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Cultural Constraints on Innovation-Based Growth

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Abstract

To what extent does the cultural composition of a society impose a constraint on its long-run growth potential? We study this question in the context of an innovation-based model of growth where cultural attitudes are endogenously transmitted from one generation to the next. Focusing on attitudes regarding patience, we analyze the two-way interaction between economic growth and the intergenerational transmission of patience. Exploiting this interaction, we compare the long-run growth performance of a culturally heterogeneous society where patience is initially underrepresented in the population with a culturally homogeneous society where all agents are perfectly patient. Our main result is that in the absence of any intrinsic preferences of patient parents to transmit their attitudes to their children, the development paths of the two societies are bound to diverge, with the culturally heterogeneous society experiencing lower growth rates. Yet, if patient parents ceteris paribus prefer their children to be patient like them, we show that the two societies can in the long run grow at the same rate.

Keywords: Innovation-Based Growth, Cultural Transmission, Patience, Comparative Development.

JEL Classification: D91, E24, O30, O40, Z10.

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1 Introduction and Overview

The potential role of culture in influencing the process of economic development across societies and time has always been a subject of great debate among economists and other social scientists. Commonly held views range from those of Marx (1859), who viewed a society's culture as simply a superstructure reflecting but not affecting the material conditions under which a society is operating, to those of Weber (1905), who considered the Protestant Reformation and the sweeping cultural changes that followed it across Europe as planting the seeds for the continent's subsequent Industrial Revolution. Traditionally, the majority of economists tended to abstract from cultural elements in their analyses, considering values and attitudes to be adjusting quickly to changes in the underlying economic structure. In recent years, though, a growing literature within economics has documented strong and persistent influences of various cultural attributes on economic development, thus indicating that such attributes may display substantial inertia.[1]

In this paper we seek to reconcile these different views on the role of culture by proposing a simple model of endogenous growth and cultural change that allows us to investigate the extent to which the cultural composition of a society will impose a constraint on its long-run course of economic development. Out of possibly many cultural attributes that are deemed important for economic development, we focus our analysis on time preference (patience).[2] We do so given the central role of patience in intertemporal decision making and the attention that it has already received in the literature.[3]

Our model economy is a closed economy populated by overlapping generations of agents who over the course of their lifetime need to make choices regarding human capital accumulation and occupation. The engine of growth in the economy lies in a competitive research and development (R&D) sector that employs skilled labor and produces quality-improving intermediate inputs that are employed in the production of a unique final good as in Aghion and Howitt (1992). Because of its skill-intensity, employment in the R&D sector requires a minimum skill level. Hence, in order to be employed as researchers, agents need to make investments in human capital early in life. The extent to which agents will do so depends on how patient they are and this creates a link from the distribution of patience in the society to its rate of economic growth.

At the same time, the distribution of patience across generations is not fixed, but evolves endogenously as parents take deliberate actions to socialize their children. Specifically, we assume

[1] See Guiso, Sapienza, and Zingales (2006) or Fernández (2010) for a comprehensive survey of the literature on culture and economic behavior as well as Beugelsdijk and Maseland (2011) for a less technical overview.

[2] In the present paper we use the term patience to refer to the rate at which individuals discount future costs and benefits. This is occasionally interchanged with the terms time preference and time discounting, although, we acknowledge that these concepts are not necessarily equivalent. For more on this point, see Frederick, Loewenstein, and O'Donoghue (2002)

[3] The link between patience and economic growth has a long history in economics, going back at least to classical economists such as Adam Smith and John Rae. Recent summaries of the literature on this topic can be found in Frederick, Loewenstein, and O'Donoghue (2002) and Doepke and Zilibotti (2013).

that the transmission of patience across generations is governed by the cultural transmission mechanism of Bisin and Verdier (2001). Parents are imperfectly altruistic toward their children. They care about their children's future well-being resulting from their occupational choices, but they ceteris paribus prefer their children to share their own attitudes regarding patience. Moreover, parental socialization requires effort, which comes at a cost. Thus, parents make their socialization decisions optimally by balancing out the costs and benefits of transmitting their attitudes to their children. In particular, given the presence of different employment opportunities available, parental socialization efforts will depend on the relative returns to skilled and unskilled labor in the economy. Hence, the current economic environment will influence the future distribution of patience in the society.

This two-way interaction between the mechanics of cultural transmission and economic growth in the model allows for the joint determination of the distribution of patience in the economy and the rate of growth. Exploiting this interaction, we compare the long-run growth performance of a culturally heterogeneous society where patience is initially underrepresented in the population with a culturally homogeneous society where all agents are perfectly patient. This comparison, although extreme, is instructive as it allows us to assess the importance of the constraints on economic development imposed by differences in the degrees of patience.

Our main result is that the relative economic performance of the two societies will depend in a surprising way on the strength of the intrinsic preferences of parents for children sharing their cultural attributes. Specifically, if socialization decisions are solely based on parental perception of future expected returns to skilled and unskilled labor and parents do not care whether their children share their cultural attributes, the development paths of the two societies will diverge. In the culturally heterogeneous society patience will remain underrepresented and skilled labor will be scarce relative to the cultural homogeneous one, limiting R&D employment and economic growth. However, if patient parents carry an intrinsic preference to instill patience in their children beyond the perceived economic benefits of doing so, divergence between the two societies is not bound to happen. Instead, it is possible for the culturally heterogeneous society in the long run to grow at the same rate as the homogeneous one.

An important implication of our analysis is that it offers a reconciliation between the findings of authors such as Algan and Cahuc (2010), Tabellini (2010), Nunn and Wantchekon (2011), and Gorodnichenko and Roland (2010), whose work indicates that differences in cultural values and attitudes have persistent effects on economic outcomes, with those of Fernández, Fogli, and Olivetti (2004), Alesina and Fuchs-Schündeln (2007), Di Tella, Galiani, and Schargrodsky (2007) and Giuliano and Spilimbergo (2009), who show culture to be malleable and adapting to changes in economic conditions. In the context of our model economy, we show that differences in the prevalence of patience across societies can have long-lasting effects on comparative economic development, notwithstanding that these attributes are not fixed but subject to change from generation to generation. Thus, culture can shape the process of economic development, despite its ever-evolving nature. This is because the process of cultural change hinges crucially on intergenerational linkages and the degree of attachment that parents have to their culture.

In addition to its implications for the role of culture in the process of economic development, our analysis also contributes to the literature on the cultural transmission of values and attitudes. Following the seminal of work of Bisin and Verdier (2001), several authors have studied the intergenerational transmission of cultural attributes related to altruism (Jellal and Wolff, 2002), corruption (Hauk and Saez-Marti, 2002), trustworthiness (Francois and Zabojnik, 2005), or civicness (Michau, 2013).[4] Our work differs from the aforementioned contributions as it studies the implications of cultural transmission in the context of a fully specified macroeconomic model, which enables the analysis of the general-equilibrium effects of cultural change on economic growth.[5]

Furthermore, our analysis of how patience evolves over the course of economic development is related to earlier contributions by Hansson and Stuart (1990), Falk and Stark (2001), Doepke and Zilibotti (2008) and Strulik (2012). Among those, closest to ours is the approach of Doepke and Zilibotti. They also allow patience to be intergenerationally transmitted, with parents influencing the degree of patience of their children in expectation of their future lifetime income patterns. In contrast to our model, though, the authors consider a dynastic optimization problem where children follow the same occupation as their parents.[6] Abstracting from intergenerational linkages, Strulik (2012) suggests a different mechanism for the evolution of patience that is based on an introspective approach in the spirit of Becker and Mulligan (1997) where individual agents become increasingly more patient as they get richer. Finally, Hansson and Stuart (1990) and Falk and Stark (2001) indicate how the process of natural selection over the course of economic development will give rise to more patient individuals through genetic transmission.[7] This approach has also recently been championed by Clark (2007) who stresses the downward mobility of upper class descendants during the Middle Ages to account for the increase in patience observed in Britain prior to the Industrial Revolution.[8]

In what follows, we begin our analysis with a description of the production structure of our model economy in Section 2. Section 3 discusses the occupational choice problem of agents

[4] See Bisin and Verdier (2010) for more details and further references to related studies.

[5] In a related paper Klasing (2012) employs a similar structure to study the general equilibrium effects of the cultural transmission of risk aversion for entrepreneurial activity and growth.

[6] Thus, in Doepke's and Zilibotti's model, the evolution of patience over the course of economic development is driven by dynasties who become increasingly more patient as they face steeper lifetime income profiles, and not by a diffusion of patience within the population as in our case.

[7] A similar approach has also been recently invoked to analyze the evolution of several other cultural attributes which are central to the process of economic development, such as preference for offspring quality rather than quantity (Galor and Moav, 2002), body size (Dalgaard and Strulik, 2011) as well as risk aversion (Galor and Michalopoulos, 2012).

[8] Given that genetic selection forces operate over a much longer time horizon compared to cultural transmission forces, we view the genetic and cultural approaches to the study of the evolution of patience as complementary.

and the resulting steady state equilibrium in the context of a homogeneous society. In Section 4 we introduce cultural heterogeneity and the cultural transmission mechanism, and analyze the resulting changes to the model economy's equilibrium. Finally, in Section 5 we turn to a comparison of the equilibrium development path of the culturally heterogeneous society with that of the homogeneous one. A set of concluding remarks stemming from our analysis are offered in Section 6.

2 Production Structure

The production side of our model economy features a three-sector structure in the tradition of Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992), which is used in most innovation-based models of endogenous growth. It comprises a final-goods sector, an intermediate-goods sector and a research-and-development (R&D) sector, each of which are described below.

2.1 Final-Goods Sector

In period t, the unique final good, Y_t, is produced by a large number of competitive firms using the Cobb-Douglas production technology

$$Y_t = (L_t^U)^{1-\alpha} \int_0^1 [A_t(s)]^{1-\alpha}[x_t(s)]^{\alpha} ds. \tag{1}$$

The technology combines unskilled labor L_t^U together with a continuum of intermediate goods x indexed by s. Intermediate good variants differ in terms of quality and this is captured by the productivity parameter $A_t(s)$. Final good producers employ unskilled labor and intermediate goods in order to maximize their profits, leading to the inverse demand functions

$$w_t^U = (1-\alpha)(L_t^U)^{-\alpha} \int_0^1 [A_t(s)]^{1-\alpha}[x_t(s)]^{\alpha} ds, \tag{2}$$

and

$$p_t(s) = \alpha[A_t(s)L_t^U]^{1-\alpha}[x_t(s)]^{\alpha-1}, \tag{3}$$

where w_t^U corresponds to the real wage earned by unskilled workers and $p_t(s)$ to the price of intermediate good s relative to that of the final good.

2.2 Intermediate-Goods Sector

Intermediate-good production transforms the unique final good into the different intermediate good variants. The production process of each variant takes place under perfect or imperfect competition depending on whether in a given period and for a given variant a new vintage has been invented or not. In the former case, there is a unique firm that holds the patent for the new vintage and is able to produce it with the simple one-for-one technology $x_t(s) = Y_t^X(s)$. This implies, given the demand for intermediate goods from the final-goods sector, that the profit-maximizing price that the patent-holding firm would like to charge is $p_t = \frac{1}{\alpha}$.[9]

Following Aghion, Howitt, and Mayer-Foulkes (2005) and Acemoglu, Aghion, and Zilibotti (2006) we assume that the patent holder is constrained by a competitive fringe of imitators that can produce an alternative version of the latest vintage of the intermediate good, albeit at higher marginal cost of $\eta > 1$ units of the final good. This implies that the competitive price of these alternative versions would be $p_t = \eta$. Letting $\eta < \frac{1}{\alpha}$ we have a situation where the patent-holding firm is not able to charge the profit maximizing price of $\frac{1}{\alpha}$, as the final-good producers would then opt for the imitators' product. Hence, the firm is forced to charge the competitive price, which keeps the imitators out of the market and still allows for some positive profits. These profits, however, only last for one period. In the subsequent period, the incumbent monopolist retires and the production is taken over either by the competitive fringe or by a new incumbent that has succeeded in inventing and patenting a new improved vintage of the intermediate good.[10] In either case, the above set of assumptions guarantee that all intermediate good variants are priced at $p_t = \eta$, independently of how the market for each variant is structured. The quantities produced for each variant and the corresponding profits for the patent-holding firms are respectively:

$$\hat{x}_t(s) = (\frac{\alpha}{\eta})^{\frac{1}{1-\alpha}} A_t(s) L_t^U \tag{4}$$

$$\pi_t(s) = (\eta - 1)(\frac{\alpha}{\eta})^{\frac{1}{1-\alpha}} A_t(s) L_t^U. \tag{5}$$

2.3 Research-and-Development Sector

The productivity $A_t(s)$ of each intermediate good variant depends on its vintage. New vintages of intermediate goods are assumed to yield a quality improvement of a fixed factor $\gamma > 1$ over the immediately previous one. Each new vintage is the result of an intensive research and development process undertaken by competitive firms employing skilled labor. The outcome of

[9] This solution can be obtained from the first-order condition of the monopolist's profit maximization problem, $\max_{\{x_t(s), Y_t^X(s)\}} \{p_t(s)x_t(s) - Y_t^X(s)\}$, after the inverse demand for $x_t(s)$, equation (3), has been substituted in. Because the optimal price is the same for all variants we subsequently drop the reference to s.

[10] This assumption is in line with our overlapping generations structure and is important because it allows us to eliminate profits from older intermediate good vintages. For more details on the rationale behind this assumption the reader is referred to Acemoglu, Aghion, and Zilibotti (2006).

this process is uncertain, with $\mu_t(s)$ denoting the probability of a new vintage of intermediate good variant s being invented in period t. This implies that the productivity level of variant s evolves according to:

$$A_{t+1}(s) = \left\{ \begin{array}{cc} \gamma A_t(s) & \text{w.p. } \mu_t(s) \\ A_t(s) & \text{w.p. } 1-\mu_t(s) \end{array} \right\}. \tag{6}$$

The arrival probability $\mu_t(s)$ of a new vintage is assumed to depend on the number of skilled workers employed in the research and development process, $L_t^S(s)$, their human capital level h_t and a time-invariant productivity parameter, λ:

$$\mu_t(s) = \lambda h_t L_t^S(s). \tag{7}$$

Skilled labor differs from unskilled labor in terms of human capital. Specifically, we assume that skilled laborers are characterized by a human capital level $h_t > 1$, which contributes positively to the R&D process, while unskilled laborers whose human capital level is normalized to 1 are not employable in the R&D sector.

The development of new vintages of intermediate goods is motivated by the prospects of acquiring a patent for it and earning the resulting profits. Assuming that entry into the R&D sector is free and that potential entrants are all risk neutral, in equilibrium all active R&D firms will earn zero expected profits. Thus, the allocation of resources in the research sector will be governed by the following research arbitrage condition,

$$\mu_t(s)\pi_t(s) = w_t^S(s) h_t L_t^S(s), \tag{8}$$

where $w_t^S(s)$ denotes the wage paid per unit of employed skilled labor. Incorporating expression (7), we obtain that $w_t^S(s) = \lambda\pi_t(s)$. Assuming additionally that the labor input of each skilled worker employed in the research sector contributes symmetrically toward R&D activities across the whole spectrum of intermediate-good variants we have that the actual wage, w_t^S, that skilled laborers earn equals:[11]

$$w_t^S = \int_0^1 w^S(s)ds = \lambda \int_0^1 \pi_t(s)ds. \tag{9}$$

Under the above assumption the innovation process is ex ante symmetric across intermediate goods and the corresponding probabilities of success statistically independent. Thus, by the law of large numbers the total number of successful innovations is deterministic and simply equal to: $\hat{\mu}_t = \lambda h_t L_t^S$, where $L_t^S = \int_0^1 L_t^S(s)ds$ corresponds to the total supply of skilled labor in the economy.

[11] Alternatively, this assumption can be justified if R&D firms engage in research and development activities that are not focused on any particular intermediate good variety. Either of the two assumptions reflect the potential synergies that may exists between R&D activities across intermediate goods.

2.4 Wages and Growth Rates

As the above description indicates, productivity growth in our model economy is driven by vertical innovations yielding higher-quality intermediate-good inputs. Moreover, the symmetric structure of the innovation process across sectors implies balanced productivity growth at the aggregate level. Specifically, letting $A_t = \int_0^1 A_t(i)di$ be the average productivity parameter, we have that the economy-wide rate of technological progress, g_t, is deterministic and given by:

$$g_t \equiv \frac{A_{t+1} - A_t}{A_t} = (\gamma - 1)\lambda h_t L_t^S. \tag{10}$$

Substituting (5) into (9) and writing the latter in terms of the aggregate productivity parameter A_t we obtain the following expression for the wage rate of skilled labor:

$$w_t^S = \lambda(\eta - 1)\left(\frac{\alpha}{\eta}\right)^{1/(1-\alpha)} A_t L_t^U. \tag{11}$$

Substituting (4) into (2) we obtain a similar expression for the wage rate of unskilled labor:

$$w_t^U = (1 - \alpha)\left(\frac{\alpha}{\eta}\right)^{\alpha/(1-\alpha)} A_t. \tag{12}$$

Given these wage rates, in what follows, we analyze the occupational choices of agents between skilled and unskilled employment and the implications that these have on productivity growth. To develop some intuition regarding the link between occupational choice and the mechanics of growth, in Section 3 below, we first discuss the case where there is no cultural heterogeneity among agents. This will also provide us with a useful benchmark for subsequent comparisons.

3 A Culturally Homogeneous Society

Suppose our model economy is populated by overlapping generations of identical agents. Each generation consists of a constant mass L of individuals who live for two periods. Time evolves discretely, which implies that the time index $t = 0, 1, 2, \cdots$ also reflects generations. During their first period of life, childhood, agents have one unit of time at their disposal, which they can allocate between human capital accumulation and leisure activities. In their second period of life, adulthood, agents have to decide whether to work as skilled or unskilled -supplying one unit of labor inelastically in either case- and then consume all their labor earnings. Reproduction of agents is asexual with each agent giving birth to one child in the beginning of the second period of life.

3.1 Lifetime Utility and Human Capital Accumulation

Agents derive utility from their leisure time during childhood as well as their level of consumption during adulthood, which they discount at the rate $\beta \leq 1$. Specifically, for an agent who is an adult in period t we postulate the following lifetime utility function:

$$u(l_{t-1}, c_t; \beta) = \ln l_{t-1} + \beta \ln c_t, \tag{13}$$

where l_{t-1} indicates leisure during childhood and c_t indicates consumption during adulthood, which equals earned income.[12]

Time not spend on leisure activities in period $t-1$ is used to accumulate human capital. In the spirit of Bils and Klenow (2000) we consider human capital, h_t, to be formed in a Mincerian fashion with $h_t = e^{\psi(1-l_{t-1})}$, with $\psi > 1$ capturing the returns to education. The assumed human capital formation function reflects the above made distinction between skilled and unskilled labor. Agents who spent their whole unit time endowment during childhood enjoying leisure will be characterized by a human capital level of 1 and can only be employed in the final-good sector as unskilled laborers, earning income w_t^U. Agents who as children devote some time to accumulate human capital will as adults be characterized by $h_t > 1$ and can be employed in the R&D sector as skilled laborers, earning income $w_t^S h_t$. In particular, agents' human capital accumulation decisions will be governed by the following lemma:

Lemma 1 *For $\beta \geq \frac{1}{\psi}$, any agent planning to work as skilled will optimally choose during childhood to enjoy leisure $\widehat{l}(\beta) = \frac{1}{\beta\psi}$ and accumulate human capital $\hat{h}(\beta) = e^{\psi - 1/\beta}$ independently of the level of w_t^S. Agents planning to work as unskilled will not accumulate any human capital. For $\beta < \frac{1}{\psi}$, all agents will optimally choose $\widehat{l}(\beta) = 1$ and $\hat{h}(\beta) = 1$ and as a result will opt for unskilled employment.*

Proof. The result follows from the maximization of the agent's utility function (13) after substituting in $c_t = w_t^S h_t$ and $h_t = e^{\psi(1-l_{t-1})}$ or alternatively $c_t = w_t^U$, noting the boundary condition that $l_{t-1} \leq 1$. ■

3.2 Occupational Choices and Equilibrium Growth Rate

In the context of the above described objective problem of agents, their lifetime utility maximization effectively hinges on their occupational choice. Although in a culturally homogeneous society all agents are ex ante identical, in equilibrium agents will differ in their occupational choices. Some will choose to accumulate human capital and work as skilled while others will

[12] The utility function is parametrized in terms of the discount factor, β, which in the subsequent section will be allowed to vary across agents.

not invest in human capital and work as unskilled. Specifically, for the share of agents in each occupation we can derive the following lemma:

Lemma 2 *Assuming that $L > \frac{(1-\alpha)\eta(\beta\psi)^{1/\beta}}{\alpha(\eta-1)\lambda\hat{h}(\beta)}$, there is a time invariant share $\hat{\sigma} > 0$ of adult agents who work as skilled. This share depends positively on the elasticity of output with respect to intermediate goods, α, the discount factor, β, the cost gap between innovators and imitators, η, the productivity of R&D, λ, the returns to education, ψ, and the size of the economy, L, and is given by:*

$$\hat{\sigma}(\beta) = 1 - \frac{1-\alpha}{\alpha}\frac{\eta}{\eta-1}\frac{(\beta\psi)^{\frac{1}{\beta}}}{\lambda\hat{h}(\beta)L}. \tag{14}$$

Proof. When making their occupational choices agents will compare their lifetime utilities as skilled and unskilled workers. Let $v^S_{t-1}(\beta)$ denote the indirect utility of an agent born in period $t-1$ and employed in period t as skilled and $v^U_{t-1}(\beta)$ the corresponding indirect utility of an agent working as unskilled. In the first case, as explained in Lemma 1, the agent will in the first period of life enjoy leisure $\hat{l}(\beta)$ and accumulate human capital $\hat{h}(\beta)$. This leads, given the wage for skilled labor w^S_t, to the lifetime utility $v^S_{t-1}(\beta) = \ln\frac{1}{\beta\psi} + \beta\ln(w^S_t\hat{h})$. In the second case, the agent will not to accumulate any human capital during childhood, earn wage w^U_t as an adult and enjoy the lifetime utility $v^U_{t-1}(\beta) = \beta\ln(w^U_t)$. Substituting expressions (11) and (12) for skilled and unskilled wages in each respective expression and equating the two we obtain that the economy's share of skilled employment is constant across time and equal to expression (14). Note that $\hat{\sigma}(\beta) < 1$ as otherwise w^S_t will be zero while w^U_t would be positive, implying that $v^S_{t-1}(\beta) < v^U_{t-1}(\beta)$. The assumption made on the population size L guarantees that $\hat{\sigma}(\beta) > 0$. The comparative statics results follow straightforwardly from differentiating (14). ■

Having documented the constancy of the equilibrium share of skilled employment at any point in time it follows naturally from the analysis of Section 2 that starting from period zero the economy will experience a constant rate of productivity growth. Given the production structure of our model economy, this implies that in equilibrium the economy will be on a balanced growth path with income, consumption and wages growing at the rate of productivity growth given by expression (10). We summarize this result in the form of a corollary to the above two lemmata.

Corollary 1 *A culturally homogeneous society where all agents discount the future at the rate β will at any point in time grow at the constant rate $\overline{g}(\beta) = (\gamma-1)\lambda\hat{h}(\beta)\hat{\sigma}(\beta)L$.*

4 A Culturally Heterogeneous Society

Let us now extend our analysis to the case of a culturally heterogeneous society where agents differ in their degree of patience. For simplicity, let us assume that the population L consists of two types of agents, patient types characterized by a discount factor of $\beta^1 = 1$, and impatient types characterized by a discount factor $\beta^0 < \frac{1}{\psi}$.[13] The distribution of types in the population evolves endogenously with $q_t \in [0,1]$ corresponding to the share of patient types in generation t. At the time of their birth agents are of no particular type. Their degree of patience is instead shaped through a socialization process controlled by their parents along the lines of the transmission mechanism of Bisin and Verdier (2001) described below.[14]

4.1 Parental Utility

Parents make their socialization decisions with implicit concerns about the well-being of their children. In addition to their own utility they care about the amount of leisure and consumption enjoyed by their children. However, they evaluate those based on their own utility function and thus based on their own discount factor.[15] In particular, for a parent of type i born in period $t-1$ we postulate the utility function:

$$U(l^i_{t-1}, c^i_t, d^i_t; \beta^i) = u(l^i_{t-1}, c^i_t; \beta^i) + \beta^i \{\sum_j P^{ij}(d^i_t)[v^j_{t-1}(\beta^i) + \tilde{v}^i I(j=i)] - \frac{1}{2}\kappa(d^i_t)^2\}. \tag{15}$$

Parents, apart from their leisure, l^i_{t-1}, and consumption, c^i_t, can also choose the amount of effort they put into socializing their children, d^i_t. The function u is as above, $u(l^i_{t-1}, c^i_t; \beta^i) = \ln l^i_{t-1} + \beta^i \ln c^i_t$. $v^j_{t-1}(\beta^i)$ corresponds to the indirect utility of a j-type child as perceived by an i-type parent. $P^{ij}(d^i_t)$ denotes the probability of an i-type parent of having a j-type child after having put effort d^i_t into the child's socialization. $\frac{1}{2}\kappa(d^i_t)^2$ reflects the utility cost of socialization, with κ being a parameter for which we assume $\kappa > \max\{\tilde{v}^1 + \ln \frac{\alpha(\eta-1)\lambda\hat{h}L}{(1-\alpha)\eta\psi}, \tilde{v}^0 + \ln\psi - \beta^0 \ln \frac{\alpha(\eta-1)\lambda\hat{h}L}{(1-\alpha)\eta}\}$.[16] Finally, $I(\cdot)$ is an indicator function with $\tilde{v}^i \geq 0$ reflecting the additional utility enjoyed by parents when having a child that shares their degree of patience.

The inclusion of the component $\tilde{v}^i$ in the parental utility function ensures that ceteris paribus parents will prefer to have a child which shares their cultural attributes.[17] This component reflects the notion of identity as modelled by Akerlof and Kranton (2000). Drawing on extensive work in psychology and sociology, Akerlof and Kranton suggest that an agent's utility increases

[13] In what follows we use the superscripts $i = 1$ and $i = 0$ to denote variables referring to the patient and impatient types respectively.

[14] The restriction to a dichotomous cultural attribute is without much loss of generality. As Bisin, Topa, and Verdier (2009) demonstrate, the cultural transmission mechanism can be generalized to the case of multiple cultural attributes.

[15] This means that parents are assumed to be imperfectly altruistic toward their children. See Bisin and Verdier (2010) for more details on this point.

[16] We impose this restriction on the value of κ to make parental utility and socialization costs comparable in terms of magnitudes. This enables us to interpret the effort levels d^i_t as probabilities of direct socialization as explained in the next subsection.

[17] For the analysis of this section we let this component be fixed and only vary across types. In the paper appendix we discuss the more general case where $\tilde{v}^i$ varies over time depending on the representation of each type in the population.

or decreases through actions that respectively affirm or conflict with their perceived identities. These identities, which in our context correspond to their membership in the group of patient or impatient agents, provide an additional distinct motivation for parental socialization efforts beyond the concerns for their children's well-being.

In this respect, our cultural transmission mechanism slightly deviates from the typical cultural transmission mechanism of Bisin and Verdier, where concerns for identity are implicit. In particular, Bisin and Verdier (2001) assume that parents are "culturally intolerant," namely they prefer children with similar rather than different cultural attributes. They do not distinguish, though, whether this is due to their misperception of children's well-being or to paternalistic considerations related to their perceived identity. On the contrary, Cohen-Zada (2006), Algan, Mayer, and Thoenig (2013), and Doepke and Zilibotti (2012) suggest that identity preservation constitutes an additional potential objective of parental socialization and explicitly model it as part of the parental utility function. Moreover, Cohen-Zada (2006) and Algan, Mayer, and Thoenig (2013) provide also empirical evidence indicating the importance of identity considerations in parental socialization decisions based respectively on religious school choices in the United States and first-name-giving patterns among Arabic immigrants in France. In what follows, we analyze how the strength of this component of parental preference influences their socialization decisions and hence the transmission of patience across generations.

4.2 Human Capital and Occupational Choices

Given the nature of the parental utility function, leisure and consumption choices of parents can be studied in isolation from their choices regarding child socialization. The former can be analyzed in the same fashion as in Lemmata 1 and 2. They imply that impatient agents will optimally decide not to accumulate human capital and just seek unskilled employment, while patient agents will only choose skilled employment as long as $v^S_{t-1}(1) > v^U_{t-1}(1)$. We summarize the optimal choices of both types of agents in the following two corollaries.

Corollary 2 *All impatient agents with $\beta^0 < \frac{1}{\psi}$ in the economy will optimally decide not to invest in human capital and will always choose to work as unskilled.*

Corollary 3 *All patient agents in the economy with $\beta^1 = 1$ will optimally decide to devote a fraction $\hat{l}^1 = \frac{1}{\psi}$ of their leisure time during childhood to accumulate human capital $\hat{h}^1 = e^{\psi-1}$ and as adults will opt for skilled employment as long as $q_t \leq \tilde{q} \equiv 1 - \frac{1-\alpha}{\alpha}\frac{\eta}{\eta-1}\frac{\psi}{\lambda L \hat{h}^1}$. Otherwise, if $q_t > \tilde{q}$, some type 1 agents will choose to work as unskilled to unsure that $v^S_{t-1}(1)$=$v^U_{t-1}(1)$.*

Corollary 3 implies that the share of skilled labor employment in the economy, $\hat{\sigma}_t$, is given by the following expression:

$$\hat{\sigma}_t = \left\{ \begin{array}{cc} q_t & \text{if } q_t \leq \tilde{q} \\ \tilde{q} & \text{if } q_t > \tilde{q} \end{array} \right\}. \tag{16}$$

This is because impatient agents cannot work as skilled and hence the share of skilled employment in the economy is constrained by the number of patient agents, $L_t^S \leq q_t L$. Thus, the comparative statics derived in Lemma 2 only hold in the case where $q_t > \tilde{q}$.

Corollary 4 *For a given q_t, increases in the elasticity of output with respect to intermediate goods, α, the cost gap between innovators and imitators, η, the productivity of research and development, λ, the returns to education, ψ, and the size of the economy, L, all have immediate positive effects on the share of skilled labor, $\hat{\sigma}_t$, provided that $q_t > \tilde{q}$.*

4.3 Parental Socialization Decisions

Turning now to the decisions of parents regarding socialization efforts we follow Bisin and Verdier (2001) and assume that the transmission of cultural attributes from parents to children (vertical transmission) is imperfect and parents can only transmit their own attribute with some probability. Specifically, we let the probability for type-i parents of directly transmitting their type to their children in period t equal the effort d_t^i they put into the child's socialization. Hence $d_t^i \in [0, 1]$.[18] If parents are unsuccessful in directly transmitting their type to their children, the latter pick their type through interaction with other adult individuals (oblique transmission). Since the likelihood of interaction with adults of each type depends on their representation in the society, whenever vertical transmission fails, children become patient with probability q_t and impatient with probability $1 - q_t$.[19] Thus, the overall probability of a patient adult agent having a patient child in period t is:

$$P_t^{11}(d_t^1) = d_t^1 + (1 - d_t^1)q_t.$$

Similarly, the transmission probabilities for the other three possible cases can be written as:

$$\begin{aligned} P_t^{10}(d_t^1) &= (1 - d_t^1)(1 - q_t), \\ P_t^{01}(d_t^0) &= (1 - d_t^0)q_t, \\ P_t^{00}(d_t^0) &= d_t^0 + (1 - d_t^0)(1 - q_t). \end{aligned} \tag{17}$$

The effort levels d_t^1 and d_t^0 are determined optimally by parents in order to balance out the costs and benefits of child-socialization. Specifically, when deciding on the amount of effort to exert in socializing their children, parents contemplate on the leisure and occupational choices that their children will make later in life and the utility levels that these choices will generate.

[18] It should be noted that the case $d_t^0 = d_t^1 = 1$ is equivalent to a case of pure genetic transmission of patience, which -as we mentioned in Section 1- has also attracted some attention in the literature. This channel has been deliberately muted in our analysis by the assumption of each parent having exactly one child, so that the discussion remains focused on the cultural nature of the transmission process.

[19] In the literature oblique transmission is typically assumed to be unbiased. In principle, one could also consider formulations where oblique transmission is biased towards one of the two types. See Boyd and Richerson (1985) for more details on this point.

However, as explained above, parents are imperfectly altruistic. When evaluating their children's well-being they do so using their own discount factor β^i. Moreover, we assume that parents cannot predict children's future wages, but instead simply expect that their children will be facing the same wage structure that they faced as adults.[20,21] Given these assumptions, the perceived indirect utilities of each type of parent as a function of the type of the child are as follows:

$$\begin{array}{ll} v^1_{t-1}(\beta^1) \equiv v^S_{t-1}(1) & v^1_{t-1}(\beta^0) \equiv v^S_{t-1}(\beta^0) \\ v^0_{t-1}(\beta^1) \equiv v^U_{t-1}(1) & v^0_{t-1}(\beta^0) \equiv v^U_{t-1}(\beta^0) \end{array} \tag{18}$$

Substituting expressions (17) and (18) in the parental utility function (15) we can obtain the optimal choices for d^1_t and d^0_t, which are summarized in the following lemma.

Lemma 3 *The optimal parental socialization effort of each type of agents is strictly inversely related to its population representation and given by the following expressions:*

$$\hat{d}^1_t = \left\{ \begin{array}{cc} (1-q_t)\frac{\tilde{v}^1 - \ln\psi + \ln\frac{\alpha(\eta-1)\lambda\hat{h}^1 L(1-q_t)}{(1-\alpha)\eta}}{\kappa} & \text{if } q_t \leq \tilde{q} \\ (1-q_t)\frac{\tilde{v}^1}{\kappa} & \text{if } q_t > \tilde{q} \end{array} \right\}, \tag{19}$$

$$\hat{d}^0_t = \left\{ \begin{array}{cc} q_t\frac{\tilde{v}^0 + \ln\psi - \beta^0\ln\frac{\alpha(\eta-1)\lambda\hat{h}^1 L(1-q_t)}{(1-\alpha)\eta}}{\kappa} & \text{if } q_t \leq \tilde{q} \\ q_t\frac{v^0 + (1-\beta^0)\ln\psi}{\kappa} & \text{if } q_t > \tilde{q} \end{array} \right\}. \tag{20}$$

Proof. Parental utility of both types of agents is strictly concave in d^i_t. Thus a unique solution to the optimization problem must exist. The restriction $\kappa > \max\{\tilde{v}^1 + \ln\frac{\alpha(\eta-1)\lambda\hat{h}L(1-\hat{\sigma}_t)}{(1-\alpha)\eta\psi}, \tilde{v}^0 + \ln\psi - \beta^0\ln\frac{\alpha(\eta-1)\lambda\hat{h}L(1-\hat{\sigma}_t)}{(1-\alpha)\eta}\}$ ensures that the optimal values are strictly interior, $\hat{d}^j_t \in (0,1)$. Thus, the first-order necessary condition for an interior maximum must hold with equality, which implies $\hat{d}^1_t = \frac{1-q_t}{\kappa}(v^1_{t-1}(\beta^1) - v^0_{t-1}(\beta^1))$ and $\hat{d}^0_t = \frac{q_t}{\kappa}(v^0_{t-1}(\beta^0) - v^1_{t-1}(\beta^0))$ respectively. Substituting in the values for w^S_t and w^U_t and noting the dependence of these values on whether $q_t \gtreqless \tilde{q}$ we obtain expressions (19) and (20). Differentiating with respect to q_t, it can be shown that $\frac{\partial\hat{d}^1_t}{\partial q_t} < 0$ and $\frac{\partial\hat{d}^0_t}{\partial q_t} > 0$. ■

The result of Lemma 3 implies the presence of a minority effect, as discussed in Bisin and Verdier (2001). The lower the current representation of a given type in the society, the more effort parents of this type exert in socializing their children. This feature is central to the dynamics of cultural transmission and guarantees that the process will not lead to a complete homogenization

[20] Note that under the above described occupational choices of type 1 agents it does not matter whether parents expect patient children to work as skilled or unskilled. This is because the indirect utility of patient agents working as unskilled is the same as of those working as skilled.

[21] The qualitative results of the model would be the same if parents formed rational expectations about the wage environment that their children will be facing. Yet, in the context of the present exposition, we make the simplifying assumption that parents form naive expectations about future wages as the assumption of rational expectations would greatly complicate the analysis of the dynamical system described in Section 4.4 without changing the qualitative nature of the results.

of the society as shown below.

4.4 Equilibrium under Cultural Heterogeneity

4.4.1 Evolution of Patience

To characterize the dynamic behavior of the economy over time it is sufficient to study the evolution of the sole state variable, the share of patient agents in the population, q_t. The evolution of that share depends on the transmission probabilities of patience, $P_t^{ij}(d_t^i)$:

$$q_{t+1} = P_t^{11}(d_t^1)q_t + P_t^{01}(d_t^0)(1-q_t). \tag{21}$$

Substituting in the corresponding transmission probabilities from (17) and simplifying we derive that $q_{t+1} = q_t[1 + (\hat{d}_t^1 - \hat{d}_t^0)(1-q_t)]$. Finally, using the results of Lemma 3 and rearranging the terms we obtain the following law of motion for q_t:

$$q_{t+1} = \left\{ \begin{array}{cc} q_t + q_t\frac{1-q_t}{\kappa}\{\tilde{v}^1 - q_t(\tilde{v}^1+\tilde{v}^0) + [1-q_t(1-\beta^0)]\ln(\frac{\alpha(\eta-1)\lambda\hat{h}^1 L(1-q_t)}{(1-\alpha)\eta}) - \ln\psi\} & \text{if } q_t \le \tilde{q} \\ q_t + q_t\frac{1-q_t}{\kappa}\{\tilde{v}^1 - q_t[\tilde{v}^1+\tilde{v}^0+(1-\beta^0)\ln\psi]\} & \text{if } q_t > \tilde{q} \end{array} \right\} \tag{22}$$

4.4.2 Stationary Equilibria and Transitional Dynamics

Given the law of motion (22), it is natural to consider whether the distribution of patient types converges to a stationary distribution. It turns out that this is indeed the case. The following proposition discusses the set of stationary values and their stability.

Proposition 1 *The set of stationary values for the share of patient types in the economy, q_t, consists of $\bar{q}^0 = 0$, $\bar{q}^1 = 1$ and $\bar{q}^{int} \in (0,1)$. Depending on the values for $\tilde{v}^1$ and $\tilde{v}^0$, it is possible for $\bar{q}^{int}$ to be either above or below $\tilde{q}$. In either case, $q_t \to \bar{q}^{int}$ for any $q_0 \in (0,1)$.*

Proof. For values $q_t \le \tilde{q}$ the dynamics of the share of patient types in the economy are governed by the first expression in equation (22). It is easy to see that $\Delta q_{t+1} = 0$ whenever $q_t = 0$ as well as for any value less than $\tilde{q}$ that satisfies the equation $H(q) \equiv \tilde{v}^1 - \bar{q}(\tilde{v}^1+\tilde{v}^0) + [1-\bar{q}(1-\beta^0)]\ln(\frac{\alpha(\eta-1)\lambda\hat{h}^1 L(1-\bar{q})}{(1-\alpha)\eta}) - \ln\psi = 0$. Noting that $H(0) > 0$ and $\frac{dH}{dq} < 0$ it is clear that there is at most one additional stationary value in the range $0 < q_t \le \tilde{q}$. Since $H(\tilde{q}) = (1-\tilde{q})\tilde{v}^1 - \tilde{q}\tilde{v}^0 - \tilde{q}(1-\beta^0)\ln\psi \gtrless 0$ it is evident that there is an interior stationary value q^* in the range $q_t \le \tilde{q}$ provided that $\tilde{q} \ge \frac{\tilde{v}^1}{\tilde{v}^1+\tilde{v}^0+(1-\beta^0)\ln\psi}$. Otherwise, $\bar{q}^0 = 0$ will be the only stationary value. Furthermore, provided that the condition $\tilde{q} \ge \frac{\tilde{v}^1}{\tilde{v}^1+\tilde{v}^0+(1-\beta^0)\ln\psi}$ holds we can see from (22) that $\Delta q_{t+1} > 0$ for any $0 < q_t \le q^*$ and $\Delta q_{t+1} < 0$ for $q^* < q_t \le \tilde{q}$, which renders the interior stationary value q^* stable and the boundary value at $\bar{q}^0 = 0$ unstable.

For values $q_t > \tilde{q}$ the dynamics of the share of patient types in the economy are governed by the second expression in (22). For this range of values we have that $\Delta q_{t+1} = 0$ whenever $q_t = 1$ or $q_t = \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi}$. The interior solution $\bar{q}^{int} = \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi}$ will be in the admissible range $q_t > \tilde{q}$ provided that $\widetilde{q} < \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi}$. Otherwise $\bar{q}^1 = 1$ will be the only stationary value. Furthermore, equation (22) implies that $\Delta q_{t+1} \gtrless 0$ whether $q_t \lesseqgtr \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi}$, which renders $\bar{q}^1 = 1$ unstable and $\bar{q}^{int}$ stable, provided that it is admissible. ■

Thus, there is a unique interior stationary value $\bar{q}^{int}$ given by:

$$\bar{q}^{int} = \left\{ \begin{array}{cc} q^* & \text{if } \widetilde{q} \geq \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi} \\ \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi} & \text{if } \widetilde{q} < \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi} \end{array} \right\}, \tag{23}$$

with q^* being defined implicitly by $H(q^*) = 0$.

The dependency of the interior steady state share of patient types on the values of the model parameters implies the following comparative static results.

Corollary 5 *The long-run share of patient types in the population is increasing in the discount factor of impatient types, β^0, and the relative strength of the patient parents' preference to preserve their type, $\tilde{v}^1$, and falling in the corresponding one for impatient parents, $\tilde{v}^0$. Provided that $\bar{q}^{int} \leq \tilde{q}$ the presentation of patient types is increasing in the elasticity of output with respect to intermediate goods, α, the cost gaps between innovators and imitators, η, the productivity of research and development activity, λ, and the size of the population, L. An increase in the returns to human capital, ψ, has an ambiguous effect on $\bar{q}^{int}$ if $\bar{q}^{int} \leq \tilde{q}$ and a negative effect if $\bar{q}^{int} > \tilde{q}$.*[22]

As the corollary makes clear, a more favorable economic environment for innovators will only influence the long-run distribution of patience in the economy if there are differences in the perceived earnings of different types in the economy, which is the case as long as $q_t < \widetilde{q}$. Otherwise, the long-run distribution will be determined solely by the relative strength of parental preferences to preserve their types, $\tilde{v}^1$ and $\tilde{v}^0$, the discount factor of impatient types, β^0, and the returns to human capital, ψ.

[22] This is due to the fact that higher returns to human capital raise on the one hand the earnings of skilled agents, but on the other hand also lead to a reduction in leisure. Thus an increase in ψ has an ambiguous effect on the relative indirect utilities -as perceived by parents- of patient and impatient children.

4.4.3 Equilibrium Growth Rate

Proposition 1 together with equation (10) implies that in the long-run the growth rate of per-capita output in the economy will be constant and given by

$$\bar{g} = \left\{ \begin{array}{ll} (\gamma - 1)\lambda\hat{h}^1 q^* L & \text{if } \widetilde{q} \geq \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi} \\ (\gamma - 1)\lambda\hat{h}^1 \tilde{q} L & \text{if } \widetilde{q} < \frac{\tilde{v}^1}{(\tilde{v}^1+\tilde{v}^0)+(1-\beta^0)\ln\psi} \end{array} \right\}. \tag{24}$$

Given the dependence of q^*on $\tilde{q}$ and on the model parameters we have the following comparative static results regarding the economy's long-run growth rate:

Corollary 6 *The growth rate of the economy in its unique interior stationary equilibrium depends positively on the elasticity of output with respect to intermediate goods, α, the magnitude of innovations, γ, the cost gap between innovators and imitators, η, the productivity of research and development, λ, the returns to education, ψ, and the size of the economy, L. Provided that the steady state share of patient types in the economy is below $\tilde{q}$, the growth rate is increasing in the relative strength of the patient parents' preference to preserve their type, $\widetilde{v}^1$, and falling in the corresponding one of impatient parents, $\widetilde{v}^0$.*

In the following section, we compare what our model implies for the rates of long-run growth for a culturally heterogeneous society and a homogeneous society consisting only of patient types. This offers an extreme, yet instructive, comparison regarding the effects that the cultural composition of a society can have on its course of economic development.

5 Implications for Comparative Development

Contrary to most existing growth models where cultural attributes are treated as exogenously fixed, in our model the cultural attribute of interest, patience, evolves endogenously with the economic environment. This allows us to address important questions regarding the influence that culture can have on comparative economic development and vice versa. Specifically, let us consider a comparison between two economies A and B for which the population size, L, and the model structural parameters $(\alpha, \gamma, \eta, \kappa, \lambda, \psi)$ are the same. The only difference between the two economies lies in the distribution of patience among individuals agents. In economy A the population is homogeneous with all individuals being perfectly patient, i.e. all agents are characterized by a discount factor of 1, and thus, $q_0^A = 1$. In economy B the population is heterogeneous as in Section 4, with patient agents having a discount factor of 1 and others discounting the future based on a factor $\beta^0 < 1/\psi$. Let the initial share of patient agents in economy B be low, $q_0^B < \tilde{q}$. Given these premises let us assess how the cultural differences between the two countries will influence their respective development paths.

For economy A, following the analysis of Section 3, it is clear that the equilibrium share of skilled employment will be $\tilde{q}$. Moreover, as there are no transition dynamics, the economy will instantaneously jump to this equilibrium and grow at the rate $g_{ss}^{A} = (\gamma - 1)\lambda\hat{h}^{1}\tilde{q}L$ in all time periods. For economy B, however, due to the initial low share of patient agents, as discussed in section 4.3, the share of skilled employment will initially be constrained by the share of patient agents, $\sigma_{0}^{B} = q_{0}^{B} < \tilde{q}$. Thus, the growth rate of economy B will be $g_{0}^{B} = (\gamma - 1)\lambda\hat{h}^{1}q_{0}^{B}L$, which is lower than that in A. This implies that the GDP levels of the two economies will begin to diverge.

Since the overall degree of patience is endogenous in our model, though, over time in economy B a virtuous circle will kick in. This is because the greater returns to skilled employment, which exceed those to unskilled employment as long as $\sigma_{t}^{B} < \tilde{q}$, will induce parents to socialize their children to become more patient. This will lead over time to an increase in the number of patient agents in the population and at the same time ease the constraint on skilled labor in the R&D sector. Consequently this implies that over time the growth rate of economy B will rise.

Will this process enable economy B to catch up with economy A? This depends on whether the steady state growth rate of economy B will remain below g_{ss}^{A} or not. Given the dynamics of growth in our model economy, this hinges on whether the steady state share of skilled employment in economy B will be increasing to or staying below $\tilde{q}$. In the former case, there will be no differences in the equilibrium growth rates between A and B and over time the GDP gap between the two economies will stabilize. In the latter case, the growth rate in B will remain permanently below that of economy A and the two economies will diverge indefinitely.

Given the invariance of the model's structural parameters between the two economies, which of the two scenarios will materialize depends crucially on the values of $\tilde{v}^{1}$ and $\tilde{v}^{0}$, the strength of parental preferences for having children who share their cultural attributes. In particular, as we can see from (23), the steady state share of skilled employment in country B will be $q^{*} < \tilde{q}$ if condition $(1-\tilde{q})\tilde{v}^{1} - \tilde{q}\tilde{v}^{0} - \tilde{q}(1-\beta^{0})\ln\psi < 0$ is satisfied. In that case, the resulting steady state growth rate will be $g_{ss}^{B} = (\gamma-1)\lambda\hat{h}q^{*}L < g_{ss}^{A}$. On the contrary, if $(1-\tilde{q})\tilde{v}^{1} - \tilde{q}\tilde{v}^{0} - \tilde{q}(1-\beta^{0})\ln\psi > 0$, then over time the skilled employment share in country B will increase to $\tilde{q}$ and the growth rate will converge to that of country A.

To understand the intuition behind the above condition that determines the capacity of country B to catch-up with country A in terms of growth rates it is instructive to re-write it as follows:

$$\tilde{v}^{1} > \frac{\tilde{q}}{1-\tilde{q}}\tilde{v}^{0} + \frac{\tilde{q}}{1-\tilde{q}}(1-\beta^{0})\ln\psi. \tag{25}$$

This condition indicates that $\tilde{v}^{1}$, the parameter reflecting the intrinsic preference of patient parents to have children who are like them independently of the economic returns to patience, should be strong enough to overcome $\tilde{v}^{0}$ - the corresponding preference parameter of impatient parents - as well as the difference in the perceived economic benefits to patience between patient and impatient agents, $(1-\beta^0)\ln\psi$, corrected for their relative shares in the population at the threshold point, $\frac{\tilde{q}}{1-\tilde{q}}$.

What is evident from the above discussion is that in the absence of any intrinsic preferences of parents to preserve their type, namely when $\tilde{v}^1 = \tilde{v}^0 = 0$, condition (25) is not satisfied and the steady state value of q_t^B will be below $\tilde{q}$. Hence, the share of skilled employment in country B will remain permanently below that of country A and so will its growth rate. This implies that the development paths of a culturally homogeneous and a heterogeneous society are bound to diverge, as long as the transmission of attitudes regarding patience across generations is solely governed by the relative perceived market returns to patience. What is necessary in order for divergence between the two economies to be avoided is the presence of an additional force promoting the dissemination of patience. This force is coming from parental preferences, in particular from the desire of patient parents to see their children carrying the same cultural attribute as them. The proposition below summarizes the above result.

Proposition 2 *Consider two economies, A and B, that are similar in all aspects apart from the initial distribution of attitudes regarding patience, with $q_0^A = 1$ and $q_0^B < \tilde{q}$. If the transmission of cultural attributes is governed by the above described mechanism, the two economies will in the long run grow at the same rate ($g_{ss}^A = g_{ss}^B$) if and only if $\tilde{v}^1 \geq \frac{\tilde{q}}{1-\tilde{q}}\tilde{v}^0 + \frac{\tilde{q}}{1-\tilde{q}}(1-\beta^0)\ln\psi$. Otherwise $g_t^A > g_t^B$ in all time periods.*

The above result may appear initially surprising, yet there is a simple intuition behind it. In the absence of cultural heterogeneity, agents will sort themselves into skilled and unskilled occupations up to the point where lifetime earnings in the two occupations, as perceived by patient agents, are equalized. The presence of impatient agents alters this equilibrium as their heavier discounting of future income induces them to only consider the unskilled employment option. In the short-run, this will lead to a temporary deviation from the benchmark labor market equilibrium. However, if attitudes regarding patience are subject to change across generations and their evolution is responsive to market returns to patience, it is natural to expect that over time the economy would return to the benchmark equilibrium prevailing in the absence of cultural heterogeneity.

The reason this does not happen is the presence of an important friction in the cultural transmission process. Parents in our model economy are only imperfectly altruistic toward their children and their socialization decisions are biased by their own degree of patience. Specifically, since impatient agents heavily discount the benefits that their children would enjoy as skilled workers in their second period of life, their socialization decision is biased against patience. As a consequence, the prevailing long-run equilibrium under cultural heterogeneity involves an under-representation of patience in the population and a lower share of skilled employment compared to the benchmark labor market equilibrium.

6 Concluding Remarks

The present paper has demonstrated how combining an innovation-based model of endogenous growth with a cultural transmission mechanism enables the study of the interplay between the mechanics of economic growth and the process of cultural change. Focusing our attention on patience, a cultural attribute central for intertemporal decision-making, we have analyzed the conditions under which societies that are characterized by different degrees of patience will end up following different development paths. This allows us to address important questions regarding the extent to which a society's culture can impose a constraint on its long-run growth potential.

The main conclusion that emerges from our analysis is that in an environment where culture is subject to change across generations, the initial cultural composition of a society is not bound to hold back the process of economic development. Specifically, we have shown that even a society where patience is initially underrepresented in the population can make up for it and in the long run grow at the same rate as a society of perfectly patient economic agents. However, in order for this to happen it is not sufficient that the intergenerational transmission of patience is responsive to the relative economic returns to patience. Patient parents need to have an additional intrinsic motivation to instill patience in their children. This is necessary in order to overcome the socialization decisions of impatient agents, whose distorted assessment of the returns to patience biases the cultural transmission process in the opposite direction.

Moreover, our analysis of the dynamic interaction between patience and economic growth offers a set of testable predictions regarding their joint evolution over the course of economic development and how they can influence the choices of economic agents regarding human capital accumulation and occupation. In particular, our theory suggests that differences in patience across individuals should be associated with differences in incomes, education, and the steepness of income profiles, predictions that have been supported by evidence from Lawrance (1991), Atkeson and Ogaki (1996), and Harrison, Lau, and Williams (2002). It also suggests more generally an overall increase in patience as economies develop, a prediction corroborated by Hansson and Stuart (1990), Becker and Mulligan (1997), and Clark (2007). Most importantly, it suggests that the presence of greater returns to patience will induce parents to influence their children to become more patient, leading to a diffusion of patience within the population. Although our analysis here has been theoretical, we consider an empirical assessment of this prediction a potentially fruitful avenue for further research.

Finally, we would like to stress that although in the context of the present paper we have chosen to focus our attention on patience, the general structure of our model is flexible enough and can be easily applied to investigate the coevolution of economic development and various other cultural attributes.[23] Thus, we believe that our analysis can provide important insights regarding

[23] Klasing (2012) uses a similar setup as this paper to study the interaction of risk preferences and economic development, while Doepke and Zilibotti (2013) suggest the use of a closely related framework for the more general

the extent to which culture should be understood as a fundamental determinant of economic development of not.[24] In this respect, our results should raise caution against treating cultural attributes as exogenous to economic development given the natural ways in which changes in the economic environment may induce cultural change. At the same time, they suggest that although values and attitudes are subject to change over time, this does not necessarily imply that culture is perfectly malleable and will have no effect on a country's path of economic development.

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analysis of the link between culture and economic growth.

[24]For more on this point, see the discussion in Acemoglu, Johnson, and Robinson (2005).

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Appendix: Varying Parental Attachment to Own Cultural Attributes

One limitation of the analysis offered in the main body of the paper is that the strength of parental preferences to preserve their own cultural attributes are treated as something exogenous and independent of the dynamics of cultural transmission. Here, we consider an alternative scenario, where we allow these preferences for each group of agents to vary with their representation in the population. As we demonstrate below, the qualitative nature of the cultural transmission dynamics and the model equilibrium do not change when this more natural assumption is introduced.

In the context of the culturally heterogeneous society described in Section 4, let us now consider the following slightly modified version of the parental utility function:

$$u(l_{t-1}^i, c_t^i; \beta^i) + \beta^i \{ \sum_j P^{ij}(d_t^i)[v_{t-1}^j(\beta^i) + \tilde{v}^i(q_t) I(j = i)] - \frac{1}{2}\kappa (d_t^i)^2 \}.$$

Note that the additional utility that parents enjoy when having a child that shares their cultural attributes now depends on q_t. Specifically, for the purpose of the present analysis, let us parametrize the function $\tilde{v}^i(q_t)$ as follows:

$$\tilde{v}^i(q_t) = \left\{ \begin{array}{cc} \tilde{v}^1(1-q_t)^2 & \text{if } i = 1 \\ \tilde{v}^0 q_t^2 & \text{if } i = 0 \end{array} \right\}.$$

Just as in Sections 4 and 5, $\tilde{v}^1, \tilde{v}^0 \geq 0$ can still be interpreted as reflecting the preference of parents for a child sharing their cultural attribute. But the difference is that here $\tilde{v}^i$ corresponds to the additional utility enjoyed when type i agents are an infinitesimal minority in the population, while the strength of these preferences weakens as type i's representation increases and vanishes in the limit as type i agents come to dominate the population.

How does this modification affect parental socialization choices and the dynamics of cultural transmission? This can be seen from the expressions below, which resembles expressions (19) and (20):

$$\overset{\vee}{d}{}_t^1 = \left\{ \begin{array}{ll} (1-q_t)\frac{\tilde{v}^1(1-q_t)^2 - \ln\psi + \ln\frac{\alpha(\eta-1)\lambda\hat{h}^1 L(1-q_t)}{(1-\alpha)\eta}}{\kappa} & \text{if } q_t \leq \tilde{q} \\ (1-q_t)\frac{\tilde{v}^1(1-q_t)^2}{\kappa} & \text{if } q_t > \tilde{q} \end{array} \right\} \tag{26}$$

$$\overset{\vee}{d}{}_t^2 = \left\{ \begin{array}{ll} q_t\frac{\tilde{v}^0 q_t^2 + \ln\psi - \beta^0 \ln\frac{\alpha(\eta-1)\lambda\hat{h}^1 L(1-q_t)}{(1-\alpha)\eta}}{\kappa} & \text{if } q_t \leq \tilde{q} \\ q_t\frac{\tilde{v}^0 q_t^2 + (1-\beta^0)\ln\psi}{\kappa} & \text{if } q_t > \tilde{q} \end{array} \right\} \tag{27}$$

The key difference compared to the previous case is that the amount of effort exerted by parents is more responsive to changes in their representation in the society since $\frac{\partial \overset{\vee}{d}{}_t^1}{\partial(1-q_t)} > \frac{\partial \hat{d}{}_t^1}{\partial(1-q_t)} > 0$ and $\frac{\partial \overset{\vee}{d}{}_t^2}{\partial q_t} > \frac{\partial \hat{d}{}_t^2}{\partial q_t} > 0$.[25] Substituting the above expressions into equation (21) we obtain the new law of motion for the share of patient agents in the population:

$$q_{t+1} = \left\{ \begin{array}{ll} q_t + q_t\frac{1-q_t}{\kappa}[\tilde{v}^1(1-q_t)^3 - \tilde{v}^0 q_t^3 + [1 - q_t(1-\beta^0)]\ln(\frac{\alpha(\eta-1)\lambda\hat{h}L(1-q_t)}{(1-\alpha)\eta}) - \ln\psi] & q_t \leq \tilde{q} \\ q_t + q_t\frac{1-q_t}{\kappa}[\tilde{v}^1(1-q_t)^3 - \tilde{v}^0 q_t^3 - q_t(1-\beta^0)\ln\psi] & q_t > \tilde{q} \end{array} \right\}. \tag{28}$$

The new law of motion for q_t can be analyzed in the same way as in Section 4. Despite its higher-order nature compared to equation (21), the resulting dynamics are qualitatively unchanged. Thus, following the steps outlined in Proposition 1, we can prove the existence of three stationary points. Two of them, $\bar{q}^0 = 0$ and $\bar{q}^1 = 1$, are unstable and one of them, $\bar{q}^{int}$, is stable, lying either above or below $\widetilde{q}$. Specifically, for the unique stable interior equilibrium $\bar{q}^{int}$ we can show that:

$$\bar{q}^{int} = \left\{ \begin{array}{ll} < \widetilde{q} & \text{if } \tilde{v}^1(1-\tilde{q})^3 - \tilde{q}^3\tilde{v}^0 - \tilde{q}(1-\beta^0)\ln\psi < 0 \\ \geq \widetilde{q} & \text{if } \tilde{v}^1(1-\tilde{q})^3 - \tilde{q}^3\tilde{v}^0 - \tilde{q}(1-\beta^0)\ln\psi \geq 0 \end{array} \right\}, \tag{29}$$

Although we cannot explicitly solve for $\bar{q}^{int}$, using the implicit function theorem it can be shown that, just as in the previous case, $\frac{\partial\bar{q}^{int}}{\tilde{v}^1} > 0$ and $\frac{\partial\bar{q}^{int}}{\tilde{v}^0} < 0$. We summarize this result in a proposition.

Proposition 3 *The set of stationary values for the share of patient types, q_t, in the economy with varying parental attachment to their cultural attributes consists of $\bar{q}^0 = 0$, $\bar{q}^1 = 1$ and $\bar{q}^{int} \in (0,1)$, with $q_t \to \bar{q}^{int}$ for any $q_0 \in (0,1)$. Depending on the values for $\tilde{v}^1, \tilde{v}^0$, β^0 and ψ it is possible for $\bar{q}^{int}$ to be either above or below $\tilde{q}$. In particular, for $\tilde{v}^1$ and $\tilde{v}^0$ we have that $\frac{\partial\bar{q}^{int}}{\tilde{v}^1} > 0$ and $\frac{\partial\bar{q}^{int}}{\tilde{v}^0} < 0$.*

The rest of the analysis of Sections 4 and 5 can follow through as before with the only difference being that the critical value that $\tilde{v}^1$ has to exceed in order for the culturally heterogeneous society to grow at the same long-run rate as the culturally homogeneous one now is:

$$\tilde{v}^1 > \frac{\tilde{q}^3}{(1-\tilde{q})^3}\tilde{v}^0 + \frac{\tilde{q}}{(1-\tilde{q})^3}(1-\beta^0)\ln\psi. \tag{30}$$

[25] In the terminology of Bisin and Verdier (2001), this modification of the parental preferences strengthens the minority effect on their socialization decisions.