assumption of discrete initial priors but modify below the uninformed prior to be consistent with technology upgrading. For cultural indoctrination, it is necessary to specify which grade of technology is used to evaluate an offspring's payoff from entrepreneurship. We assume this depends on the growth regime: if technology is being upgraded regularly, even wage working parents will anticipate their offspring doing so. Otherwise, they anticipate their offspring using the current technology. In either case, wage working parents still evaluate their offspring's payoff under their own diffuse prior. Parents also take into account the growth of wages should technology be upgraded regularly.

Updating and Upgrading

We begin by studying what an entrepreneur learns if he were to upgrade his technology compared to the one his entrepreneurial parent used. Recall from the previous section that continuous updating of information without changing the technology will lead to perfect mastery of that technology. In the presence of a menu of technologies distinguished by (**??**), upgrading to the next one causes posteriors to become more dispersed, business expertise to be diluted, because the prior for vintage $n+1$ is $\alpha x_n + \sigma_\eta^2$.

First consider a hypothetical scenario of constant upgrading-without-updating. If this were to be repeated over time, the diffuse prior – which does not get sharpened through updating – evolves according to

$$x_{n+1,t+1} = \mathcal{H}(x_{nt}) \equiv \alpha x_{nt} + \sigma_\eta^2. \tag{2.27}$$

$\alpha \in (0,1)$ ensures that the fixed point of this mapping is a well defined $x' = \sigma_\eta^2/(1-\alpha) > 0$, independent of n. The greater the uncertainty surrounding new technologies, that is the higher is σ_η^2, the more diffuse is this long-run value. The absence of updating ensures that expertise remains weak. We assign this fixed point to be the diffuse prior of wage-workers, analogous to $\overline{x}_n$

in the baseline model. In other words, we are endowing wage workers with the “best of the worst” possible priors when a menu of technologies is available.[7] We also assume that the economy starts in $t = 1$ with technology n in use and a population endowed with the discrete priors x' and $\underline{x}_n < x'$. $G_1(\underline{x}_n)$ fraction of the initial population is indoctrinated as entrepreneurs, $1 - G_1(\underline{x}_n)$ fraction as wage workers.

When an entrepreneurial line is updating priors as well as upgrading technologies, the evolution of entrepreneurial human capital is described by

$$x_{n+1,t+1} = \mathcal{F}\left(\mathcal{H}(x_{nt})\right) = \mathcal{F}\left(\alpha x_{nt} + \sigma_\eta^2\right) \tag{2.28}$$

the fixed point of which, x^{**}, is the positive root of $\alpha x^2 + \left[(1-\alpha)\sigma_\nu^2 + \sigma_\eta^2\right] x - \sigma_\nu^2\sigma_\eta^2 = 0$. It is easy to show that $x' > x^{**}$. Lemma **??** below summarizes these results and will be important in establishing results later. Changes in the three fixed points referenced there or their relationship to other critical values of x drive the decisions that agents make on whether or not to work in accordance with their indoctrination and, as entrepreneurs, whether or not to upgrade technologies.

Lemma 1

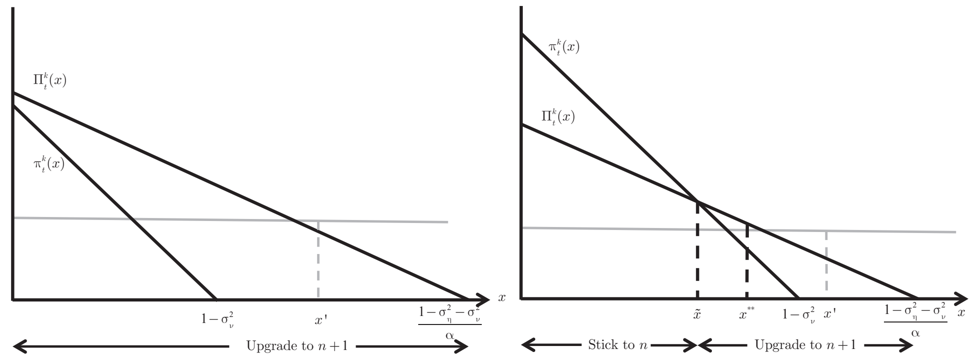
The fixed points of the mappings $\mathcal{F}$, $\mathcal{F}(\mathcal{H})$ and $\mathcal{H}$ are 0, x^{**} and x' respectively such that $0 < x^{**} < x'$.

This model can generate a steady state where advanced businesses do not innovate, resulting in stagnation. The model of section 2 is therefore a special case of this one if we take $\overline{x}_n = x'$. This equilibrium can be shocked by changes in a, the rate of technological change or TFP, and α, the human capital specificity of different technologies. When this happens, existing entrepreneurs may start adopting more productive technologies or a new generation of entrepreneurs may do so and leap-frog over existing ones. Either way the economy moves from stagnation to endogenous growth.

To understand these results it will help to keep in mind four cases – Figures 4 and 5 – depending on parameter values. The gray line in each figure indicates the equilibrium wage rate

[7] Assuming that the diffuse prior takes this particular value is not essential. All that is needed is for the prior to be sufficiently diffuse, above x^{**} (Lemma 1) and below $1 - \sigma_\nu^2$, the latter opening up the possibility for indoctrination to be non-persistent.

which strictly exceeds the payoff from entrepreneurship under the diffuse prior x'. For simplicity, the decision whether or not to upgrade is shown for the entire range of x.



(a) $\Pi^k(0) < \pi^k(0)$, $\alpha a > 1$

(b) $\Pi^k(0) < \pi^k(0)$, $\alpha a < 1$

FIGURE 4. Technology Choice when $\Pi^k(0) < \pi^k(0)$

Long-run Stagnation

For an individual who has been culturally indoctrinated by the entrepreneurial line k, define $\Pi^k(x)$ as the expected payoff to switching to $n+1$ based on the expertise x that he has over technology n. Similarly, let $\pi^k(x)$ be the expected payoff to staying with n, similar to before.

$$\Pi_t^k(x) \equiv E(\tilde{\pi}_{nt}^k | x_{nt}^k = x) = \kappa_t a^{n+1}(1 - \sigma_\eta^2 - \sigma_\nu^2 - \alpha x) \tag{2.29}$$

$$\pi_t^k(x) \equiv E(\tilde{\pi}_{t,n+1}^k | x_{nt}^k = x) = \kappa_t a^n (1 - \sigma_\nu^2 - x) \tag{2.30}$$

Because $\Pi^k(x)$ and $\pi^k(x)$ represent the expected payoffs to choosing technologies $n+1$ and n respectively, their ranking determines whether entrepreneur k will upgrade or not.

Long-run stagnation can occur in two scenarios, both illustrated in Figure 4 and formalized in the proposition below. This happens when the productivity gain from switching a is relatively small and the optimum scale of a new technology is not easy to learn based on the old one (high σ_η). The two cases differ in whether a new technology requires expertise sufficiently different from the old one (α) which determines whether or not upgrading is worthwhile at any level of business expertise.

Proposition 3

Suppose that $\Pi_t^k(0) < \pi_t^k(0)$, that is $(1 - \sigma_\nu^2) > (1 - \sigma_\nu^2 - \sigma_\eta^2)a$.

(i) If $\alpha a > 1$, $\Pi_t^k(x) < \pi_t^k(x)$ for all $x \geq 0$,

(ii) If $\alpha a < 1$, then for some $\tilde{x} \in (0, (1 - \sigma_\eta^2 - \sigma_\nu^2)/\alpha)$, $\Pi_t^k(\tilde{x}) = \pi_t^k(\tilde{x})$ such that $\Pi_t^k(x) < \pi_t^k(x)$ whenever $x < \tilde{x}$ and vice versa.

Fig 4(a) illustrates the case for Proposition 3(i): no matter what an entrepreneur's expertise (belief) is, the prevailing technology always dominates. No entrepreneur has any incentive to upgrade technologies which means the economy stays with n forever.

Suppose instead, as in Fig 4(b), we have $\alpha a < 1$, that is a lower value of α than above. Here an entrepreneur's expertise determines whether or not he is better off upgrading. An entrepreneur with a very low x, that is, a lot of expertise in technology n, will not want to upgrade because his substantial expertise in n does not readily transfer to $n+1$. The threshold $\tilde{x}$ is given by

$$\tilde{x} = \frac{a\sigma_\eta^2 - (a-1)(1-\sigma_\nu^2)}{1 - \alpha a}$$

which is positive since $\Pi^k(0) < \pi^k(0)$ and independent of time. Whereas for low values of x technology n dominates expected earnings, for a high value (still low enough to yield positive expected returns over wage work) $n+1$ dominates. This means, if all entrepreneurs start off with minimally dispersed priors (low values for x), it is possible that *all* entrepreneurial lines keep using the vintage n without ever upgrading. Formally this requires, following the equilibrium outlined in section 2, that entrepreneurs start with a prior $\underline{x}_n \leq \tilde{x}$ corresponding to the initial technology n, and that a modified version of (**??**) holds

$$\beta < 1 - G_1(\underline{x}_n) < \beta \left[\frac{1}{\beta + (1-\beta)\gamma}\right] \tag{A3}$$

to allow for more than one technologies, where $\gamma \equiv a(1 - \sigma_\nu^2 - \sigma_\eta^2 - \alpha x')/(1 - \sigma_\nu^2)$. If (**??**) holds, all businesses will continuously update as in section 2 without ever upgrading their technologies.

The outcomes from Fig 4(a) and Fig 4(b) under $\underline{x}_n \leq \tilde{x}$ and (**??**) are the same: no entrepreneur ever switches to a more productive technology than n. This means the economy converges to the stationary equilibrium of section 2 where aggregate output is constant, indoctrination is dynamically persistent (see section 3.4 below for details) and the supply of entrepreneurs is $1 - \mu^*$.

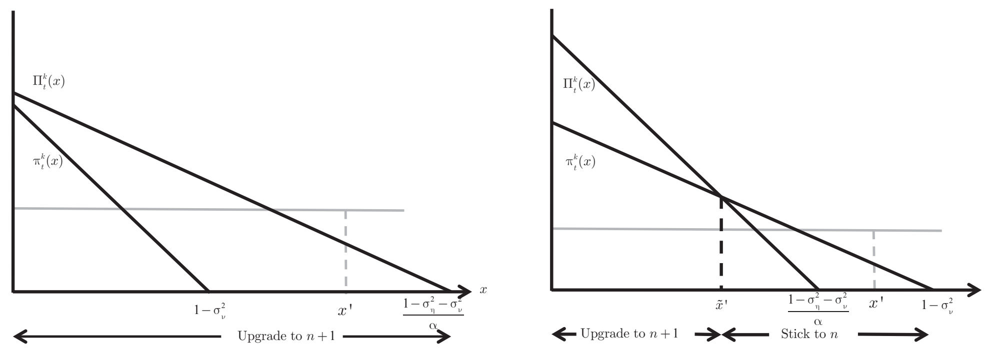
Depending on parameter values, it is possible to have a long-run equilibrium where well-established entrepreneurial lines spur growth by constantly upgrading their technology.

Proposition 4

Suppose that $\Pi_t^k(0) > \pi_t^k(0)$, that is, $(1-\sigma_\nu^2) < (1-\sigma_\nu^2-\sigma_\eta^2)a$.

(i) If $\alpha a < 1$, $\Pi_t^k(x) > \pi_t^k(x)$ for all $x \geq 0$,

(ii) If $\alpha a > 1$, then for some $\tilde{x}' \in (0, 1-\sigma_\nu^2)$, $\Pi_t^k(\tilde{x}') = \pi_t^k(\tilde{x}')$ such that $\Pi_t^k(x) > \pi_t^k(x)$ whenever $x < \tilde{x}'$ and vice versa.



(a) $\Pi^k(0) > \pi^k(0), \quad \alpha a < 1$

(b) $\Pi^k(0) > \pi^k(0), \quad \alpha a > 1$

FIGURE 5. Technology Choice when $\Pi^k(0) > \pi^k(0)$

In Fig 5(a), corresponding to Proposition 4(i), the payoff from a new technology always exceeds that from the existing one no matter how precise or diffuse the entrepreneur's prior is. In this case, all entrepreneurs always upgrade. This scenario is more likely when the productivity gain from switching (a) is large enough, the optimum scale of the new technology is easy to learn based on the old one (low σ_η) and, at the same time, the new technology requires expertise sufficiently different from the old one (low α). To see the last point, note that both Π and π decline monotonically with x. Since $\partial\Pi_t^k(x)/\partial x = -\alpha\kappa_t a^{n+1}$ while $\partial\pi_t^k(x)/\partial x = -\kappa_t a^n$, so long as $a\alpha < 1$, the returns to using a new technology will fall at a lower rate when x rises than returns to the old one.

In contrast, for a sufficiently high value of α as in Fig 5(b) and Proposition 4(ii), it is an entrepreneur with a lot of business expertise, $x < \tilde{x}'$, who has an incentive to upgrade, where

$$\tilde{x}' = \frac{(a-1)(1-\sigma_\nu^2) - \alpha\sigma_\eta^2}{\alpha a - 1}.$$

Recall that entrepreneurs are endowed with the prior $\underline{x}_n$ at $t = 1$. If $\underline{x}_n > \tilde{x}'$, no entrepreneur is sufficiently good at business for upgrading to be worthwhile – the economy would stagnate as in section 3.2 above. If instead $\underline{x}_n < \tilde{x}'$, similar to Fig 5(a) all entrepreneurs keep upgrading their technology.

Given the higher level of business knowledge available to incumbents and the tendency of developing countries to be far from the technological frontier, it is useful to understand what might unleash technological catchup and growth in our model. A natural candidate is an exogenous shock, a sharp change in technological or market access, that improves overall productivity a. This raises entrepreneurial returns from both existing and new technologies. Starting from the no-growth stationary equilibrium described by Fig 4(a), if a were to increase sufficiently such that $(1 - \sigma_\nu^2) < a(1 - \sigma_\nu^2 - \sigma_\eta^2)$, then $\Pi_t^k(0) > \pi_t^k(0)$ and, as in Fig 5(b), entrepreneurial lines would now prefer to upgrade rather than stay with their existing technology. Further, because this increase in a increases the marginal cost of diffuse priors, wage worker cultural lines prefer not to enter the business world. With all old businesses simultaneously switching from n to $n + 1$, economic growth takes off without the creation of any new business lines. In this sense, culture ceases to be a constraint on economic growth: a sufficiently large change that improves overall productivity can tip the economy from stasis towards rapid change. In another respect, however, culture remains a drag as we explain below.

For Fig 5(a) and for Fig 5(b) when $\underline{x}_n < \tilde{x}'$, constant updating and upgrading of technologies sees all entrepreneurs' priors converging to x^{**} over time. Each generation sees technologies upgraded by one step, so that if technology $r > n$ was being used in t, technology $r + 1$ will be used in $t + 1$. This means, along such a balanced growth path, expected business capital for each entrepreneur at t is

$$z_t^k = a^r \left[1 - \sigma_\nu^2 - x^{**}\right]$$

which grows at the (gross) rate a between any successive generations. In order for this to be a stationary equilibrium, cultural indoctrination should also reach a steady state. This requires, from section 2, that the difference $V^{ii} - V^{ij}$ for $i, j \in \{k, w\}$ be constant. From (**??**) this means the wage rate will be growing at the same rate as expected entrepreneurial income whether at the informed (x^{**}) or uninformed (x') prior. Expected entrepreneurial income for any x is

$$\pi_{rt}^{k}(x) = a^{r}(1-\beta)\left(\frac{\beta}{w_t}\right)^{\beta/(1-\beta)}\left[1-\sigma_{\nu}^{2}-x\right].$$

For the ratio

$$\frac{\pi_{rt}^{k}(x)}{w_t} = \frac{a^{r}(1-\beta)\beta^{\beta/(1-\beta)}\left[1-\sigma_{\nu}^{2}-x\right]}{w_t^{1/(1-\beta)}}, \quad x \in \{x', x^{**}\}$$

to be constant, the growth factor of wages must be $a^{1-\beta} > 1$, equal to the growth factor of expected entrepreneurial income. With relative payoffs remaining stationary, indoctrination efforts are again given by equation (**??**) evaluated at these new relative payoffs, leading to a steady-state indoctrination rate of $\bar{\mu}$ analogous to equation (**??**). The example below provides conditions under which this steady state is inefficient.

Example 3

Using an approach similar to Examples 1 and 2 above, the steady-state $\bar{\mu}$ when entrepreneurs constantly upgrade technologies implicitly solves

$$\ln\left(\frac{1-\bar{\mu}}{\bar{\mu}}\right) = \ln\left(\frac{1-\beta}{\beta}\right) + \bar{\mu}\ln\delta_b - (1-\bar{\mu})\ln\left[\delta_w\left(\frac{1-\sigma_{\nu}^{2}-x^{**}}{1-\sigma_{\nu}^{2}-x'}\right)\right].$$

This is inefficient when

$$\delta_b < \left[\delta_w\left(\frac{1-\sigma_{\nu}^{2}-x^{**}}{1-\sigma_{\nu}^{2}-x'}\right)\right]^{(1-\beta)/\beta}.$$

Setting $\overline{x}_n = x'$ in Example 2 implies $\bar{\mu} < \mu^{*}$: the upgrading-updating steady state is closer to the efficient outcome than the stagnation steady state.

In this steady state, aggregate output (and output per capita)

$$Y_t = \sum_k Y_t^k = \bar{\mu}^{\beta}(1-\bar{\mu})^{1-\beta}\left[a^{r}\left(1-\sigma_{\nu}^{2}-x^{**}\right)\right]^{1-\beta}$$

also grows at the growth factor $a^{1-\beta}$ and the economy is in a balanced growth path (BGP). This growth rate is independent of cultural factors. Indeed it is the maximal growth rate possible when entrepreneurs can upgrade only one-step ahead. But a static inefficiency remains from $\bar{\mu} > \beta$, with a higher cultural bias lowering the BGP.

Overtaking

A more interesting growth takeoff is also possible, one associated with social mobility and the emergence of a new economic elite. Start again with the no-growth stationary equilibrium described in section 3.2 with dynamically persistent cultural indoctrination. Since the economy is in steady-state, there is a single entrepreneurial prior of $\underline{x}_n = 0$ and a single wage-worker prior of x' and the wage rate exceeds expected business returns at x'. Dynamic persistence in the no-growth steady state requires that wages be greater than the expected returns of an entrant who uses the current technology. Here, however, the potential entrant can use technology $n+1$ besides n. Dynamic persistence therefore requires that $w(\mu^*) > \max\{\pi^k(x', \mu^*), \Pi^k(x', \mu^*)\} = \Pi^k(x', \mu^*)$ since $\tilde{x}' < x'$. Earlier we defined γ as the expected entrepreneurial return from upgrading under a prior of x' relative to the expected return from staying with the existing technology for a prior of zero: $\gamma(\alpha) = a(1 - \sigma_\nu^2 - \sigma_\eta^2 - \alpha x')/(1 - \sigma_\nu^2)$. Hence for dynamic persistence we must have

$$\gamma(\alpha)\frac{\mu^*}{1-\mu^*} < \frac{\beta}{1-\beta}. \tag{2.31}$$

Suppose now that the economy is shocked by a change in technology access or regulatory environment. Instead of raising a, the shock lowers the value of α, how easily expertise in one line of business can be transferred into other lines.[8] Lowering α lowers the magnitude of $\partial\pi(x)/\partial x$ while $\partial\Pi(x)/\partial x$ is unchanged. The key values of business expertise are x^{**}, the fixed point for continual upgrading and updating and $\tilde{x}$, the level of business expertise at which payoffs to n and $n+1$ are identical.[9] That the marginal cost of a more diffuse prior falls when α falls means that (**??**) may be overturned. To have a meaningful impact, we assume that the decrease in α to α' is

[8] Of course in practice such a policy shock may also raise a. The BGP implications are similar, the difference being both incumbent and entrant lines may upgrade depending on parameter values.

[9] Since $x' = \sigma_\eta^2/(1-\alpha)$, it also falls. We adopted x' as the completely naive prior but we keep the naive prior unchanged for two reasons. First, the shock to α occurs after cultural indoctrination, that is, after x has been acquired from the cultural parent. Secondly, changing x' requires a theory how the naive prior actually adjusts to the new reality. The analysis below is robust to letting the naive prior change with α.

large enough so that

$$\gamma(\alpha') > \frac{\beta(1-\mu^*)}{\mu^*(1-\beta)}.$$

Larger the cultural inertia, that is further above β is μ^*, the greater the α shock necessary to make this happen. After the shock, individuals culturally indoctrinated to be wage workers are better off if they were to become entrepreneurs despite their lack of business expertise. The ranking of $\pi_n(0)$ and $\Pi_n(0)$ is not changed by the change in α, so only the occupational choices of wage workers will be initially effected. By Lemma **??** and Proposition **??**, when α is lowered, the following ordinal ranking $\tilde{x} < x^{**} < x'$ (see sections 3.1 and 3.2) is maintained. Because only their ranking determines occupational decisions – as opposed to decisions about parental investment which is determined by cardinal measures – this means that it is optimal for wage workers to want to become entrepreneurs.

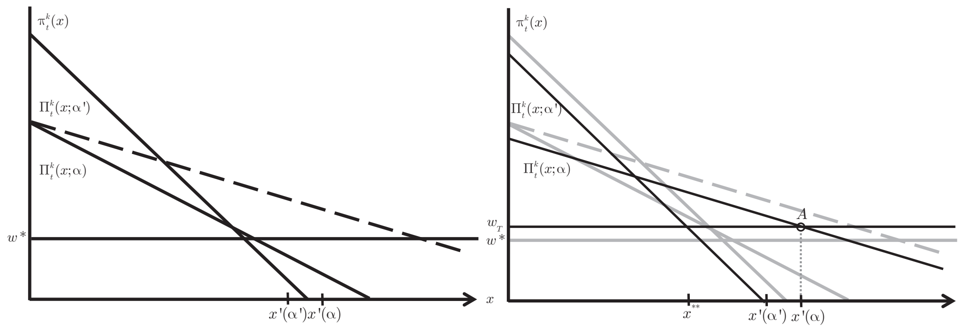
If within-family indoctrination were perfect, we would be assured of overtaking as these wage workers ended up upgrading and updating in each period until their priors equalled x^{**} at which point their productivity would increase by a with each generation. Eventually these newly emerged entrepreneurial lines become more productive than incumbent businesses despite the latter's significant advantage in the technologies they have specialized in. Upgrading will keep occurring because the priors of these new business entrants will be such that $\pi(x) < \Pi(x)$ for all vintages and, since $\tilde{x} < x^{**}$, they will reach the steady-state level of expertise x^{**} before this ceases to be true. That is, entrant entrepreneurial families always keep updating, never in a position to have learned enough about an existing vintage for updating not to be worthwhile.

In the presence of imperfect within-family indoctrination, however, we also have to consider the socialization effort of different families. For expositional clarity, we separate occupational choices and cultural indoctrination of the first generation from subsequent ones.

First Generation

Let, as before, the fraction of generation t who were culturally indoctrinated in wage work be m_t and the fraction who become workers be μ_t.

Start with Fig 4(b) and suppose that α falls to α' at the beginning of $t = T$ when indoctrination has already occurred but people are yet to make an occupational choice. The post-shock economy, before equilibrium is restored, is shown in Fig 6(a). The dashed line represents the new Π_t^k line corresponding to α'. At the uninformed prior x', wages were strictly higher than both π_t and Π_t, so that none of the workers would have preferred entrepreneurship as (**??**) indicates. Now at x', expected entrepreneurial income from upgrading Π_t^k exceeds the wage rate but expected entrepreneurial income from the prevailing technology π_t^k does not.[10]



(*a*) Post-indoctrination, Pre-Occupational Choice

(*b*) Post-Occupational Choice Equilibrium

FIGURE 6. The period-T problem when α falls to α'

This creates, for the first time, a separation between an agent's cultural line and his occupational choice. As culturally indoctrinated wage workers opt for entrepreneurship, it will drive up labor demand and drive down labor supply. This increases the wage rate w_T and decreases the expected entrepreneurial returns for both of the n and $n+1$ technologies. Fig 6(b) shows – pre-equilibrium relationships are in gray, equilibrium ones in black – that an occupational equilibrium is restored at point A where enough such people have opted for entrepreneurship using $n+1$ that the remaining workers are indifferent between the two occupations, that is, the wage rate and expected profits of entrant entrepreneurs are equalized. None of the culturally indoctrinated entrepreneurs switch to wage-work since they acquired perfect mastery over n from their cultural parents.

Denote the first-generation entrepreneurs, the entrants, by the set $\mathcal{E}_T^E$. Using their labor demand function from (**??**) and the arbitrage condition that $w_T = \pi_{n+1,T}(x')$, these entrepreneurs employ

$$L_T^k = \frac{\beta}{1-\beta} \ \forall k \in \mathcal{E}_T^E \tag{2.32}$$

[10]Fig 6 identifies $x'(\alpha') = \sigma_\eta^2/(1-\alpha')$ to illustrate that if the uninformed prior were to change to $x'(\alpha')$, the implications are similar.

units of labor. The relative return between an incumbent and entrant's businesses, γ_t, is

$$\gamma_t(x_t) = \frac{a^{T-t+1}(1-\sigma_\nu^2 - \sigma_\eta^2 - \alpha x_t)}{1-\sigma_\nu^2} \text{ for } t \geq T \tag{2.33}$$

where we use the result that along the transition path entrant entrepreneurial lines will keep updating their technology. Incumbent entrepreneurial lines who were employing $\mu^*/(1-\mu^*)$ units of labor before the shock, now hire

$$L_T^k = \frac{\beta}{(1-\beta)\gamma_T} \;\; \forall k \in \mathcal{E}_T \backslash \mathcal{E}_T^E. \tag{2.34}$$

This labor demand is lower than before, since the entry of first-generation entrepreneurs raises the wage rate. The end result of this post-shock equilibrium is $\mu_T < m_T$, a decline in business returns for existing entrepreneurial lines and the rise of a new class of entrepreneurs who are, initially, no better off than wage workers.

By the end of T, three groups of people have emerged: those indoctrinated as workers and chose to be so, those indoctrinated as workers but chose to venture into entrepreneurship and those indoctrinated as entrepreneurs who chose to be so. We will refer to the last group, that is, those culturally indoctrinated and choosing to be entrepreneurs with priors $x_n = 0$, as incumbents. Denote by i_t the fraction of the population indoctrinated into incumbent entrepreneurship and by ι_t the fraction who choose to be (incumbent) entrepreneurs. Refer to the other group of entrepreneurs and their progeny (those emerging from first-generation entrepreneurs) as entrants even though by $T+1$ they are no longer first-generation entrepreneurs. Denote the fraction of the population culturally indoctrinated in entrant entrepreneurship as e_t, while the actual number of entrants who choose to be entrepreneurs is ϵ_t. As before, m_t denotes the population fraction indoctrinated into wage work and μ_t the fraction actually involved in it.

Using these definitions, we can describe the proportions of each of the three types in T using μ^* and γ as

$$\iota_T = i_T = 1-\mu^*, \epsilon_T = \mu^* - (1-\mu^*)\left(\tfrac{\beta}{1-\beta}\right)\tfrac{1}{\gamma_T}, \mu_T = \mu^* - \epsilon_T. \tag{2.35}$$

We proceed to show that for $t > T$, culturally indoctrinated wage workers do not become entrepreneurs. This maintains three kinds of priors in the population: incumbents will culturally pass along priors of $x_n = 0$ to every generation ($\tilde{x} > 0$ still holds), entrants will culturally pass along x_{n+t} moving from x' to x^{**} through constant upgrading and updating, and wage workers will culturally pass along the prior of x'.

Second Generation and Beyond

Since wages and expected entrepreneurial income for entrants are equalized in $t = T$, a wage worker will behave (from paternalism bias) as if his child on becoming a first-time entrepreneur will see no change in expected income and likewise a first-generation entrepreneur parent will surmise that their child becoming a wage worker will not alter their income. Both types of parents therefore indoctrinate their children based only on their occupational biases, δ_w and δ_b. This results in a low level of parental investment from these groups. On the other hand, despite seeing their business returns drop, incumbent cultural lines will still view any movement towards wage work as a drop in their offspring's income. They will invest more intensively in cultural indoctrination than the other groups (indoctrination effort, though, will be lower than before because of lower business earnings), thereby increasing the frequency of their cultural trait in the population. This will result in $m_t < m_T$, $e_t < e_T$ and $i_t > i_T$ for $t > T$. As wages rise further due to lower labor supply, the children of some entrants may become wage workers. This results in $\mu_t > m_t$ and $\epsilon_t < e_t$ in these periods, with the differences logically being of equal magnitudes. However, there will still be at least some entrant lines maintained (who will be upgrading and updating) in each period t so long as the number of incumbents is sufficiently small or γ_t is sufficiently high:

$$\iota_t < \frac{(1-\beta)\gamma_t}{(1-\beta)\gamma_t + \beta} \quad \text{for } t > T. \tag{2.36}$$

If (**??**) does not hold, the number of cultural incumbents is driven sufficiently high that wages are pushed above the expected income an entrant business line obtains. The result is that all entrant business lines are wiped out as their cultural offspring become wage workers.

So long as (**??**) holds, some entrant entrepreneurial lines may disappear but on the whole entrepreneurship will come to be dominated by the first-generation entrants. This is because cultural indoctrination alone cannot wipe out the entire cultural line of a group, only diminish it by some fraction in each generation. Moreover, under (**??**), the discrete priors for population will be maintained. This is because there are no wage workers becoming new entrepreneurs after the first generation, as the original shift of wage workers towards business will force equation (**??**) to be true once again. Although the demographics based on indoctrination and occupational choice are complex, we conclude that so long as entrant lines are not wiped out under (**??**), they will eventually have higher business earnings than incumbents. This leads to the following proposition.

Proposition 5

Since $a > 1$ and $\tilde{x} < x^{**} < x'$, after sufficient technology upgrading and updating, new technologies will yield higher expected earnings than n. As entrants' priors fall with each upgrade and update, their productivity rises faster than that of incumbents. Their indoctrination effort will come to dominate that of incumbents' and wages will rise such that at some $t = T' > T$, $w_{T'} = \pi^k_{T'}(0)$. For $t > T'$, incumbent cultural lines are wiped out as their offspring choose to become wage workers.

Example 4

For the socialization cost function from Example 1, socialization efforts are

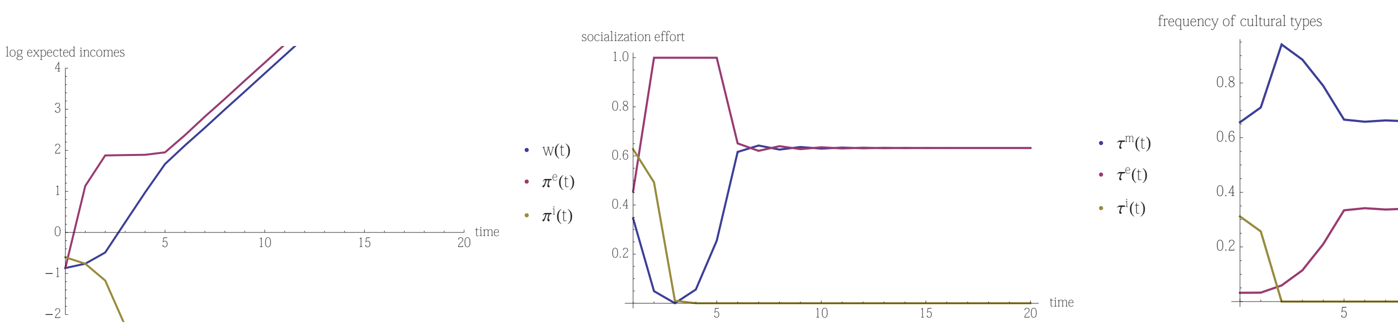
$$
\begin{aligned}
\tau_t^w &= (1 - m_t)\left(V_t^{ww} - V_t^{wk}\right) \\
\tau_t^e &= m_t\left(V_t^{ee} - V_t^{kw}\right) \\
\tau_t^i &= m_t\left(V_t^{ii} - V_t^{kw}\right).
\end{aligned}
$$

As before these are increasing in the perceived payoff differential and decreasing in the frequency of own occupational type.

Figure 8 presents an example of overtaking. The pre-shock human capital parameter is set to $\alpha = 0.85$ to produce a naive prior of 0.7 as in the previous examples. The shock lowers this to 0.75 in some initial period, normalized to 0 in the figure. Suppose that both incumbent and entrant entrepreneurial parents have the same δ_b and they do not distinguish between what kind of entrepreneur (human capital) their offspring becomes (have).

Figure **??** illustrates the time path of occupational (expected) income, socialization effort and occupational frequency in the population. As explained above, in the initial period, socialization by entrant and wage-working families is dominated by that in incumbent families. As long as non-upgrading incumbents are present, wages increase at a slower rate than entrant entrepreneurial profits (Fig **??**a). Since their earnings rise faster than wages, from period 1 onwards, entrant families invest more intensively in cultural indoctrination (Fig **??**b). This ensures that their frequency rises faster than that of incumbent entrepreneurs.

By the third generation, wages have risen high enough that all incumbent lines have been absorbed into wage-work and their human capital dies out. Note the possibility that the frequency of wage workers in the population can increase for a while (Fig **??**c) until this happens. During this transition phase, wages are pinned down by an arbitrage condition between incumbent entrepreneurship and wage work. Steady state is reached when wage-workers' and entrant entrepreneurs' socialization efforts converge and their incomes increase at the same rate, 1.8% per year if a generation is taken to be 25 years. The long-run proportion of entrepreneurs in this example is 0.34, higher than the 0.31 before the shock, and consisting entirely of "first generation" entrepreneurs. $\beta = 0.6, \delta_w = 6, \delta_b = 2, \sigma_\eta^2 = 0.1, \sigma_\nu^2 = 0.2, a = 3, \alpha = 0.85, \alpha' = 0.75$



(a) Expected incomes, T onwards (b) Socialization, $T + 1$ onwards (c) Evolu

FIGURE 7. Overtaking

The BGP characteristics of this economy are similar to that of the previous section: growth is driven by continuous technology upgrading and the fraction of wage workers is equal to $\bar{\mu}$. So long as assumptions (**??**) and (**??**) hold for $\bar{\mu}$, the result will be a monotonic, dynamically persistent movement toward $\bar{\mu}$ after T', with discrete priors $x_{n+t} = x^{**}$ for entrepreneurs and x' for wage workers. The key difference from before is that growth here is driven entirely by entrant entrepreneurial lines.

Discussion

Our model of culture and entrepreneurship, while relatively simple in its broad classification of occupations and the cultural determination of preferences, can inform how culture has shaped the development path of several societies in recent history. consequences of "opening up". We present three examples. The first, on Japan and South Korea, shows the scope of top-down development arising out cultural and economic change. The Indian case that follows is an instance of growth takeoff fueled partly by the emergence of a new entrepreneurial class. We also highlight how colonial policies could have biased the population towards safer occupations.

Japan and South Korea

Japanese society presents an interesting case of stagnation before the Meiji era, with a focus on stability, stagnation and an increase in wealth resulting solely from population increase. According to the historian E. Herbert Norman, this Tokugawa period was "one of the most conscious attempts in history to freeze society in a rigid hierarchical mold" (Norman, 1940, cited in Lockwood, 1968, p 5). Infanticide was widely practiced for family planning and this was opposed vociferously by the daimyo on expressly amoral ground because population growth was the only source of wealth creation for the nobility (Honjo, 1935). Along with proscriptions against foreign interactions, there were significant prohibitions on the use of high-quality soil for the production of cash crops and for villagers seeking non-agricultural work ("...a village could be punished for failing to get the maximum amount of production from its land, planting commercial crops on land assessed as taxable rice land [all land which had been under cultivation during the last tax assessment], or neglecting farming in favor of other occupations.") (Jansen, 1980, chapter 9). All of this can be understood in the framework of the model as an attempt to maintain and master an existing technology and create wealth for incumbents without potentially upsetting their privileges. In the model, the only way for incumbents to become richer in a stagnating economy is for the working population to increase.

After Commodore Perry opened up Japan, the country was poised for a deep cultural revolution. The existing elites were driven by a perception of the military necessity of economic reform, and a society accustomed to and proficient in existing technologies was confronted by a regime in which competition and innovation were extolled, embodied by the slogan *Fukoku kyohei*, “enrich the economy to strengthen the army” (Smith, 1988, p 259). During the Meiji era, economic growth was spurred by liberalization in agriculture that allowed for the introduction of new techniques and the use of existing land for crops other than rice as well as the end to the system of privilege by which merchants and high-ranking samurai attained wealth during the Tokugawa era (Macpherson, 1995, p 26). Silk and other cash crops were grown on land which had previously been employed to produce rice. This transformation was largely due to the Land Tax Reform of 1873 which overturned the idea that cash was to be kept out of the hands of all save merchants (best exemplified by the slogan *kikoku-senkin*, “revere grain, despise money”) and allowed transactions to be carried out in cash for the permanent transfer of land. Land transfers allowed for plots which had been divided up by family into areas of five or fewer acres, ideal for rice cultivation, in each village into larger plots, ideal for activities such as sericulture. At the same time, the intoduction of Western technology brought the application of phosphate fertilizers. As Macpherson (1995, p 71) points out, this agricultural revolution was the primary source of financing for subsequent industrialization, and provided a wellspring of entrepreneurs as well as financing. This growth was characterized by the outsized role that the existing elites (samurai and merchants) played, with Smith going so far as to describe this as an aristocratic revolution (Smith, 1988, p 135) in response to the new opportunities. Within our model, we can understand these changes as either changing the degree of human capital specificity (by lowering the power of rank and privilege) or by increasing the returns to newer technologies. In the case of the reduction in the power of privilege, a reduction in the need to cultivate government contacts to be permitted to engage in commercial activity would make commercial activity easier for all potential entrants, and give less of an edge to those incumbents with the most experience and, therefore, the most contacts. In either case, a shift from stagnation to long run growth will occur. That the elites were the ones to have led Japan towards modernization suggests that the second channel was more instrumental.

Korean society before Japanese colonization (1910-1945) was in many ways similar to Tokugawa-era Japan, with a strong Confucian focus on maintenance of the status quo (Jones and Sakong, 1980, p 18) and pressure from the nobility to expand population countered by a large farmer class who responded with strict family planning to control populations and maintain their standard of living (Song, 1994, p 34). Under the Japanese colonial government, most opportunities were limited to the Japanese (Jones and Sakong, p 17). This structure gave way, in the post-independence years, to an economy with little economic growth or entrepreneurship until the Park regime. One of General Park's first major actions in regards to the domestic economy was to imprison business leaders, allegedly for corruption. However, all of these leaders were eventually released after agreeing to Park's economic plans. The founder of Samsung, Lee Byung Chull, who was abroad at the time of the arrests had to commit to Park's economic program to avoid imprisonment on his return. A growth explosion followed, spurred in large part by demands from Park that businesses engage in new activities that were deemed to be of industrial importance. Originally, this growth was autocratically demanded from the top down, and firms received explicit or implicit subsidies. As time went on, however, firms were successfully weaned and began engaging in new ventures without state request. This growth was primarily driven by firms like Samsung which were led by entrepreneurs who had explicitly agreed to Park's industrial strategies. Indeed, Korean entrepreneurs and major businesses during this period were predominantly descendants of the elites of previous eras (Jones and Sakong, 1980). Within our model, we understand this to be a forced movement from technology n to $n+1$, a movement that would not have been privately optimal had it not been for the threat of political retribution. Subsequently, as Korean businesses gathered sufficient expertise, technology upgrading would have been in their strict economic interest.

The Long Shadow of Colonialism

The diverse development paths taken by former European colonies in Africa, North America and Australasia have attracted much research in recent years. A compelling line of work highlights the extractive nature of some colonies. It is argued that the effects of colonization have persisted in the form of inferior political and economic institutions long after the departure of the colonists (Acemoglu and Robinson, 2012).

Not all countries fit this general pattern and the appropriateness of specific institutions can be hard to identify *ex ante*. A feature common to most former colonies, excepting the western offshoots, is the pursuit of state-led development soon after independence. In part, the Soviet Union's rapid industrialization was seen as a model worth emulating by many of these countries. The policy choice also reflected in part a deep distrust of the forces of capitalism. Whether consciously or as an unintended by-product of global trade, colonization had often led to the decimation of local industries, avaricious extraction of natural resources and non-development of domestic industries, local entrepreneurs being confined to trade and commerce. The decision to pursue state-led development stemmed from a perception that market-based development would be likewise rapacious and ill suited to societies suffering from chronic poverty.

The model provides some insight into how the cultural impact of colonization, complementing the effect on political institutions, shaped national identities and economic development. Take the case of India, whose independence from Great Britain in 1947 was embraced with much focus on nation-building, the creation of a pan-Indian identity, and a development strategy implemented through five year plans (Khilnani, 1997). After an initial spurt, growth of output per capita faltered, averaging only 1.7% per year during 1950-80 even as Asian economies like Japan, South Korea and Taiwan were showing much dynamism. The institutionalist argument for this is weak: "in 1980, India's level of income was about one-fourth of what it should have been, given the strength of its economic institutions. On the other hand, if political institutions are the true long-run determinants of income, India's income is about 15 percent of what it should be" (Rodrik and Subramanian, 2005, p 219).

Even though India's economic policies were not explicitly socialist in the early decades after independence – liberal even compared to the overtly restrictive policies that were to follow from the mid-1960s – the overarching theme was state-led development via directed investment (especially in heavy industries) and manipulated prices (Panagariya, 2008). The task of administering a large country fell on the shoulders of the administrative service, a carryover from the British era civil service. Public servants were also necessary for the expansion of the public sector. Soon the government was providing employment not just to the educated and skilled but also the relatively less skilled workforce in public sector enterprises and in the form of a retinue of support staff to federal, state and local bureaucracies. By 1961 the public sector accounted for close to 58 percent of the total organized sector employment, a number that increased to 68 percent by 1981 before reversing in the 1990s (India Labour Market Report, 2008).

One way to understand India's colonial legacy is to entertain the idea that the British often promoted certain kinds of educational training and role models. In this framework, entrepreneurs, by engaging in uncoordinated activity, created unaccounted and uncontrolled wealth, whereas a bureaucratic system of production lent itself optimally to control and wealth extraction. In creating an employment and social structure dedicated to bureaucracy, they created a value system among the "natives" where securing a government job was perceived as a lifetime guarantee of success and stability and belonging to an emerging educated elite, rather than striking out on one's own, that is, being entrepreneurial broadly defined. Generously remunerative public sector jobs – public sector wages often increased faster than the inflation rate or private sector wages – that were mostly secure made it a great attraction for college graduates and the less skilled. The focus on and breadth of the state's involvement shrank the space for private enterprise. By the mid-1960s, this benign neglect turned to active discouragement when restrictive licensing policies were used to give preferential credit and foreign exchange access to large-scale enterprises, many in the public sector, and labor market regulations that stifled a more entrepreneurial base of smaller industries from diversifying and growing. With entry into formal sector manufacturing heavily regulated and biased in favor of big players, entrepreneurship would have been perceived to be less desirable on that margin too. Lal (1999) is explicit about the cultural bias underlying this approach: "The contempt in which merchants and markets have traditionally been held in Hindu society was given a new garb by Fabian socialism which appealed to the newly westernized but traditional literary castes of India" (p 36). The resulting high δ_w would have, not surprisingly, meant a sizable fraction of the population locked into safer occupations, many in the highly remunerative public sector. That was no doubt worsened by a high α implied by preferential access granted to insiders and the bureaucratized, centrally coordinated nature of production.

Beyond this intensification of cultural biases and its growth implications, our model is also useful to understand India's growth recovery since the 1980s. Contrary to popular perception, this recovery does not start with the 1991-92 liberalization necessitated by a balance-of-payments crisis, but predates it to the piecemeal reforms initiated during the 1980s (Panagariya, 2008, Rodrik and Subramanian, 2005). Rodrik and Subramanian (2005) empirically distinguish between the two periods: while the growth recovery of the 1980s was due to a pro-business "attitudinal shift" that favored the interests of existing businesses, as in the case of South Korea following General Park's takeover, the reforms of the 1990s are seen as pro-market, making possible the emergence of new, dynamic firms. By 1999, 8 of the top 10 Indian billionaires were first generation entrepreneurs, and 6 of the top 10 had made their fortunes in knowledge industries (Das, 2000). Indeed, post-liberalization, "middle class" entrepreneurs have often entered sectors and industries that were made possible by liberalization (information, biotechnology) or relatively untouched by existing ones (agribusiness).

Following the discussion in the previous section there are two ways to interpret a "liberalization shock" in our model: as an exogenous increase in the TFP parameter a for all technologies, or as an increase in the same accompanied by a reduction in the human capital specificity parameter α. Viewed this way, while the earlier liberalization of the 1980s was mainly about favoring existing businesses – higher a alone – that raised growth without seeing the birth of a new generation of entrepreneurs, that of the 1990s was more disruptive, forcing the economy to confront the global economy and making available new entrepreneurial opportunities. This interpretation may also explain why the liberalization of 1991 has remained robust – giving rise as it has to shared prosperity by the middle class and the established elite – contrary to an earlier episode in 1966 that was soon reversed (Srinivasan, 2005).

Conclusion

Using a model of intergenerational cultural transmission, this paper has studied the evolution of risk-taking and economic development. Risk-neutral individuals work in one of two occupations, operating a risky business whose expected return depends on business expertise or working for a riskless wage. Parental comparative advantage in entrepreneurship is culturally transmitted to children through costly, but imperfect, intra-family education. This human capital determines occupational choice. Experience in a particular occupation also imparts an occupational bias that affects the intergenerational transmission of human capital.

Our paper can explain the strong and persistent positive correlation observed in the data between occupational choice and family background without appealing to market imperfections.

Depending on technological characteristics it can also generate various patterns of economic development, from long-run stagnation to sustained growth to leap-frogging in economic status. Culture – occupational biases and the intra-family transmission of human capital – can lead to stagnation in the long run when productivity growth is relatively small or past policies were geared towards low-risk occupations. For sufficiently high productivity gains from technological change or sufficiently low human capital specificity of new technologies, culture becomes irrelevant for long-run growth though it is still associated with static inefficiency. In this the model's implications are similar to Krugman (1991) where history turns out to be decisive only when the rate of inter-sectoral adjustment, and hence economic growth, are slow.

There are three directions in which the present work may be extended. While occupational biases are taken to be immutable, they may be endogenous to the economic fortune of different sectors. Allowing parents to indoctrinate their children in an occupation different from their own and to alter their own biases depending on market outcomes would be one way to study how the social esteem with which certain occupations are held changes over time. Risk aversion, which we have ignored here, may be important in that evolution, creating a natural bias towards safer occupations unless the return from riskier ones is substantially high. Secondly, there are likely complementarities between entrepreneurship and the pace of technological progress. An innovation or adoption process that endogenies the productivity gain from new technologies, for example if technologies can be upgraded by more than one step, could yield significantly different implications for long-run growth which, at present, is independent of culture in a growing economy. In yet another respect culture may be more deterministic than the positive growth equilibrium suggests. Our model of entrepreneurship does not include credit frictions that are often seen to discourage risk-taking and entry of productive businesses. By creating additional barriers for workers seeking to become entrepreneurs, credit market imperfections will only worsen the cultural inertia that slows economic progress.

CHAPTER III

THE COORDINATION GAME AND CULTURE

Introduction

The economics of heterogeneous populations is of the utmost importance in the modern world as trade in labor follows the route laid out centuries ago by trade in goods and begins to flow internationally with little concern for borders.[1] Whether or not it is privately or publicly optimal to maintain a culture which is separate from the maintstream or to adopt the culture of others for the purpose of conformity is the issue. In this paper, I add to the existing literature by creating a formal model of exchange with two key assumptions; that different cultures produce goods or services with differential productivity and that there exists some difficulty in coordinating activities across cultural boundaries. The resulting formal model is able to generate rational decisions to keep a separate culture from the mainstream or to assimilate even in the absence of costs to cultural switching, as well as the result that heterogeneous populations may be either socially optimal or socially suboptimal.[2] These two results (of maintaining or dropping minority cultural status from the standpoint of a rational agent and minority population optimality/suboptimality) help to explain how variations in the production differential between cultures and the difficulty of cross-cultural coordination alter the decision to assimilate or not, from the perspective of a rational economic agent, and the desire on the part of social planners to push for or against assimilation.

Culture can best be understood, from the perspective of economics, as the set of behaviors, expectations and norms that a group commonly holds. Cultural aesthetic items, such as choice of clothing, are therefore nothing more or less than markers of cultural type, expressions and communication of culture. Idiomatic language, references to specific cultural allegories, non-verbal cues and intra-cultural aesthetic markers are all methods of quickly and efficiently communicating within a culture, but can be meaningless or even have the opposite meaning

[1]Previous historical epochs of mass migration have primarily involvedmass movements into relatively uninhabited areas or displacement of existing populations, so the present and emerging state of increasing cross-cultural interaction is in some ways unique historically.

[2]The purpose of allowing costless switching is to show that persistent minority cultures can be maintained even in the absence of standard model assumptions of paternalism or frictions, not because it is assumed to be the case that there truly are no costs to switiching.

when communicating between cultures. Holding aside, temporarily, potentially important cross-cultural differences in expectations and resources, culture's most economically important role is in facilitating or hindering coordination. Culture could then be understood as a technology for living and interacting with other economic agents. Critically, culture should not be understood as synonymous with ethnicity; cultural differences (especially in terms of primary language) are rife throughout areas of Europe which are ethnically indistinguishable. Understood this way, two people could be physiologically identical and culturally different, whereas it is also possible that two people could be racially different but use the same cultural cues and have the same expectations imparted by culture.

The prevalence of culturally transmitted propensities to produce certain goods is so great that in the recent past examples of some cultures predominating production in specific fields, at least within a country, abound. French Huguenots created the watch-making industry in Switzerland and England (Scoville, 1960, p 325). The English finance industry was effectively created by the Lombards (Cunningham, 1897, p 69) Germans pioneered the creation of the piano industry in many countries, especially czarist Russia (McKay, 1970, p 35). Jews became the dominant force in leather tanning in Poland before World War II (Weinryb, 1973, p 68). Japanese immigrants became dominant in the production of apples in Oregon, Washington and Northern California (Chiswick, 1979). The mechanism for this outsized representation of certain groups in certain types of production, though not the focus of this paper by any means, is simple enough to understand; cultural lines transmit skills, knowledge and attitudes more amenable to some types of production than others.

Given this understanding of culture, the present model has the ability to present several potentially valuable policy suggestions. I assume that people of different cultures have, in an ideal world, the ability to gain from trade. However, cross-cultural communication is difficult, making it possible that coordination across cultures is not successful. The result of this is that there are costs and benefits to heterogeneity (not completely assimilating) both privately and publicly. Agents always prefer the opportunity to trade with those who are different, so long as they can coordinate, but this coordination is more difficult as differences increase. Based on this, it may be the case that support for cultural assimilation will be more attractive when the difficulty of cross-cultural coordination is greater. At the same time, when cross-cultural communication is easy, support for persistent multiculturalism may be welfare maximizing. As economies, both historically and contemporaneously, transition from the production of goods to the production of services, it may be that assimilation was less important in the past (with presumably easier coordination in production of goods than in production of services), and may help to understand the increased support for assimilation efforts on the part of government and social planners, even without resorting to any assumptions of psychic costs to diversity or immigration.

The existing literature on the subject of the decision to maintain minority culture, with the seminal work being Bisin and Verdier (2000, 2001, 2004), focuses primarily on the role of culture transmission from parent to child. Most of this literature, even recent work, such as Ghidi (2012), relies on some degree of paternalism to drive the result of persistent minority culture. This paternalism, though largely unobjectionable, assigns preferences to agents which are difficult to completely reconcile with standard neoclassical rational decision-making. At the same time, the present model uses play between and within networks and allows for rational network formation, and is therefore following in the vein of Jackson and Watts (2002). The network formation decisions in this literature are largely created by assumptions of homogenous agents.

This paper adds to the literature by presenting a formal model of how cultural distance creates costs and benefits in a simple coordination game. In so doing, I use the model to explain the rational choice to maintain minority culture or assimilate. This framework, in which agents make a rational decision and are allowed to switch cultures costlessly, differs from that put forward elsewhere in the literature to explain the persistence of culture. By allowing cultural type to be switched without cost and by maintaining economically rational behavior on the part of agents, I present a much more powerful model for understanding cultural dynamics and the endogenous relationship between culture and economic activity. Again, I do not presume that switching culture is truly costless, but, the fact that my results can be generated even with costless switching suggests that the model is more robust than those in the existing literature. My results suggest that, when previously stable minority populations see the gains (costs) of being different shrink (grow), members of this group are apt to assimilate. I also show that a wide range of interior equilibria (heterogeneity in population types) is possible, with some internal equilibria being locally stable and others locally unstable, as well as the possibility of simultaneously locally stable and locally unstable internal equilibria, presenting very interesting long-term dynamics resulting from even simple parameter perturbrations. At the same time, looking at social outcomes overall, my results show that changes in the difficulty in coordination alone can cause a shift in regime from a socially optimal outcome of complete homogeneity to a socially optimal outcome of persistently mixed population, helping to explain the impetus for policy to be for or against assimilation. Finally, my results demonstrate that equilibria determined by private decision making are almost never socially optimal because the minority culture (the culture which is less prevalent) does not receive its full value for exchange as it becomes more and more rare in the population as a whole.

Conceptual Model

Coordination

Every agent has a cultural type, either i or j. Every agent in the economy plays a simple coordination game in two rounds. In each round, one player is designated as the matchmaker and the other is designated as the matchreceiver. Both players will ultimately make a simple selection of play over a binary set of options. The matchmaker proceeds to send a signal of intended play, and the matchreceiver receives this signal. This is the first way in which culture enters the model, as, so long as matchmaker and matchreceiver are of the same cultural type (i.e., matchmaker of cultural type i and matchreceiver of cultural type i), the signal is understood perfectly. I assume that both agents in a match observe the cultural type of the other agent with perfect clarity. In this case, optimum play is for the matchmaker to send an accurate signal of intended play, and for the matchreceiver to coordinate based on this play. I assume symmetric payoffs to successful cross-cultural coordination, so that there is no preference for one succesful coordination over the other. If, however, the matchmaker is not of the same cultural type as the matchreceiver, so that the match is across cultural types, there is some probability that the message will not be properly interpreted by the match receiver. Specifically, I define $P \in (0.5, 1)$ as the probability of a successful cross-cultural communication of intended play. Based on the defined range of P, the matchmaker's optimal play is still to accurately signal intended play, and the matchreceiver's optimal play is still to match the signalled play, but with some probability $(1-P)$ of failure in this case.

Payoffs

In any successful round of coordination, both agents will contribute to the creation of two types of goods. This is the second way in which culture enters the model, with the two cultural types producing these two goods with differential productivity. Specifically, I assume that culture type i is more productive in good type X_i and culture type j is more productive in good type X_j. I further assume that both types of goods enter the utility function for both agents, so that there is some value to both types of good being consumed in some measure. When successful coordination and production occurs in either round, agents split production equally.

Demographics

I assume that agents may switch effortlessly between types i and j, and do so with no paternalism, from a purely rational standpoint. This results in two types of equilibria, locally stable and locally unstable, depending on how population demographics respond to shocks. In unstable equilibria, if the fraction of the population of type i, which I define as G, increases from the equilibrium value, agents of type i won't change their types and agents of type j will switch to type i until another equilibrium is reached. If G falls below the unstable equilibrium, agents of type j will not change types and agents of type i will switch to type j until another equilibrium is reached. In the case of stable equilibria, small population perturbations of G around the equilibrium are corrected by opposite shifts of population. I define pure assimilation as the outcome of the entire population becoming a single cultural type, and multiculturalism as the outcome of a minority population being persistent. I assume that a benevolent social planner uses a simple Benthamite social welfare function and assigns equal weight to the expected utility of every agent in the economy and therefore that the socially optimal value of G is that for which this sum is maximized. This analysis of socially optimal and suboptimal minorities is later used to analyze government and social policy in regards to promoting assimilation or multiculturalism.

Formal Model

There exist in the economy n agents, which I normalize to measure 1. G proportion of agents have cultural type i and $1 - G$ proportion of agents have cultural type j. The coordination game proceeds as follows. Note that the ordering of agents is arbitrary, and the analysis would proceed with agent roles reversed in just the same fashion.

Step 1 Agents 1 and 2 rationally choose their cultural type, with the overal demographics of the population being a rational expectations equilibrium.

Step 2 Agents 1 and 2 are matched in the first round. Each observes their own and their partner's cultural type.

Step 3 Agent 1 is randomly assigned to be the matchmaker. Agent 2 is therefore the matchreceiver

Step 4 As matchmaker, agent 1 decides on a play and sends an accurate signal of intent to Agent 2.

Step 5 As matchreceiver, agent 2 receives a signal.

Step 5a If agents 1 and 2 share a cultural type, the signal is understood accurately with certainty.

Step 5b If agents 1 and 2 do not share a cultural type, the signal is understood accurately with a probabilty of $P \in (0.5, 1)$.

Step 6 Agent 1 plays as signalled.

Step 7 Agent 2 plays as agent 2 understood the signal from 1.

Step 8 Agents 1 and 2 split the proceeds of the coordination game, if there are any, equally.

Step 9 Steps 2 through 8 are repeated in a second round of play.

The utility which agents receive from play is defined as

$$U_i(G) = X_i^A X_j^B \tag{3.1}$$

where I assume $A + B = 1$. I normalize production for cultural type i of good X_i to be 1, and similarly I normalize production for culturaly type j of good X_j to be 1. I define the cross-cultural productivity of goods as follows; agents of cultural type i produce good type X_j with productivity of α, while agents of cultural type j produce goods of type X_i with productivty of β. I assume that $0 \leq \alpha, \beta \leq 1$. Remembering that G represents the proportion of the population having cultural type i and that P represents the probability of successful cross-cultural coordination, the normal form representations of gameplay with all two-player combinations of cultural types i and j are thus presented in Tables 1 and 2. Note that play between types i and j is symmetric regardless of who is designated as matchmaker and matchreceiver.

TABLE 1. Type i-Type i Game

Matchreceiver	Matchmaker Left	Matchmaker Right
Left	$(X_i + \alpha X_j), (X_i + \alpha X_j)$	0,0
Right	0,0	$(X_i + \alpha X_j), (X_i + \alpha X_j)$

Type i-Type j Successful Coordination Payoff

$$\frac{(\beta + 1)X_i + (\alpha + 1)X_j}{2} \tag{3.2}$$

TABLE 2. Type j-Type j Game

Matchreceiver	Matchmaker Left	Matchmaker Right
Left	$(\beta X_i + X_j), (\beta X_i + X_j)$	0,0
Right	0,0	$(\beta X_i + X_j), (\beta X_i + X_j)$

The expected utility of each type of agent, based on the parameter values of the model and the demographics of the population, can thus be solved given equation (**??**).

$$E(U_i(G)) = G^2(2)^A(2\alpha)^B + 2G(1-G)P(1.5+0.5\beta)^A(0.5+1.5\alpha)^B + 2G(1-G)(1-P)(\alpha)^B \quad (3.3)$$

$$+(1-G)^2P^2(1+\beta)^A(1+\alpha)^B + 2(1-G)^2(1-P)P(0.5+0.5\beta)^A(0.5+0.5\alpha)^B$$

$$E(U_j(G)) = (1-G)^2(2\beta)^A(2)^B + 2G(1-G)P(0.5+1.5\beta)^A(1.5+0.5\alpha)^B + 2G(1-G)(1-P)(\beta)^A \quad (3.4)$$

$$+G^2P^2(1+\beta)^A(1+\alpha)^B + 2G^2(1-P)P(0.5+0.5\beta)^A(0.5+0.5\alpha)^B$$

Equations (**??**) and (**??**) represent expected utility for each cultural type of agent based on the parameters of the model and the demographics of the population. It should be intuitive that the expected utility of agents is based on the differential productivity of each of the two types of goods (α and β), the importance of each of the two types of goods in the utility function (A and B) and the demographics of the population as well as the difficulty of cross-cultural coordination (the G and P values). The two-way relationship between the expected payoff to being of either type and the current population demographics is what creates the possibility of persistent, rational minorities that can, with shifts in exogenous parameter values, lead to assimilation. Agents achieve population equilibrium in a pre-play period of costless, rational decision-making. An analysis of the stable and unstable equilibria in the model, as well as an analysis of how parameter value changes can make assimilation (multiculturalism) socially optimal (suboptimal), is presented in the subsequent subsections.

Socially Optimal and Suboptimal Minorities in the Symmetric Case

Based on the above model, minority cultures can be either socially optimal or suboptimal in the special case of perfect cultural symmetry (so that $\alpha = \beta$ and $A = B$. Specifically, it can be the case, if P is sufficiently low (so that cross-cultural communication is difficult) and $\alpha = \beta$ is sufficiently high (so that the gains from trade are small), the socially optimal outcome will occur when $G = 0$ or $G = 1$. On the other hand, if P is high and $\alpha = \beta$ is low, then $G = 0.5$ can be the socially optimal point. Specifically, when

$$0 > 3(4\alpha)^{\frac{1}{2}} - 2(1-P)(\alpha)^{\frac{1}{2}} - P(1+\alpha) - P(3+\alpha)^{\frac{1}{2}}(3\alpha+1)^{\frac{1}{2}} \tag{3.5}$$

holds, a persistent non-heterogeneous culture is socially optimal. If (**??**) fails to hold, then homogeneity is socially optimal. Figure 8 displays the contour plot of the threshold between (**??**) holding and failing to hold, mapped across α and P. Figures 9 and 10 show a socially optimal heterogeneous culture and a socially suboptimal one, respectively. It is interesting to posit that this extremely simplified case, with perfect cross-cultural symmetry, may help to explain governmental and social policy directed towards either assimilation or multiculturalism. A benevolent social planner might respond to a low P and high $\alpha = \beta$ with support for assimilation. At the same time, a shift up in P might cause this same social planner to support multiculturalism at a later date.

To the right, **??** doesn't hold and a homogenous culture is socially optimal.

$\alpha = 0.1, P = 0.5$. Minority cultures are strictly inferior to perfect homogeneity in terms of social welfare.

$\alpha = 0.1, P = 0.6$. Minority cultures are strictly superior to perfect homogeneity in terms of social welfare.

Rational Persistent Minorities

The analysis of rational cultural choice in the context of the present model is broken into five separate cases. Again, I assume that $A + B = 1$ and I normalize $\beta = 0.1$. This allows me to limit the variation in the economy to the values of A and α, getting at the role of changing importance of culture specific types of goods and changes in relative productivity in cross-cultural good production. The five cases represent the equilibria available in the demographics of the population based on the space of A and α values. In the first case, agents strictly choose to be of type i. In the second, there is a persistent, but unstable, minority group equilibrium. In the third case, there is a persistent, stable, minority group equilibrium. In the fourth case, there exist simultaneously a persistent stable and persistent unstable minority population. In the fifth and final case, all agents strictly choose to be of type j. Unstable equilibria will be reached only in

FIGURE 8. Contour plot

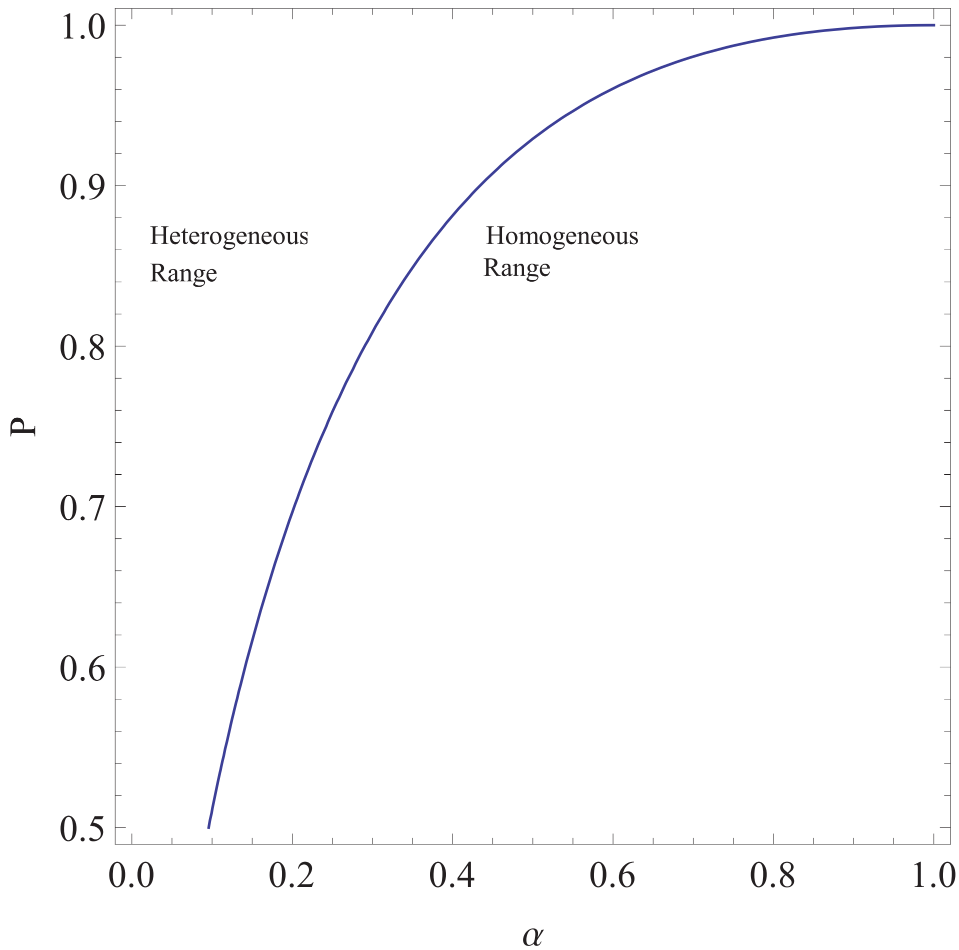


FIGURE 9. Social welfare function against fraction of culture type i, multiculturalism.

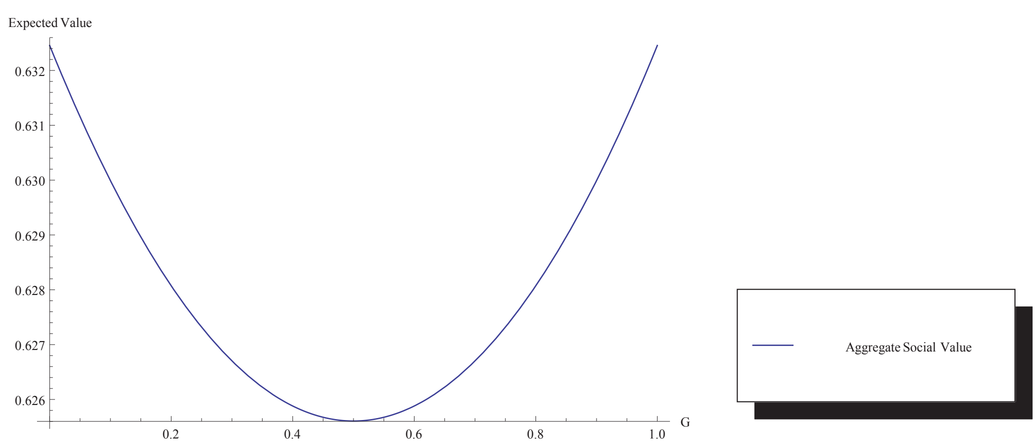
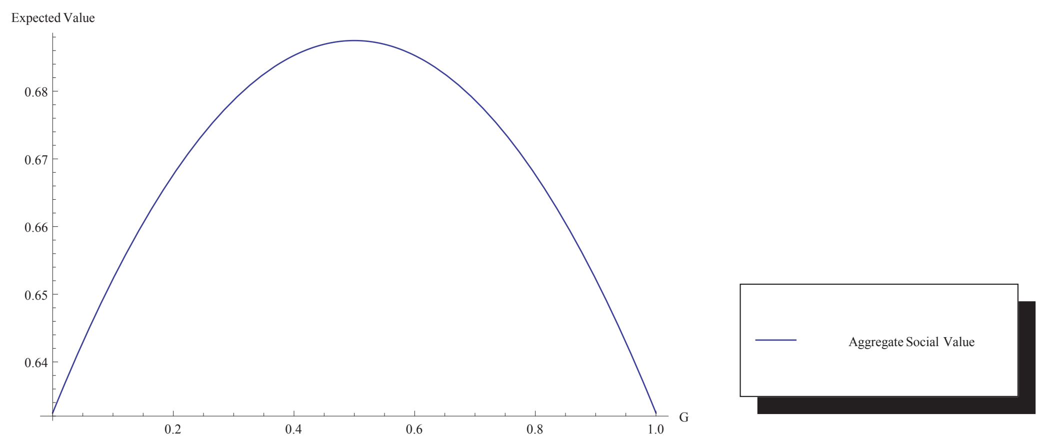


FIGURE 10. Social welfare function against fraction of culture type i, homogeneity



some cases, depending on initial demographics before the first pre-play round of cultural choice. Stable equilibria, on the other hand, are robust to shocks and any initial conditions, save for an initial condition of beginning precisely on the unstable equilibrium in the fourth case.

First Case

When $E(U_i(G)) > E(U_j(G))$ for all G, the first case will prevail, as all agents will choose to be of type i regardless of either initial conditions or the decisions of other players. This space can be found by taking the maximum value (choosing G) of (**??**)-(**??**), and will obtain so long as this value is strictly less than zero. This will occur in an A, α space contained within the space defined by

$$1 < P(\frac{1+\beta}{2\beta})^A(\frac{1+\alpha}{2})^B \tag{3.6}$$

$$1 > P(\frac{1+\beta}{2})^A(\frac{1+\alpha}{2\alpha})^B. \tag{3.7}$$

Figure 11 presents an example case of case 1, in which all agents, regardless of demographics, prefer to be type i (parameter values are α=0.1, A=0.7, P=0.6).

Second Case

In the second case, there is a single, unstable population equilibrium for a given set of A, α values. Whether this equilibrium is reached or maintained will be determined by initial conditions and the possibility of errors on the part of the economic agents involved. This space will be that for which $E(U_i(0)) < E(U_j(0))$ and $E(U_i(1)) > E(U_j(1))$, as this will require both an intersection of values and that the relative value of each type in comparison to the other is increasing in their own type's proportion as agents move away from the equilibrium.

Proposition If the expected value function for i is greater than the expected value function for j at $G = 0$, and the relative values reverse at $G = 1$, there must have been a single intersection of the two expected value functions.

Proof There will occur only a single intersection between the two expected value curves because the first and second derivatives of (**??**) and (**??**) with respect to G will always have the same sign at $G = 0$; therefore, they will both have the same curvature, so, if one curve has higher value for$G = 0$ and the other curve has higher value for some point $G = 1$, they must intersect an odd number of times. As ((**??**)-(**??**))= 0 has either zero, one or two roots, it must the case that, if $E(U_i(0)) < E(U_j(0))$ and $E(U_i(1)) > E(U_j(1))$, there has been exactly one intersection of the two value functions.

The space in which this holds be defined as

$$1 > P(\frac{1+\beta}{2\beta})^A(\frac{1+\alpha}{2})^B \tag{3.8}$$

$$1 > P(\frac{1+\beta}{2})^A(\frac{1+\alpha}{2\alpha})^B. \tag{3.9}$$

Figure 12 presents an example case of case 2, in which there is a single, unstable internal equilibrium (parameter values are α=0.1, A=0.57, P=0.6).

Third Case

In the third case, there is a single, stable population equilibrium for a given set of A, α values. This equilibrium will be reached and maintained regardless of transient mistakes or initial conditions. This space will be that for which $E(U_i(0)) > E(U_j(0))$ and $E(U_i(1)) < E(U_j(1))$, as this will require both an intersection of values and that relative value of each type in comparison to the other is decreasing in their own type's proportion as agents move away from the equilibrium. That this will create one and only one intersection is demonstrated by the previous proof. This space in which case 3 holds will be defined by

$$1 < P(\frac{1+\beta}{2\beta})^A(\frac{1+\alpha}{2})^B \tag{3.10}$$

$$1 < P(\frac{1+\beta}{2})^A(\frac{1+\alpha}{2\alpha})^B. \tag{3.11}$$

Figure 13 presents an example case of case 3, in which there is a single, stable internal equilibrium (parameter values are α=0.04, A=0.59, P=0.6).

<u>Fourth Case</u>

In the fourth case, it must be the case that there are two intersections of the value of being of type i and type j as G goes from 0 to 1. Specifically, for there to be both a stable and an unstable equilibrium, it must be the case that the value of being culture type i is greater than the value of culture type j as G increases, and the reverse as G decreases at the unstable equilibrium and it must be the case that the value of type i is less than the value of type j as G increases, and the reverse as G decreases, for the stable equilibrium . For this to be true, we require $E(U_i(0)) < E(U_j(0))$ and $E(U_i(1)) < E(U_j(1))$ as well as $E(U_i(G)) > E(U_j(G))$ for some G. This will be true so long as the maximum value (based on G) of (**??**)-(**??**)$>$ 0. The stable equilibrium in this case will be reached so long as the initial conditions do not perfectly match the unstable equilibrium. This space in which case 4 holds will be that defined by

$$1 > P(\frac{1+\beta}{2\beta})^A(\frac{1+\alpha}{2})^B \tag{3.12}$$

$$1 < P(\frac{1+\beta}{2})^A(\frac{1+\alpha}{2\alpha})^B \tag{3.13}$$

with the further constraint that (**??**)-(**??**)$>$ 0 for the value of G which maximizes this objective function. Figure 14 presents an example case of case 4, in which there is both a stable and an unstable internal equilibrium (parameter values are α=0.045, A=0.57, P=0.6).

<u>Fifth Case</u>

The reverse of the first case, when $E(U_i(G)) < E(U_j(G))$ for all G, all agents will choose to be of type j for a given A, α space. The space in which the fifth case is contained is defined by the further constraint that (??)-(??)<0 for the value of G which maximizes this objective function. Figure 15 presents an example case of case 5, in which all agents prefer to be of type j (parameter values are α=0.045, A=0.5, P=0.6).

Overview

The subsequent figures help provide an overview of cases one through five.

Figure 16 presents the boundary conditions for equations (??), (??) and the condition that Max (??)-(??)$=0$, mapped across A, α space. Figure 17 presents the same, with a magnified view allowing for identification of the space associated with case 4, and with all spaces appropriately labelled with corresponding prevailing demographics cases.

Note that it is possible, using this framework, to understand, as either α or A shifts, the rational decision on the part of migrant or minority populations to either migrate (looking at the model from a locational standpoint) or assimilate, even after long periods of persistence as the shift in A or α values moves the economy from one prevailing case to another. For example, the Jewish migrants to England in the period after Cromwell readmitted this group remained largely culturally separated from English culture until roughly the 20th century, at which time assimilation became much more commonplace. Understanding culture as a method for facilitating coordination and preserving skills that create differential productivity, this shift can be understood as a result of either the decreasing importrance of cultural goods in which English Jews had a production advantage, or an increase in the productivity of culturally English agents in the same good. It is important to realize that treating cultural goods as items is only a useful simplification. In fact, cultural goods can be such things as network connections, as in the case of the Maghrebi traders, or the Chinese information networks which Rauch (2002) suggests increase trade in non-commodity items. Regardless of the interpretation, this understanding of the role of culture in facilitating or hindering coordination and providing for differential productivity allows for an understanding of the decision-making involved in assimilation and can therefore powerfully tackle the question of how to obtain socially optimal outcomes.

Conclusion

This is a model for understanding policy decisions and individual rational decision making about a matter which is commonly regarded as irrational. Despite this prior belief, the present model allows for rational planners and agents to push for either assimilation or multiculturalism based on the difficulty of cross-cultural communication and the gains from being different. This allows for an understanding of numerous historical and present situations, and how it may be rational for different agents to behave in seemingly contradictory fashions at different times as situations change.

FIGURE 11. Case 1

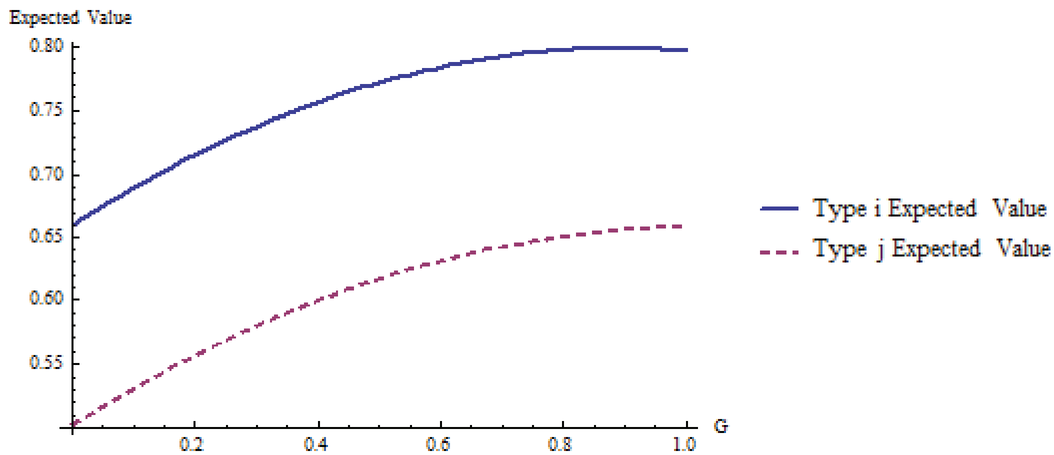


FIGURE 12. Case 2

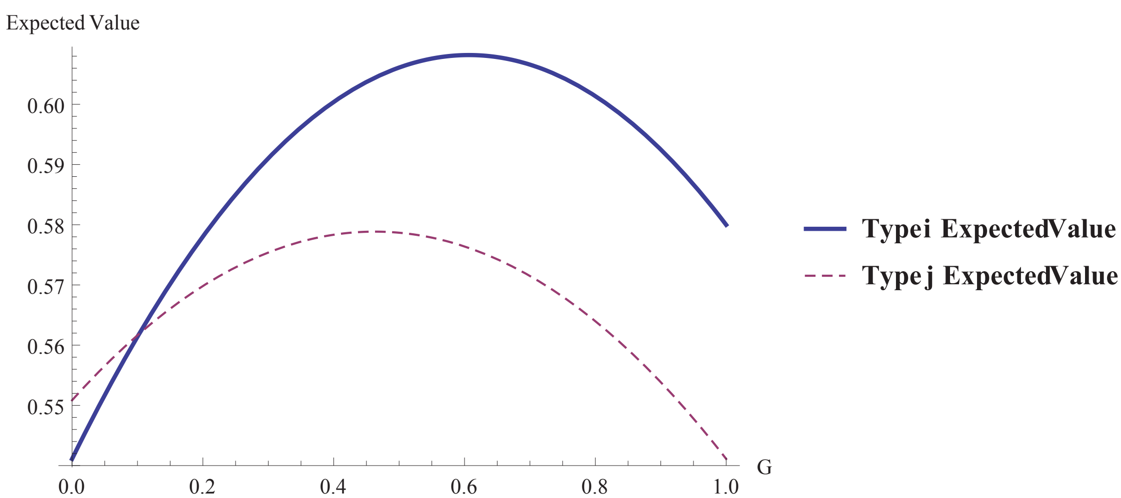


FIGURE 13. Case 3

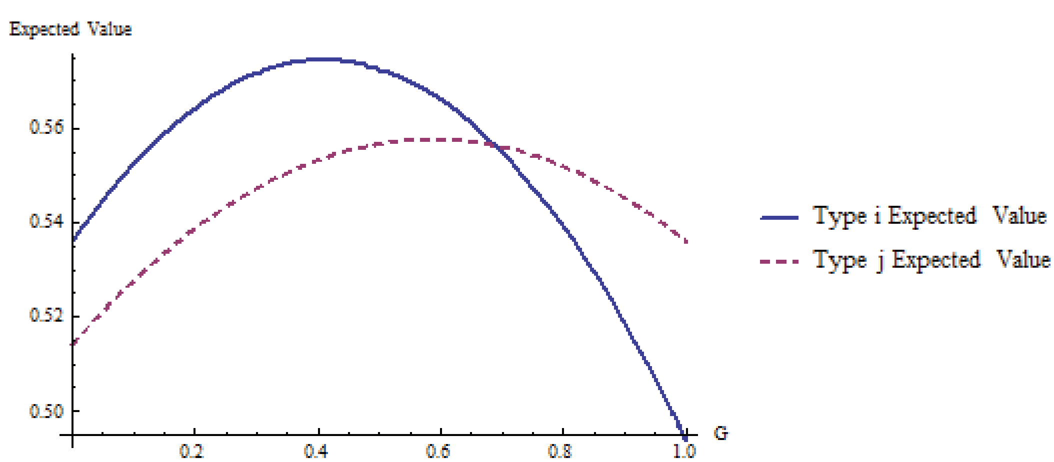


FIGURE 14. Case 4

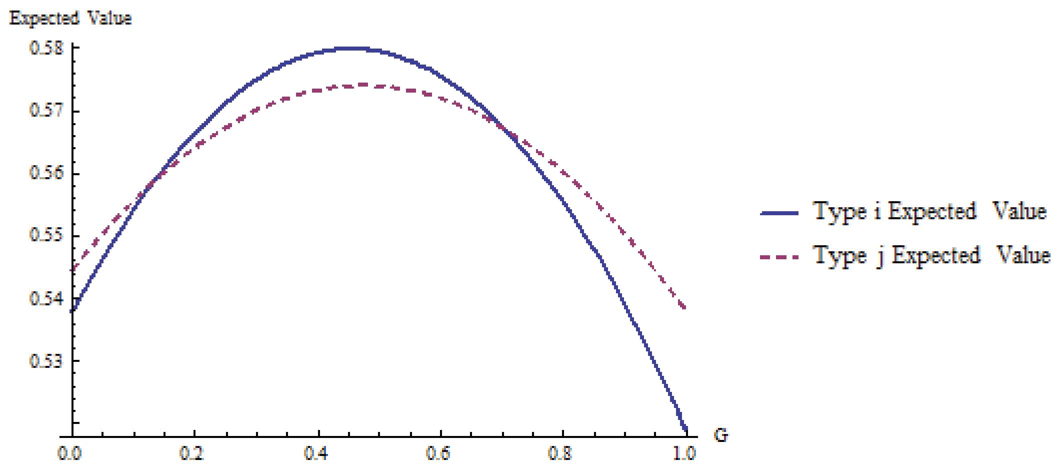


FIGURE 15. Case 5

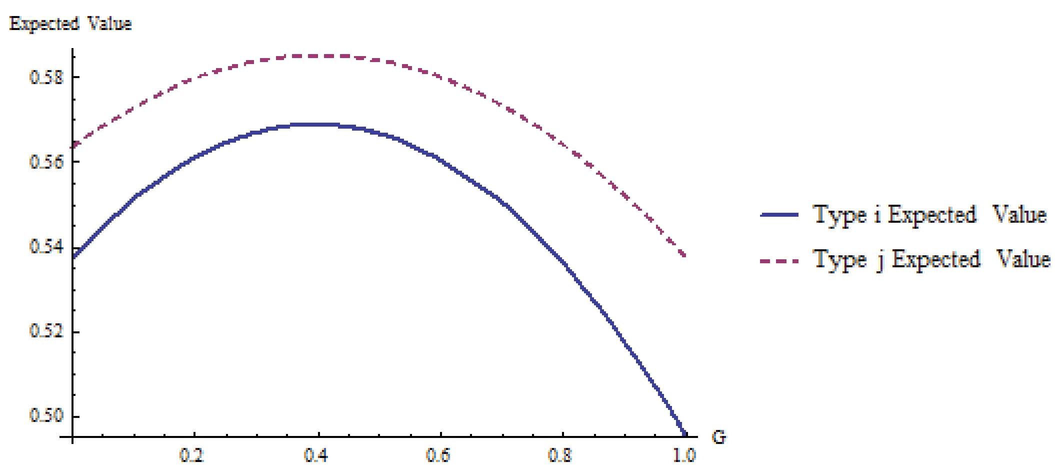


FIGURE 16. Boundary conditions in A, α space

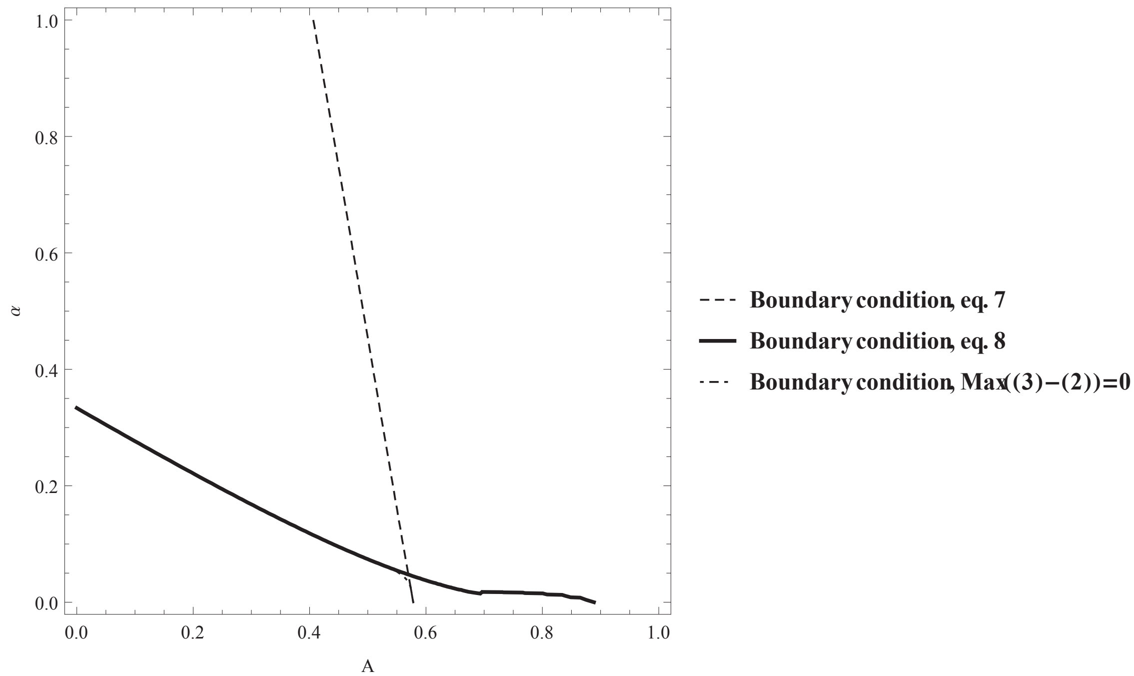
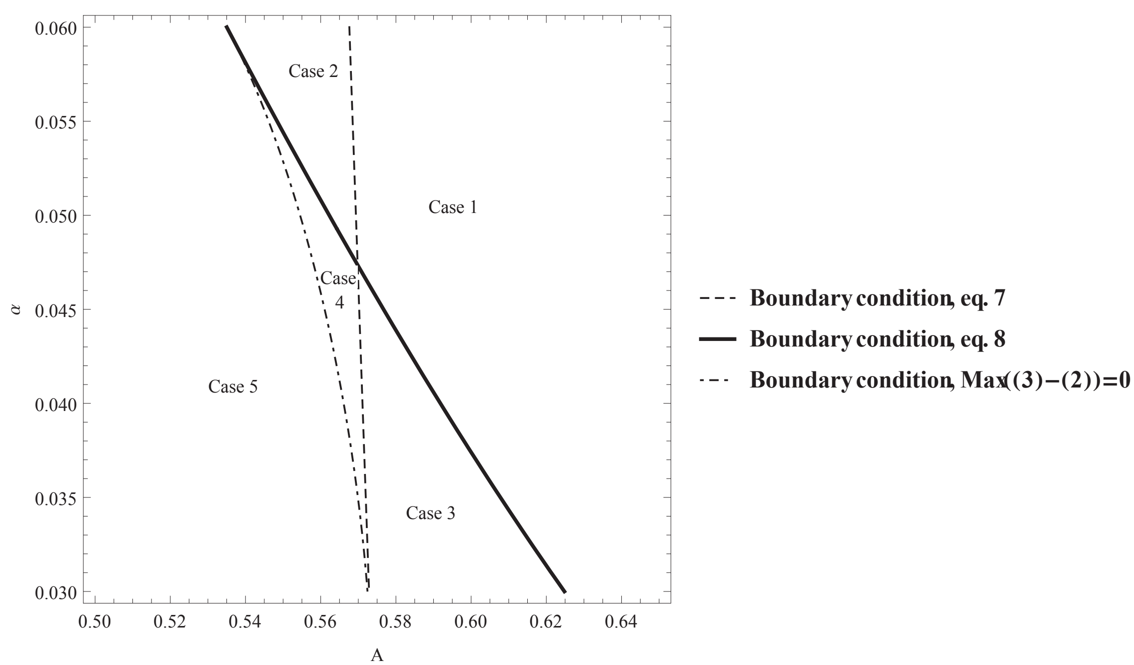


FIGURE 17. Boundary conditions in A, α space, zoomed in



CHAPTER IV

THE REPUTATIONAL EFFECTS OF CULTURE

Introduction

Which is more important to economic development, government or culture? This is an old, unresolved debate in the growth literature. Weber (1930) explained the relative economic success of some regions or countries as a result of differences in culture; different emphasis on work or entrepreneurship lead to different outcomes.[1] On the other hand, North (1990) argued that the differences in economic outcomes across countries could be explained more readily by the quality of government institutions; differences in the security of property rights or access to efficient markets explain the emergence of successful businesses and investments. I focus on the role of contracts (legal enforcement of agreements through the government) and generalized trust (a culture that puts emphasis on treating strangers as you would treat family) as a microcosm of this debate. [2]

I generate a formal theory relating the value of trading at distance to both the pressure to maintain reputation and invest in formal systems of arbitration. I use this model to formulate an instrumental variables strategy to assess the role of trust and government quality in economic development. Specifically, I instrument for government quality (trust in legal institutions) primarily using average rainfall level. I instrument for general trustworthiness with rainfall variance. These pathways are identified by the formal model elaborated below.[3] The results of the first stage of my instrumental variables regression supports most of the concrete predictions of my formal model, with the structure of the first stage being suggested by formal model. The second stage directly addresses the question of which is more important, an exogenous shift in government (trust in the legal process) or an exogenous shift in culture (trustworthiness)? The

[1]See Chakraborty et al, 2015, for a formal model of the role of culture in determining entrepreneurship.

[2]This subsection of the debate is itself contentious, with Greif (1993) arguing that the Maghribi traders used a system of reputation to maintain cooperation, while the Genoese traders used formal contracts. Others disagree with this historical interpretation; see Edwards and Ogilvie (2008). It is worth noting that this tension between social pressure and legal system informed the model by Dixit which I modify for my formal model.

[3]My formal model also suggests a relationship between average rainfall level and trustworthiness (through a similar mechanism to the one described for rainfall level and government quality) and a relationship between rainfall variance in the growing season and quality of legal processes.

results of the second stage suggest that culture, and the use of reputation to solve the problem of coordination, is far more important than government.

Contracts are viewed as facilitating development because they allow for increased safety in investment and exchange. Generalized trust (understood as the propensity to cooperate with strangers) is argued to facilitate economic development because many important exchanges happen at the level (either by scale or frequency) that makes court arbitration unattractive. As Kenneth Arrow (1972) said, "Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time." In both cases, coordinating the cooperative outcome in a prisoner's dilemma type game is the problem in search of a solution. Dixit (2007) draws distinction between reputation and a mandatory reporting system in his model (which provides the underlying framework for my formal model) as the source of cooperation in a finitely repeated prisoner's dilemma type game. I therefore focus on contracts as representative of the government (formal) solution to this problem, and a reputation-based culture of generalized trust as representative of the cultural (informal) solution to this problem. [4] If the problem of coordinating the cooperative solution in a prisoner's dilemma type game is important to development, then it follows that one or both of these solutions must be themselves important to development.

It would be attractive to directly explain economic development using generalized trust and institutional quality. However, these explanatory variables are almost certainly endogenous to economic development. Richer countries likely invest more in their legal systems, and the increased economic interaction in more developed economies might lead to stronger reputational effects on behavior, and therefore more generalized trust.[5] These variables might thus be endogenous, and the growth literature terms these potentially co-developing variables proximate causes of growth. Because of this difficulty I have focused on a formal model relating the gains from trading with partners farther away to reputation and contracts to explain how climate fundamentals might themselves create differences in the proximate outcome variables of interest (contracts and reputation). Specifically, high rainfall *variance* (increasing the likelihood of droughts or floods) increases the value of some form of insurance system, such as trading with

[4]Contracts and a perfect reporting system of player behavior are effectively interchangeable in this model.

[5]It actually seems more likely that trust tends to decrease as economic growth occurs, although the exact mechanism for this is unclear.

neighbors, which in turns fosters a culture emphasizing fair dealing with strangers to maintain this opportunity at all times and makes contracts to ensure the cooperative outcome more attractive. High rainfall *level*, on the other hand, reduces the importance of this mechanism, and increases the prevalence of self-sufficiency, both intertemporally and on average, lowering the importance of reputation and contracts. I thus use these climate fundamentals (rainfall level and rainfall variance) as instruments for the endogenous proximate variables of interest (contract quality and generalized trust) to test how exogenous variation in these two proximate variables influence economic development.

Climate fundamentals thus present me with instruments for the proximate endogenous variables of interest. I expand on Dixit (2007) to present a formal model of how these variations in fundamental variables might influence contract quality and generalized trust. This is a formal model of how a finitely repeated game with prisoner's dilemma type payoffs can obtain the joint cooperative outcome so long as either the reputational effects are strong enough or there exist sufficient formal sanctions to prevent deviation. Reputation can generate the joint cooperative outcome if the risk of subsequent private sanction (in my model, a partner in a match choosing to simply not play) creates a cost greater than the benefit of deviating. Formal sanctions operate similarly, simply by increasing the cost of deviation. I add to this by allowing for parents to indoctrinate children into one of two culture types (in a structure following Bisin and Verdier(2000, 2001)), cosmopolitans who make matches with anyone and provincials who make matches only with those close to themselves. This additional aspect of culture within the model allows me to capture the differential reputational effect of interacting broadly and narrowly.

I use rainfall level and rainfall variance during the growing season as climate fundamentals to instrument for the role of increased reputational pressure (which I argue is directly related to trust) and contract quality. Using climate data for Europe from 1900 to 1950 and European Social Survey data from all six of its rounds (2002-2012), I generally find empirical support for the key predictions of my formal model. Rainfall level is negatively related to trust in legal institutions. Rainfall variance in the growing season is positively related to generalized trust. Finally, trust appears to account for a very large fraction of variation in per capita GDP and government quality seems to have little explanatory power. I argue that this is because much of the variation we observe in government quality is the result of the endogenous relationship between government and income, and, by capturing the exogenous effects of climate, this is wiped out. This does not change the insights of papers, such as Acemoglu, Johnson and Robinson (2002), but, rather, makes the interpretation somewhat different. Rather than economies of scale leading to extractive institutions, economies of scale may lead to less generalized trust, which has the effect of reducing the quality of institutions through the endogenous relationship between government quality and income. At the same time, my results must be understood to cover only a small sub-section of the world; Europe.

Formal Model

This model follows Dixit (2003, 2004) with the addition of a new type of agent and the ability to invest in contracts to make deviation more costly. The purpose of these additions is to analyze the effects of variations in the game's parameters on trust and investment in contracting. All assumptions of the static model are identical to Dixit's except for this new type of agent and the ability to invest in contracting. I also add an intergenerational component and allow agents to invest in their child's type. Dixit's focus is on the limits of reputational systems of behavioral control; my focus is on the possibilities for cooperative outcomes based on the demographics of the population as well as the evolution of those demographics.

Agents are split into three types; a family-oriented type (which I call the provincial type) which is more insular and matches with a local bias (a direct parallel with Dixit), a socially-oriented type (which I call the cosmopolitan type) which is less insular and which I model as matching with uniform distribution across the entire population and an exploitative, Macchiavellian type whose existence drives the possibility of a finitely repeated prisoner's dilemma game with cooperative equilibrium outcomes in some rounds of the gameplay. Matching results in an opportunity to play a prisoner's dilemma type game which occurs in two sequential rounds of gameplay. The key insight is that the concern that agents have about their reputation (specifically, that their actions might label them as being Macchiavellian type) will allow the joint cooperate strategy to be a Nash equilibrium for some players in the first round, because they worry about being punished in the second round. The expected cost of punishment will be based on demographics, which will decide the probability of matching in the second round at a given distance, and the payoffs to the joint deviation outcome, which will be based on the decision to invest in contracting. I choose the parameters such that, for a sufficiently high fraction of cosmopolitan types in the population, the joint cooperative outcome can be a Nash equilibrium in the first round even at maximum distance.

Agents must then choose whether and how to invest in their children. Although this cultural transmission model broadly follows Bisin and Verdier (2000, 2001), I add the possibility that agents may invest in their children being of the opposite type if their disutility of not sharing a type with their child is less than the discounted difference in projected future incomes for their children. The model broadly finds that agents of all types can maintain the joint cooperative outcome at greater social distance as the demographics move in the direction of the cosmopolitan type, and that investment in contract protection is also increasing as the demographics move in the direction of the cosmopolitans. I use this to argue that differences in the payoff structures to the game created by climate fundamentals thus create different outcomes in trusting behavior (the joint cooperative outcome) and contract quality (contracting investment), which are my proximate variables of interest.

Static Model

Agents are arranged along a circle of circumference $2S$, so that the maximum distance between agents is S. Arc length density can be thought of as a measure of homogeneity, with a higher density implying a larger population within a given distance. Arc length density is assumed to be constant along the circle, and I normalize to one for my purposes. Agents are of one of three types; provincial provincials, cosmopolitan cosmopolitans or Macchiavellian. For now, I assume that agent types are also distributed uniformly along the circle. Each type is matched according to some kind of random matching technology with another agent along the circle in two rounds. In each match, agents are presented with a slightly modified prisoner's dilemma game. This means that the agents are guaranteed two chances to play the game as matchmakers (MM). However, for any uniform distribution of population and types, agents will also expect to be on the receiving end of two matches, as match receivers (MR). The fact that players expect to receive as well as make matches is what creates an interdependence between the scope of cooperation and the demographics; a family type will be able to sustain the joint cooperative outcome as a Nash equilibrium at greater distance as the number of cosmopolitan types increases, because of the increased potential second-round cost of deviating at distances at the margin of the original scope of cooperation. The family and cosmopolitan types are matched using different technologies, but are otherwise completely identical. The Macchiavellian type is matched and plays the game differently than the other two types; the existence of this type drives the result of possible finitely repeated prisoner's dilemma games with joint cooperative outcomes. The payoff matrix for non-Macchiavellian types with the assumption of no contract investment is displayed in table 3 for a match at generic distance x.

TABLE 3. Payoff Matrix

Trader A	Trader B Cooperate	 Cheat	 Don't Play
Cooperate	$Ce^{\theta x}$,$Ce^{\theta x}$	$Le^{\theta x}$,$We^{\theta x}$	0,0
Cheat	$We^{\theta x}$,$Le^{\theta x}$	$De^{\theta x}$,$De^{\theta x}$	0,0
Don't Play	0,0	0,0	0,0

I enforce the restrictions in (1) to generate the prisoner's dilemma.

$$W > C > D > 0 > L \tag{4.1}$$

These restrictions on the payoffs create the standard prisoner's dilemma problem. If two agents played this game once, the only Nash equilibrium is joint cheating with everyone receiving $De^{\theta x}$. Because this outcome has a higher payoff than any strategy involving Don't Play, players will always select to play regardless of the strategy they believe the other agent will use. Macchiavellian types will face a different game in the event of matching. The Macchiavellian type payoffs will be considered in table 4 (trader A is assumed to be a non-Macchiavellian type); they always deviate because of the large gains they experience, even in the case of significant reputational effects. Similarly, though the strategy for any non-Macchiavellian type is non-trivial, the payoffs are constrained to always be $Le^{\theta x}$, so the payoffs to this match will never vary in the event the non-Macchiavellian player chooses either cooperate or cheat. It is the existence of this type which subsequently drives the result of cooperative outcomes being a Nash equilibrium in some stages of a finitely repeated game, similar to the existence of such outcomes discussed by Kreps, Milgrom, Roberts and Wilson (1981); see also Benoit and Krishna (1985). The reputational effects, and specifically the concern with potentially be marked as a

Macchiavellian type in the second round, is what will drive the possibility of the joint cooperative outcome being a Nash equilibrium. In the first round, all players make and receive matches.

TABLE 4. Payoff Matrix With Macchiavellian Players

	Macchiavellian		
Trader A	Cooperate	Cheat	Don't Play
Cooperate	C$e^{\theta x}$,0	L$e^{\theta x}$,W$e^{\theta x}$	0,0
Cheat	W$e^{\theta x}$,L$e^{\theta x}$	L$e^{\theta x}$,D$e^{\theta x}$	0,0
Don't Play	0,0	0,0	0,0

With positive payoffs to any joint strategy and a sufficiently small fraction of Macchiavellian types, all first round matches result in plays. However, there is some possibility of agents receiving a signal about their counterparts in the second round based on the counterpart's play in the first round. Because playing with a Macchiavellian type always results in a payoff of $Le^{\theta x}$, this signal will potentially cause non-play in the second round only when one agent plays cooperate and the other plays cheat. If the cost of the possibility of second round non-plays (the loss of up to $2De^{\theta}S$, depending on signal strength and probability of matching) exceeds the benefit of cheating (always a value of $(W - C)e^{\theta x}$), then a Nash equilibrium of joint cooperation is possible in the first round. Thus, so long as the cost of deviating exceeds the benefits for both players in the first round, players can maintain joint cooperation as a Nash equilibrium. The second round results in joint deviation so long as neither player received a negative signal about the other player. If either player receives a negative signal about the other player, this results in one of the Don't Play outcomes. I assume that agents can discern the matching technology of their partner in any match (whether the partner is MM or MR), the demographics (γ, the fraction of cosmopolitan players) and the fraction of Macchiavellian types (ϵ), and players respond to the uncertainty about the type of their partner (whether the partner is or is not Macchiavellian) by treating them as non-Macchiavellian unless a signal is received, in which case the Bayesian inference that players make is that any payoff of $Le^{\theta x}$ to any player is indicative of their partner being Macchiavellian type. Macchiavellian types are distributed evenly along the circle, as are the other two types, and have cosmopolitan matching technology with probability γ and provincial matching technology with probability $1 - \gamma$. The proportion of the population which is of the Macchiavellian type is fixed at ϵ, drawn representatively from the socially and provincial types.

The scope of joint cooperation as a Nash equilibrium will be a function of the probability of matching and signal strength. Provincial types are assumed to have a significant local bias in the matches that they make, and act as matchmakers with agents at generic distance x according to equation **??**.

$$P_F(x) = \frac{e^{-\alpha x}}{2(1 - e^{-\alpha S})\alpha} \tag{4.2}$$

α is therefore a measure of the strength of the local bias of provincial types. The denominator in equation **??** is simply designed such that the probability of a match somewhere on the circle sums to one. Cosmopolitan types are assumed to have no local bias and match with uniform distribution along the entire circle, according to equation **??**.

$$P_S(x) = \frac{1}{2S} \tag{4.3}$$

In the event that two players, player A and player B play a game in the first round, and player A at generic position 0 plays such that player B receives $Le^{\theta x}$ (either because player A is actually a Macchiavellian type or because player A plays cheat while player B plays cooperate), a signal will emanate from player B with probability decaying with distance y according to equation **??**. This signal is what creates the possibility of a Nash equilibrium at the joint cooperate outcome, as the reputational effects of deviating when your partner doesn't can be very expensive. It is these reputational effects and not any assumption of intrinsic utility that drive my results. This signal will state that there is some chance of player A being Macchiavellian type; in equilibrium, a deviation for a non-Macchiavellian player causing a payoff of $Le^{\theta x}$ will cause other players to come to the Bayesian inference that the player is Macchiavellian. Any joint outcome will fail to send this signal; joint cooperate will not, and I assume that joint cheating will not either (as reporting your partner would also mean reporting yourself).

$$P_{Signal}(y) = e^{-\beta y} \tag{4.4}$$

β is therefore the rate of decay of the signal of perfidy. I assume for simplicity that information transmission is unidirectional and goes along the shortest arc between player B and any other agent. See Figure 18 for a graphical example of this model; note that the matching technology displayed is that of provincial types. The matching technology of cosmopolitan types can be thought of a special type with $\alpha = 0$. x is the distance between an arbitrary player ("You") and the first round match. y is the distance between the first round match and the second round match. Cosmopolitans are only different in that they make matches with equal probability independent of distance.

I define the benefit to cheating in the first round, the difference between cooperating and deviating, as k, explicitly given in equation **??**.

$$k = We^{\theta x} - Ce^{\theta x} \tag{4.5}$$

So long as k is less than two times the maximum cost of cheating (not playing in two second round matches at distance S, or $2De^{\theta S}$) for $x = 0$, there is a possibility of some range of cooperation. Within that range, first round play between non-Macchiavellian types can maintain the joint cooperative equilibrium as a Nash equilibrium and both second round play and first round play outside that range will result in the joint cheating equilibrium. The joint cooperative outcome can be a Nash equilibrium so long as the first round match is between two agents such that their partner is within their range of cooperation for either agent. Because agents act as both matchmakers and match receivers in the second round, the demographics of the population will have an effect on the matching in the second round and therefore on the cost to potentially deviating from the joint cooperative equilibrium. I define the fraction of the population which is cosmopolitan as γ. I also define the population of Macchiavellian types as ϵ and assume that that population is very small (technically, it can approach zero so long as it doesn't actually equal zero so as to avoid the collapse of the joint cooperative outcome as a Nash equilibrium in the presence of a Cho-Kreps simplification). Specifically, provincial types have a second round probability of matching at generic distance x given by equation **??**.

$$P_F(x) = \frac{(\gamma)}{2S} + \frac{2-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}) \tag{4.6}$$

The second round probability of matching at distance x for a cosmopolitan type when the population has γ fraction of the population being cosmopolitan is given in equation **??**.

$$P_S(x) = \frac{(1+\gamma)}{2S} + \frac{1-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}) \tag{4.7}$$

Agents make the decision to deviate from a potential joint cooperative strategy only when the probability of matching with someone who has heard of this deviation multiplied by the loss of this outcome exceeds the benefits of cheating, formally expressed in equations **??**, **??** and **??** (the script J is used to generically represent either family or cosmopolitan types). Equations **??** and **??** are specifically the expected cost of a second round match having heard of first round deviation from joint cooperation for a provincial and cosmopolitan type, respectively.

$$Cost_J \leq ((W - C)e^{\theta x}) \tag{4.8}$$

$$\begin{aligned} Cost_P(x) = D(&\int_0^x (\frac{(\gamma)}{2S} + \frac{2-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(x-R)})dR \\ &+ \int_x^S (\frac{(\gamma)}{2S} + \frac{2-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(R-x)})dR \\ &+ \int_0^{S-x} (\frac{(\gamma)}{2S} + \frac{2-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(x+R)})dR \\ &+ \int_{S-x}^S (\frac{(\gamma)}{2S} + \frac{2-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(2S-x-R)})dR) \end{aligned} \tag{4.9}$$

$$\begin{aligned} Cost_S(x) = D(&\int_0^x (\frac{(1+\gamma)}{2S} + \frac{1-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(x-R)})dR \\ &+ \int_x^S (\frac{(1+\gamma)}{2S} + \frac{1-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(R-x)})dR \\ &+ \int_0^{S-x} (\frac{(1+\gamma)}{2S} + \frac{1-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(x+R)})dR \\ &+ \int_{S-x}^S (\frac{(1+\gamma)}{2S} + \frac{1-\gamma}{2}\frac{\alpha}{1-e^{-\alpha S}}(e^{-\alpha x}))(e^{\theta x})(e^{-\beta(2S-x-R)})dR) \end{aligned} \tag{4.10}$$

So long as k is less than $Cost_J$ for both players, the joint cooperative strategy will be a Nash equilibrium. Figure 19 presents a graph of $Cost_J$ (on the vertical) at any distance (on the horizontal, considered at generic distance x) up to S for both provincial types (red tint) and cosmopolitan types (green tint) at various levels of γ from 0 to 1. The cost of cheating at a distance of zero is decreasing in γ, and begins at a higher cost for provincial types than for cosmopolitan types. We can therefore see that the highest value of $Cost_J$ at distance of zero is for $\gamma = 0$ and provincial types, decreasing in γ from there until we switch to cosmopolitan types.

Note that I have normalized D to one for simplicity. Note that each type is graphed for four values of γ from 0 to 1. The cost of deviation for provincial types with $\gamma = 1$ is identical to the cost of deviation for cosmopolitan types with $\gamma = 0$. Figure 19 allows us to graphically analyze some of the main questions of the model. Specifically, if k is less than the value of $Cost_S$ when $\gamma = 0$, both types cooperate at any distance in the first round. More interestingly, when we set k such that it is less than $Cost_F$ for some value of γ, we allow for cooperative outcomes between cosmopolitan types matched in the first round even at maximum distance. This suggests that as γ increases, the realm of cooperation expands for both types (provided it is not already equal to S). This is itself a powerful result; the inclusion of a second type of agent with a less localized matching process can result in an increasing range of cooperation for the original, locally biased type. Indeed, if k is chosen such that cosmopolitan types cooperate even at maximum distance match when $\gamma = 0$, then the realm of cooperation for the provincial types approaches S as γ goes to one. This interaction between the demographics and the realm of cooperation helps to drive my intergenerational results. It is worth realizing that if k is greater than $Cost_S$ when $\gamma = 1$ (the horizontal line in the graph), and still less than $Cost_F$ when $\gamma = 0$, then the reverse results will hold, as an increase in γ will actually decrease the realm of cooperation; the realm for which the joint cooperative strategy is a Nash equilibrium, and cosmopolitan types will have a smaller area of cooperation than provincial types. This is intuitive; if reputational effects are very weak, then only those who match frequently with the same people will be able and willing to trust and be trustworthy with each other. I focus on the case where k is less than $Cost_S$ when $\gamma = 1$ because it intuitively means that for a sufficiently cosmopolitan population, cooperation at all points is possible, which is impossible for higher levels of k.

To analyze the payoffs to being of either type, either individually or socially, I look at the fraction of first round matches that result in the joint cooperative outcome and the value of second round matches, which are only different between cosmopolitans and provincials because of the frequency of matching at different distances rather than the outcome of play, which, in equilibrium, will always be the joint cheat outcome. Social valuation is just the average value of each type weighted by their population. So long as k is less than $Cost_S$ when $\gamma = 1$, $\gamma = 1$ will be weakly socially superior to all other demographics. Specifically, so long as k is less than the value of $Cost_S$ for some value of γ, then for $\gamma = 1$ the first round will result in an average of 2 successful cooperative games for each player. So long as k is greater than $Cost_S$ when $\gamma = 0$ there will be a realm of non-cooperation for a sufficiently low γ. The payoff structure creates two mechanisms for increasing γ to increase social value; first, by increasing the likelihood of cooperation in the first round (as discussed above), and second, by increasing the inherent value of second round matches. The value of being either type (and therefore the number of successful cooperative games) can be found as a simple function of the realm of cooperation and the demographics along the circle. Equations **??**, **??** and **??** describe the value of being each of the two types and the total social valuation as a function of γ and the distance of maximum cooperation for cosmopolitan types (D_S) and provincial types (D_F). The maximum distance of cooperation is simply the distance at which $Cost_J = k$ for each type. [6] D_1 and D_2 are the payoffs to joint non-cooperation in the first and second rounds, respectively (differences in these payoffs are introduced in the next subsection).

$$\begin{aligned} Value_S(\gamma) = C((1-\gamma)\int_0^{D_F} \frac{\alpha e^{(\theta-\alpha)R}}{1-e^{-\alpha R}}dR + \frac{(1-\gamma)}{S}\int_0^{D_F} e^{\theta R}dR + 2\frac{\gamma}{S}\int_0^{D_S} e^{\theta R}dR) \\ +D_1((1-\gamma)\int_{D_F}^{S} \frac{\alpha e^{(\theta-\alpha)R}}{1-e^{-\alpha R}}dR + \frac{(1-\gamma)}{S}\int_{D_F}^{S} e^{\theta R}dR + 2\frac{\gamma}{S}\int_{D_S}^{S} e^{\theta R}dR) \\ +D_2((1-\gamma)\int_0^{S} \frac{\alpha e^{(\theta-\alpha)R}}{1-e^{-\alpha R}}dR + \frac{(1-\gamma)}{S}\int_0^{S} e^{\theta R}dR + 2\frac{\gamma}{S}\int_0^{S} e^{\theta R}dR) \end{aligned} \tag{4.11}$$

$$\begin{aligned} Value_F(\gamma) = C((2-\gamma)\int_0^{D_F} \frac{\alpha e^{(\theta-\alpha)R}}{1-e^{-\alpha R}}dR + \frac{\gamma}{S}\int_0^{D_F} e^{\theta R}dR) \\ +D_1((2-\gamma)\int_{D_F}^{S} \frac{\alpha e^{(\theta-\alpha)R}}{1-e^{-\alpha R}}dR + \frac{\gamma}{S}\int_{D_F}^{S} e^{\theta R}dR) \\ +D_2((2-\gamma)\int_0^{S} \frac{\alpha e^{(\theta-\alpha)R}}{1-e^{-\alpha R}}dR + \frac{\gamma}{S}\int_0^{S} e^{\theta R}dR) \end{aligned} \tag{4.12}$$

$$Valuation(\gamma) = \gamma Value_S + (1-\gamma)Value_F \tag{4.13}$$

Figures 20-22 demonstrate how these values evolve in the case where $k < Cost_S$ at $x = S$ and $\gamma = 1$. Figure 20 presents the relationship between the value of being cosmopolitan or provincial and γ. Figure 21 is simply social value against γ. Figure 22 presents the value for

[6] I assume that $D_S > D_F$, as mentioned previously.

both types against θ, which shows that, so long as $D_S \geq D_F$, $\frac{dV_S}{d\theta} \geq \frac{dV_F}{d\theta}$. This means that cosmopolitan types benefit more from an increase in the θ parameter which captures the value of trading at greater distance than do the provincial types. This is the model format of the mechanism through which the climate hypothesis that holds that an increase in rainfall variance will lead to trust.

The model so far presented suggests that parameter changes (changes to θ or k) will change the value of being either type, as well as social value. However, as of right now, agents make no decision over how second round matches work out (contracting) or the demographics of society. That is corrected in the next sections.

Contracting

Following Dixit (2007), I model contracting by assuming that a benevolent social planner makes the decision over whether to invest in mandatory formal reporting or not. [7] There is a set cost to mandatory reporting, and the social benefit is based on the change in social value from successful coordination of the cooperative outcome in the first round. For a given population, the benefit of mandatory reporting is always greater for cosmopolitan types than it is for provincials. This means that marginal increases in the proportion of cosmopolitans will increase the social value of reporting.

Dynamic Model

Following Bisin and Verdier (2000, 2001), I model intergenerational culture transmission as being the result of parental decision to invest in their children. If parents fail to indoctrinate children in their own type (vertical transmission) the result is oblique transmission in which children are randomly matched from within the existing population with probability of a match with each type based on the fraction of the population being of that type. It should be apparent that there will be an intergenerational equilibrium any time the investment of each type is exactly equal and opposite, given the same cost of intergenerational transmission. If the cost of intergenerational transmission is not equal across types, the result will be the same so long as

[7] Assuming that any threat of second-round non-play is costly enough to potentially induce the first-round cooperative strategy to be a Nash equilibrium, mandatory reporting is identical in this model to perfect contracting.

the investments are opposing but of the correct size to result in equal probabilities of vertical transmission. I have added an extension to Bisin and Verdier in two ways; the first is that this is a model of intergenerational culture transmission with economic consequences, and the second (related) extension is that parents may now invest in their children being of a different type than themselves. The result is a stable intergenerational equilibrium which is decreasing in the cost of indoctrinating children with social-orientation type.

Parents of type J receive utility given by equation **??**, where Y_J is the income based on the plays of the game that the parent experiences, P_{JJ} is the probability of a type J parent having a type J child (partially based on indoctrination effort), P_{JK} is the probability of having a type K child as a type J parent given indoctrination effort, V_L is the discounted future expected income of being type L, and d is just a paternalistic preference for having children of the same type as the parent. The effort level of the parent, τ_J, causes disutility linearly and non-linearly increases probability of a child being of the preferred type.

$$U_J = Y_J + P_{JJ}(V_J + d) + P_{JK}V_K - \tau_J \tag{4.14}$$

Parents of type J will always choose to invest in their children being of their type so long as $V_J + d \geq V_K$. If this is not true, parents will invest in their children being of the opposite type to themselves (specifically, family oriented types will invest to make their children socially oriented, and socially oriented types will invest to make their children family oriented). The investment in indoctrination has an effect on vertical transmission as described in equation **??**, with T_J being the probability of vertical transmission given parental effort τ_J. C_L is the technology associated with vertical transmission to culture type L; as C_L increases, the cost of investment to achieve a given level of τ_J decreases.

$$T_J = \sqrt{C_L \tau_J} \tag{4.15}$$

From this, equation **??** can be used to find the probability of a child being of the parent's chosen type. Understand γ_J to be the fraction of the existing population of the parent's chosen type.

Equation 18 describes the probability of a child not having the parent's chosen type.

$$P_J = \tau_J + \gamma_J(1 - \tau_J) \tag{4.16}$$

$$P_K = 1 - P_J \tag{4.17}$$

A stable equilibrium will require parents of both types to favor children of their own type, and for the difference to be converging with $V_S \geq V_F$ as γ increases. Looking back to figures 20-22, for a given set of parameter values it is the case that V_S is both greater than V_F and converging with it as γ increases. For sufficiently high values of d, this results in a stable equilibrium which is increasing in the technology of vertical culture transmission. If there is a population shock, the converging value of being each type results in sufficient opposing investment in subsequent generations to return to an equilibrium which is described by equation **??** as the point where investment in each type effectively cancels each other out.

$$\gamma = \frac{C_S(V_S - V_F + d)}{C_S(V_S - V_F + d) + C_F(V_S - V_F - d)} \tag{4.18}$$

Because V_S and V_F are both based on γ, this result will hold so long as $|V_S - V_F| < d$. In the absence of these conditions, internal equilibria are all unstable, and move toward either all family-orientation or all society-orientation over time. Because these conditions, though laborious, create an internal stable equilibrium which can respond to exogenous shocks by altering the position of the equilibrium, I focus on this case. With the caveat that other internal equilibria are unstable, however, there are always internal equilibria which may be of some interest in cases when the exact set of assumptions necessary to drive the internal stable equilibrium are deemed unacceptable.

Overview

The above model suggests that the effect of reputation is enough to obtain the joint cooperative outcome in cases where the fraction of cosmopolitans is sufficiently high, regardless of whether the types in the match are provincial or cosmopolitan (for the case in which $Cost_S > k$ at $\gamma = 1$). Specifically, I interpret these model results to suggest that as the benefit of being cosmopolitan grows (because of an increase in θ), the number of cosmopolitans grow, and the trusting outcome is obtained with greater frequency. At the same time, with more cosmopolitans, contracting is generally more attractive for a benevolent social planner. I believe the results of this model can be interpreted in one of two ways. In the first case, rainfall variation might cause an increase in the value of trading at distance, because these trades represent contingent claims against the possibility of future droughts or floods. This has the effect of increasing θ and therefore increasing the power of reputation and the investment in contract quality. At the same time, in the second case, rainfall level might be associated with less of a need to interact at distance; a higher mean level of rainfall might suggest either greater self-sufficiency or a lower likelihood of a failed crop. This would suggest that higher rainfall would lower θ, implying that trade at distance is less attractive. In either case, rainfall, either through its variance or its level, is interpreted as determining the fundamental nature of agricultural production, which then informs social outcomes in terms of trust or investment in contracting in the pre-modern era. Higher rainfall variance implies a greater need to maintain a good reputation to hold onto trade as a possibility in case of drought or flood. Higher average rainfall level implies a lesser need to trade at great distance and a lesser concern for reputation. These effects then change the prevalence of provincial and cosmopolitan types in the economy. The greater is the fraction of cosmopolitan types, the greater the importance of reputational effects and the greater the willingness to invest in any form of mandatory reporting. Thus, the informal system (reputation) and the formal system (such as a mandatory reporting system, as seen in Dixit (2004)) will both be increased by agricultural phenomena which increase θ.

Data

My data comes from three main sources. The European Social Survey, which is conducted every two years, beginning in 2002 and with the last available data from 2012, gives regional level responses to social survey questions; those of greatest interest for my purposes pertain to trust ("[W]ould you say that most people can be trusted, or that you can't be too careful in dealing with people? ") and faith in legal processes ("[H]ow much [do] you personally trust...the legal system?"). Both of these are presented allowing respondents to score them from 0, the lowest, to 10, the highest. These surveys are not balanced, but the sub-national level of data allows me to use country-level fixed effects. The ESS uses the NUTS system, with occasional differences in the level of aggregation; level 0 is the least aggregated and represents the country as a whole, while level 3 represents a very small area and generally a small population. [8] [9] This is a well respected social survey in Europe, similar to the GSS in the United States of America, and the EU has used ESS data for analysis of, most importantly, local opinions of government quality, mirroring part of what I use it for.

From the University of East Anglia I have obtained weather and elevation data for most of Europe at the 10 arc-minute level, which I have further interpolated to the 1 arc-minute level (this interpolation is done using the nearest four points for inverse distance weighting). This data represents interpolation of the largest and densest historical network of weather stations in the world. The data I use in particular covers the period from 1900 to 1950, though, mirroring the results of Durante (2010), I find no obvious differences in mean or variance using earlier data. [10] I use this data to generate rainfall variance, average rainfall level, temperature, temperature variance, elevation, slope (using inverse distance weighting from the nearest eight points) and the correlation of rainfall and temperature with neighboring regions at the 1 arc-minute level, assigning these values to the centroid of each 1 arc-minute grid coordinate and assigning the average of the values from each centroid to every NUTS region that shows up in my ESS data. Variance figures are calculated from detrended rainfall or temperature levels, as are correlation observations.

Finally, minor data comes from a variety of sources. I use, in some regressions, rain-fed wheat soil suitability index (SSI-A slight misnomer given that the index takes into account more than soil quality, it is really regional suitability) from the FAO-GAEZ. This measure is a scientific attempt to capture every potential source of productivity for a region for rain-fed wheat, and includes climate, soil, slope, elevation, etc. I include this in some regressions as a control variable to deal with exclusion restriction concerns, discussed below. I also use Roman road data from

[8] The ESS usually reports regional data using current NUTS classification; see the appendix for additional details on transforming different regional codes into current standard NUTS codes

[9] The third level of NUTS generally covers small populations, except when it covers a single urban center, which the NUTS system does not divide; thus, Paris is covered by a single NUTS1 code, a single NUTS2 code and a single NUTS3 code. See Figure 23 for the NUTS regions used by the ESS.

[10] I chose this time frame for two reasons. The first decision was to eschew the period after 1950 to avoid fears of global warming altering results. The second is that data from before 1900, though likely accurate, is not nearly as fine-grained as the more modern data. This data choice thus represents a compromise that I intend to capture historical values without losing contemporary precision.

Harvard's Roman History department and major river and tributary data from Europe's WISE network. Just as with climate variables, SSI or being within 10 arc-minutes of a road, a river or the ocean is calculated first for each 1 arc-minute grid, assigned to a centroid and the average of this is then assigned to each NUTS region. From Eurostat, I have also obtained regional level GDP per capita, with price adjustment for 2011 for every NUTS region on which I have ESS data.

Empirics

To test the model the first stage is to look at the relationship between rainfall variance and trust on the one hand and the relationship between average rainfall level and government quality on the other. I will note that, as I use linear fixed effects models (fixed at the country-round level), the source of variation is that there are multiple regions within each country. The model predicts that both rainfall level and rainfall variance in the growing season will increase both trust and government quality. I have allowed the model to inform the structure of the first stage, but I will let results determine the validity of the model.

The first stage for trust is thus

$$Trust_{ijt} = \alpha + \beta_{jt} + \beta_1 RV_i + \beta_2 RA_i + \beta_3 X_i + \epsilon_{it} \tag{4.19}$$

Where here Trust is the trust score that people report, on average, in region i during round t of the ESS. β_{jt} is simply the fixed effect, at the country-round level. Each region, i, is in a country, j. RV is the rainfall variance. RA is the average rainfall level. X_i is a set of region level geographic controls (discussed in part above). I expect β_1 to be greater than zero and β_2 to be less than or equal to zero, as discussed previously.

The first stage for government quality is thus

$$Legal_{ijt} = \delta + \zeta_{jt} + \zeta_1 RV_i + \zeta_2 RA_i + \delta_3 X_i + \epsilon_{it} \tag{4.20}$$

Where here Legal is the quality of legal institutions score that people report, on average, in region i during round t of the ESS. β_{jt} is simply the fixed effect, at the country-round level. Each region, i, is in a country, j. RVGS is the rainfall variance. RA is the average rainfall level. X_i is a set of region level geographic controls. I expect β_1 to be greater than or equal to zero and β_2 to be less than zero, as discussed previously.

The second stage is thus

$$GDP_i = \eta + \iota_{jt} + \iota_1 \hat{Trust}_{it} + \iota_2 \hat{Legal}_{it} + \iota_3 X_i + \epsilon_{it} \tag{4.21}$$

Where here GDP is the per capita GDP in PPP terms reported in 2011, in region i. β_{jt} is simply the fixed effect, at the country-round level. Each region, i, is in a country, j. $\hat{Trust}$ is the prediction for trust based on the first round above. $\hat{Legal}$ is the prediction for quality of legal instrument based on the first stage above. I don't have any predictions about β_1 or β_2, except that one of them should be positive or else I have effectively disproven both major growth theories which predict that either trust should be related to rainfall variance (Durante, 2011) or legal quality should be related to rainfall level (Acemoglue, Johnson and Robinson, 2005).

Results

My formal model broadly suggested that an increase in θ should increase the power of reputation and the value of investing in contract quality. I interpret these results to mean that an increase in rainfall variance or a decrease in average rainfall make trading at distance more valuable, and will generally raise both trust and the quality of legal institutions. My identification of the differential exogenous effects of these two variables is ultimately based on the fact that, for reasons that go beyond my model, they are influenced in different ways by climate fundamentals.

Because my second stage includes two instrumented variables, I follow Stock and Yogo (2005); in the first stage, F stats reported are the Angrist-Pischke (AP) F statistics (where 8.96 is considered a normal critical value to reject). In the second stage, F stats reported are the Cragg-Donald Walf F statistics (where 4.58 is the critical value for two instruments, from Stock and Yogo). Table 5 reports the results for the first stage of the regression for trust. My preferred specification for this regression is for countries that are not ex-Communist (see Figure 23) for reasons discussed below; the point estimates are similar though the AP F statistic for excluded instruments is slightly lower using the whole sample. I find that rainfall variance is a relevant instrument for self-reported trust.

Table 6 reports the results for the first stage of the regression for government quality. Again, my preferred specification for this regression does not include those countries that have been Communist in the last fifty years. [11] Including those countries does not significantly alter the point estimates of the regression, though it does lower the AP F statistic significantly. I take this to mean that this governmental history is really overriding longer-term, subtle effects. Therefore, concentrating on non-ex-Communist countries is my preferred specification. Rainfall variance and rainfall average level appear to be relevant instruments. The point estimates suggest that both rainfall level and rainfall variance influence government quality.

Table 7 reports the results of the second stage using both instruments, for the whole sample and only the preferred specification of the non-ex-Communist countries, only one instrument at a time and the use of a high rainfall dummy instead of average rainfall level as well as OLS results. The second result is for my preferred specification, with rainfall variance and average rainfall instrumenting for personal trust and trust in legal systems (trust in contracts, or contract quality) for non-ex-Communist countries. In the third column, the second stage including all ex-Communist countries reports a fairly small change in point estimates, despite the loss of power (based on the Cragg-Donald Wald F statistic) this specification creates. Because these two measures, personal trust and trust in legal institutions, are correlated, I have also run them both separately to look for the effects of multicollinearity. Point estimates seem mostly unchanged. The high rainfall dummy column replaces rainfall level with a dummy which is one for regions with rainfall above 1000MM per month (following Haber, 2009). This result, though weaker in the sense that the Cragg-Donald Wald F statistic is much lower, suggests that given the small number of areas with very low rainfall in my data, the effect I observe from rainfall in the first stage (negative for legal quality) is being driven, as Haber suggests, by the extreme outliers. In the first column is the simple OLS regression. Based on my results, it seems that the coefficient on trust is significantly biased downwards by the endogeneity in the system.

My results suggest that both pathways predicted by my formal model are correct as to the effect of climate on proximate variables. However, my research suggests a small role for

[11] The effect of a recent Communist government could operate by two main channels; in the first channel, Communist governments de facto often represented control of government external to the people living in that region. The second channel is that those countries often saw very large involuntary movements of people, which would weaken my results because of the nature of the link I posit between geography and people.

TABLE 5. First Stage, Trust

	(1) Non-Communist	(2) Non-Communist	(3) Communist	(4) Full Sample	(5) Non-Communist
Rainfall Variance	1.2***	1.1***	-0.089	0.38	1.2***
	(0.42)	(0.22)	(0.38)	(0.38)	(0.27)
Rainfall Average	-0.04		0.72	0.22	
	(0.21)		(0.44)	(0.20)	
High Rainfall Dummy					-0.16*
					(0.092)
Observations	904	904	615	1519	904
Controls	Yes	No	Yes	Yes	Yes
AP F	22.39	26.93	2.05	6.89	21.74

* $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$. Standard errors in parentheses.

TABLE 6. First Stage, Legal

	(1) Non-Communist	(2) Non-Communist	(3) Communist	(4) Full Sample	(5) Non-Communist
Rainfall Variance	1.4***		-1.1	0.49	0.11
	(0.00043)		(0.00086)	(0.41)	(2.4)
Rainfall Average	-0.68***	-0.23***	0.42	-0.45**	
	(0.21)	(0.10)	(0.049)	(0.21)	
High Rainfall Dummy					-0.15***
					(0.053)
Observations	904	904	615	1519	904
Controls	Yes	No	Yes	Yes	Yes
AP F	16.63	5.16	1.63	3.00	8.02

* $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$. Standard errors in parentheses.

government quality, operating through the legal system, to explain variation in income between regions. Specifically, a one standard deviation increase in trust between people accounts for around a 0.8 standard deviation increase in income per capita, based on my preferred specification in the second stage (Table 5), a figure roughly commensurate with that found by Algan and Cahuc (2010) using an epidemiological approach to determining the inherent (exogenous) trust level of a country. This is not to suggest that government doesn't matter nor does this result override the clear correlation between government quality and per capita GDP, only that a truly exogenous shift that increased only government might not matter. Because shifts in climate fundamentals seem to shift trust and government quality at different rates, it seems likely that previous results focusing on government may have simply been falling prey to the high cross-sectional correlation between trust and government quality.

TABLE 7. Second Stage

	(1) OLS	(2) Non-Communist	(3) Communist	(4) Full Sample	(5) Non-Communist	(6) Legal Only	(7) Trust Only	(8) High Rainfall Dummy
Personal Trust	1841***	13915***	-14550	15753*	11108***		13746***	14203***
	(620)	(4311)	(11709)	(9560)	(4163)		(4283)	(4957)
Legal Quality	2376***	-2652	-3021	12314	-1812	-1288		-11818
	(601)	(5353)	(12386)	(13458)	(5433)	(4633)		(8205)
Observations	906	904	615	1519	904	904	904	904
Controls	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Fixed Effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CDW F	9.419	7.83	0.861	0.91	4.882	8.855	10.266	4.054

* $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$. Standard errors in parentheses.

Conclusion

Because of the endogeneity inherent in directly testing the effect of government quality and/or trust on economic development, I have used a formal model linking exogenous climate fundamentals to the endogenous proximate variables of interest so that I can use an instrumental variables strategy to assess the role of the proximate variables in causing economic development. Specifically, I instrument for government quality (trust in legal institutions) primarily using average rainfall level. I instrument for general trustworthiness with rainfall variance during the growing season. These pathways are identified by the formal model discussed above. My formal model also suggests a relationship between average rainfall level and trustworthiness (through a similar mechanism to the one described for rainfall level and government quality) and a relationship between rainfall variance in the growing season and quality of legal processes. The results of the first stage of my instrumental variables regression supports most of the concrete predictions of my formal model, with the structure of the first stage being suggested by the predictions of the formal model. The second stage directly addresses the question of which is more important, an exogenous shift in government (trust in the legal process) or an exogenous shift in culture (trustworthiness)? The results of the second stage suggest that culture, and the use of reputation to solve the problem of coordination, is far more important than government.

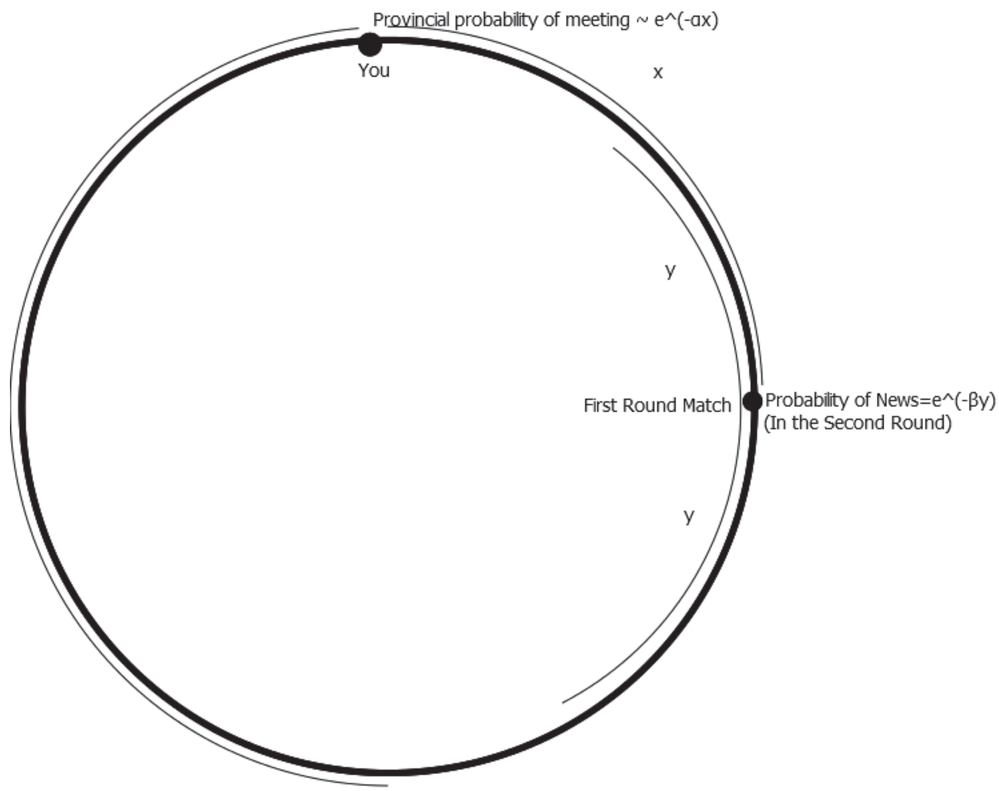


FIGURE 18. Match making along the circle for Provincial types

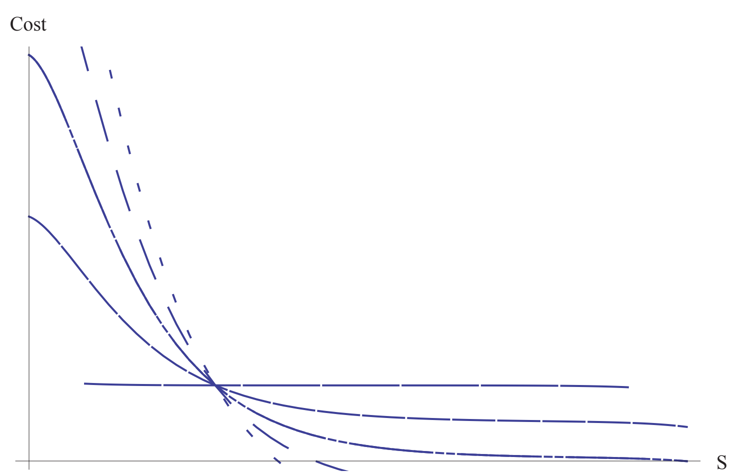


FIGURE 19. The expected cost of deviating at any distance in a first round match

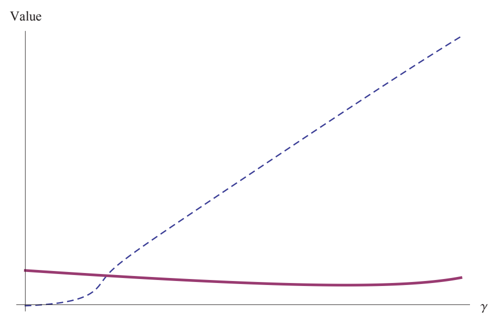


FIGURE 20. The expected value of being of each of the two types

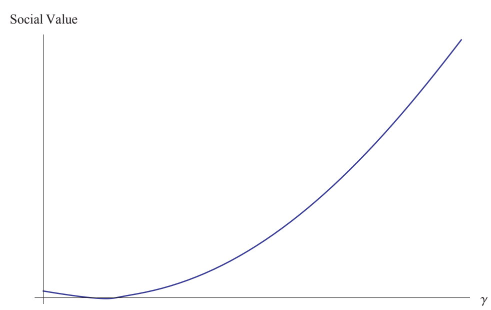


FIGURE 21. The expected social value for the population

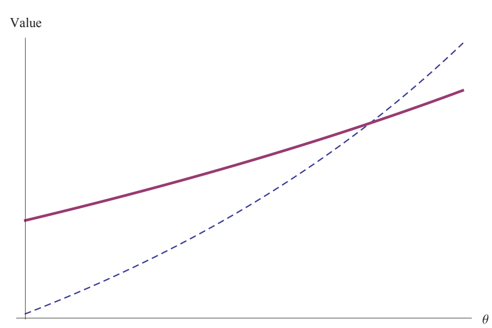
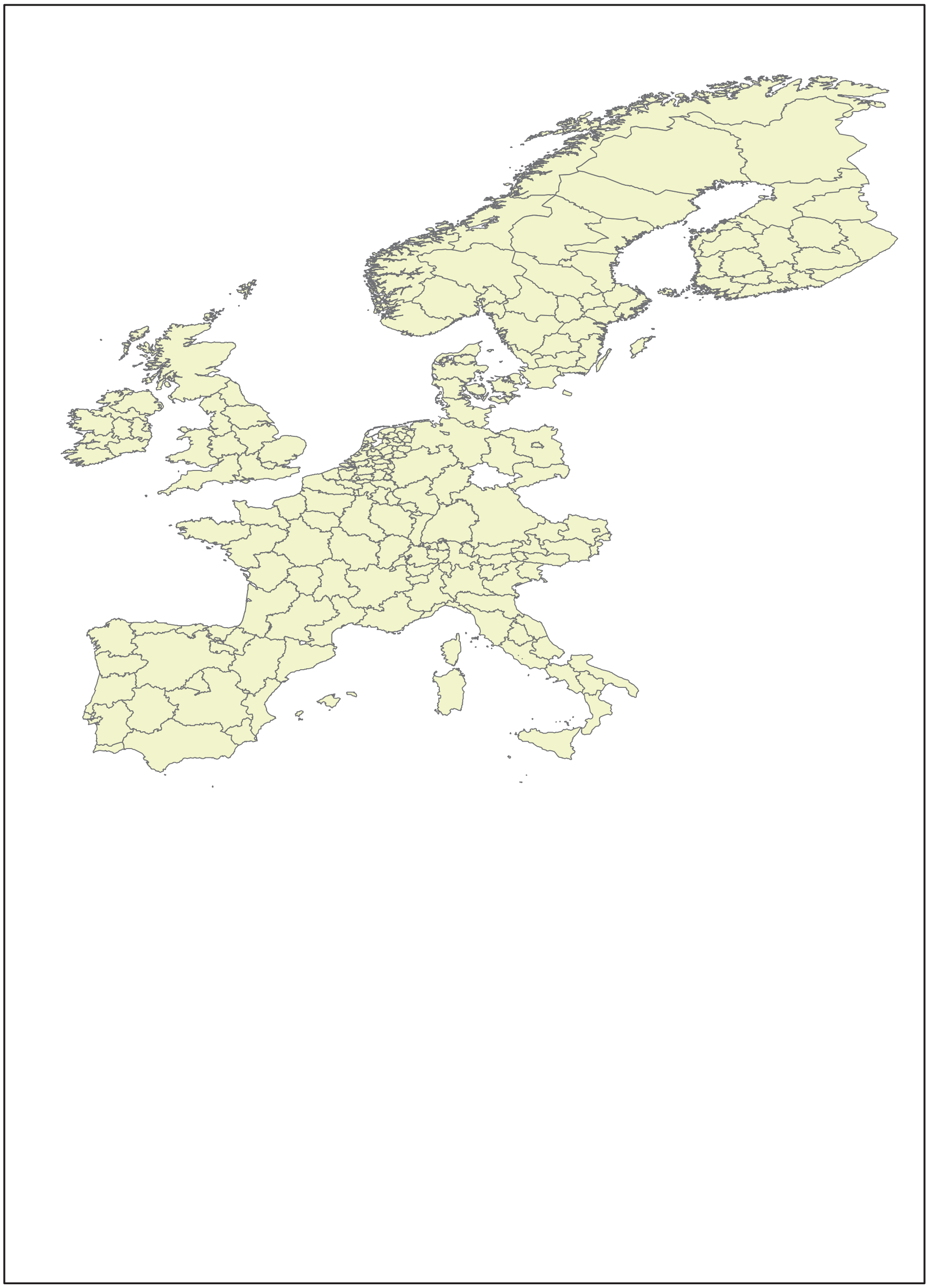


FIGURE 22. The expected value of being of each of the two types as a function of θ

FIGURE 23. NUTS Regions Included in Preferred Specification



CHAPTER V

CONCLUSION

Explaining the difference in incomes across country has been a central focus of growth economics. Understanding how culture influences growth requires a formal understanding of how culture can influence economic decision making. This dissertation has focused on how decision making responds to the expected returns of various activities, and how these expectations can be disseminated within a family. Additionally, this dissertation has outlined both a theory and empirical support for the idea that cultural bias towards or away from interaction with others can influence the ability or willingness of agents to cooperate. Within this dissertation, I have outlined three main contributions to understanding the effects of culture on economic decision making.

The first contribution of this dissertation is to provide an understanding of the cultural process through which a society inculcates an entrepreneurial spirit. People either work for a guaranteed wage or operate riskier businesses. Paternalistic parents prefer their offspring to choose occupations like theirs and accordingly indoctrinate them into their types. Specifically, having themselves developed business acumen, entrepreneurial parents try to endow their children with that human capital. Biological indoctrination may not be successful, in which case children take cultural cues from society at large. Cultural offspring may also choose an occupation different from the one they have been indoctrinated in. I examine the effect of family background on occupational choice and how society's appetite for risk-taking is shaped by culture and institution. A focus on safe occupations, possibly due to colonial and post-colonial policies, results in stagnation with entrepreneurs not upgrading technology because of their proficiency with existing methods. Sudden access to disruptive technologies, due to liberalization for instance, sees the emergence of new entrepreneurial lines who overtake established ones, spurring growth.

The second contribution looks at the relationship between cultural minorities and economic interaction. The economic effects of minority culture are examined using a coordination game to capture the simultaneous negative effect of culture on communication and the gains from trading with dissimilar agents. The model presumes there is some difference in production across cultures and difficulty communicating across cultures. From these basic assumptions, a stable, non-homogenous population distribution (one with some persistent minority culture) can be obtained even in the case of costless cultural choice by rational agents. The model can generate stable minority populations becoming unstable or disappearing as well as the result of minority populations being socially optimal and socially suboptimal depending on the gains from trade and the difficulty inherent in cross-cultural communication.

The third contribution provides an understanding of the economic effects of culture, through trust. Specifically I examine the relationship between climate and two possible causes of growth: trust and institutions. Rainfall variation might explain trust because it increases the value of local insurance;as I show using a micro-founded model. Intermediate rainfall is associated with family farms and dispersed political power. I use climate data and survey measures of trust to ask whether climate can explain both trust and institutions. I use climate as an instrument for trust and institutions to test the role of these factors in growth. My results suggest that climatic variation, acting through the medium of social trust, plays the greater role.

These contributions suggest several avenues for future research. An empirical investigation of the implications of the first two papers is the first logical extension of this research. The evolution of risk-taking or entrepreneurial spirit, based on survey responses or a similar proxy measure, in nations which have been seen to undergo the sort of cultural shift described in the second chapter is the first obvious pathway for future research. Measuring the assimilation of minority cultures might be accomplished using naming conventions to test the implications of chapter III. Finally, extending the empirical exploration in chapter IV to a larger sample of nations would help allay concerns over external validity. By continuing to investigate these issues, this research can be used to gain a better understanding of the role of culture in economic development, and this may be used to answer the most important question in economics; what causes the wealth of nations?

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