

## **Development of Economic Theories in pursuit of experiment**

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### **ABSTRACT**

Economic experiments play an important role in economic theories. These are an important role in developing economic theories and inform us about the range of relevance, the strength and the analytical influence of an economic theory. The paper displays a link between human capital and economic growth with the help of a model of economic growth with threshold externalities in human capital accumulation. Moreover, economic experiments helps to determine and segregate occurrences and challenge economic theorists to describe them in a detail way. Lastly, many economic experiments are known as “substantial” representations, used to examine and forecast how changes in the environment affect economic consequences. The Present research also contributes to a good characterization of the economic growth and development patterns that have been observed across countries.

**Keywords:** Economic experiments, economic developments, economic theories,

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### **Introduction**

Economic development is a term that economists, politicians, and others have used frequently in the 20th century. Economic development has been in existence in the West for centuries. Modernization, Westernization, and especially industrialization plays a significant role in deliberating economic development. Economic development has a direct association with the environment. While economic development is a procedure intervention attempt with aims of economic and social well-being of people, economic growth is a

phenomenon of market productivity and increase in gross domestic product. The economic growth has been driven by the expansion of services that have been growing consistently faster than other sectors. It is argued that the pattern of Indian development has been a specific one and that the country may be able to skip the intermediate industrialization-led phase in the transformation of its economic structure. Serious concerns have been raised about the jobless nature of the economic growth

In the late 2000s, India's growth reached 7.5%, which will double the average income in a decade. Analysts say that if India pushed more fundamental market reforms, it could sustain the rate and even reach the government's 2011 target of 10% (Economic survey of India 2007: Policy Brief). States have large responsibilities over their economies. The annualised 1999–2008 growth rates for Tamil Nadu (9.9%), Maharashtra (9.7%), Gujarat (9.6%), Haryana (9.1%), or Delhi (8.9%) were significantly higher than for Bihar (5.1%), Uttar Pradesh (4.4%), or Madhya Pradesh (6.5%). India is the seventh-largest economy in the world and the third largest by purchasing power parity adjusted exchange rates (PPP). On per capita basis, it ranks 140th in the world or 129th by PPP.

The progress of economic reforms in India is followed closely. The World Bank suggests that the most important priorities are public sector reform, infrastructure, agricultural and rural development, removal of labour regulations, reforms in lagging states, and HIV/AIDS. For 2015, India ranked 142nd in Ease of Doing Business Index, which is setback as compared with China 90th, Russia 62nd and Brazil 120th. According to Index of Economic Freedom World Ranking an annual survey on economic freedom of the nations, India ranks 123rd as compared with China and Russia which ranks 138th and 144th respectively in 2012. At the turn of the century India's GDP was at around US\$480 billion. As economic reforms picked up pace, India's GDP grew five-fold to reach US\$2.3 trillion in 2015 (as per IMF estimates).

India's GDP growth during January–March period of 2015 was at 7.5% compared to China's 7%, making it the fastest growing economy. During 2014-15, India's GDP growth recovered marginally to 7.3% from 6.9% in the previous fiscal. During 2014-15, India's services sector grew by 10.1%, manufacturing sector by 7.1% & agriculture by 0.2%. The Indian government has forecast a growth of 8.1-8.5% during 2015-16.

The main purpose of this paper is to study a model that leads to continued changes in development rates across countries for long periods of time then also permits countries that are originally near or at low growth stable states to lastly make the change to high growth steady states. The model can also account for the phenomenon that countries with similar initial conditions may experience quite different development paths, so that an observer of the world situation at a point in time might see countries with vastly different levels of per capita income.

### **Evaluation of experimental theory**

In the late 1940s and early 1950s, a number of economists independently became interested in the notion that laboratory methods could be useful in economics. Early interests ranged widely, and the literature evolved in three distinct directions. At one extreme, Edward Chamberlin (1948) presented subjects with a streamlined version of a natural market. The ensuing literature on market experiments focused on the predictions of neoclassical price theory. A second strand of experimental literature grew out of interest in testing the behavioral implications of non-cooperative game theory. These game experiments were conducted in environments that less closely resembled natural markets. Payoffs, for example, were often given in a tabular (normal) form that suppresses much of the cost and demand structure of an economic market but facilitates the calculation of game-theoretic equilibrium outcomes. A third series of individual decision-making experiments focused on yet simpler environments, where the only uncertainty is due to exogenous random events, as

opposed to the decisions of other agents. Interest in individual decision-making experiments grew from a desire to examine the behavioral content of the axioms of expected utility theory. Although the lines separating these literatures have tended to fade somewhat over time, it is useful for purposes of perspective to consider them separately.

### **Review of the Theoretical Literature of the model used for the present study**

This part of the paper contains a review of the literature on the link between human capital and economic growth. First of all, the Solow model and its extension to consider human capital accumulation is been discussed in relation to human capital and economic growth. Subsequently the neoclassical growth model and various endogenous growth models with human capital accumulation are discussed. These two models provide the basic approach to studying human capital and growth and the solution of these models yields the determinants of economic growth and provides the framework on which a large part of empirical analysis is based. Furthermore, these models give rise to a natural distinction between different types of human capital. The models discussed a relationship between human capital and economic growth. The paper also include the model of economic growth with threshold externalities in human capital accumulation (Azariadis and Drazen, 1990) and also other channels through which human capital affects growth nonlinearly. The paper also justifies an explanation for the existence of nonlinearities in the human capital-economic growth relationship.

### **A brief explanation of model of economic growth with threshold externalities in human capital accumulation**

As discussed earlier, that present study includes an explanation of the economic growth and development with the help of model developed by Azariadis and Drazen (1990). Model describes that Time  $t$  is discrete and takes on integer values on the real line. Moreover, at each date  $t$  there is a total population of  $2N$  agents, where  $N$  is a positive integer, with the

population evenly divided among the total sample. There is no population growth. The present study details that subscripts indicate birthdates and parentheses denote real time, while individual agents within a generation are indexed by a superscript  $i \in \{1, 2, \dots, N\}$ . Aggregate variables have no subscript or superscript. Agents are endowed with one unit of time at every date  $t$ . During the first period of life, young agents may choose to spend some fraction,  $r_t \in [0, 1)$ , of their time endowment in training. There is a general training technology, denoted  $h(r_t, x_t)$ , which all agents can access, where the variable  $x_t$  is the average quality of labor of both the young and the old at time  $t$ :  $x_t = \frac{1}{N} \sum_{i=1}^N x_{it}$ . This variable is measured as effectiveness units per unit time worked. An individual agent can offer time to training when young in order to accept more effectiveness units in the second period of life via  $x_{it+1} = h(r_{it}, x_t) x_{it}$ .

The main feature of the model is that the individual agent's return to training depends positively on the economy-wide standard level of effectiveness units. The research includes a model developed by Azariadis and Drazen (1990) and specify  $h(\cdot)$  as  $h(r_t, x_t) = 1 + \gamma(x_t)r_t$ .

However, we depart from Azariadis and Drazen (1990) in that we use a specific parametric form for  $\gamma(\cdot)$ , the private yield on human capital. In particular, we use the sigmoid function:  $\gamma(x_t) = \frac{1}{1 + e^{-\beta x_t}}$  which is strictly increasing in  $x_t$  and implies the bounds given by  $\gamma(0) = 0$  and  $\lim_{x_t \rightarrow \infty} \gamma(x_t) = 1$ . Every young agent succeeds to the average level of efficiency units in the economy in the previous time period. Young agents combine this endowment with a training decision  $r_t$  in order to receive  $x_{it+1}$ , as the model permit within generation heterogeneity in the decision variable  $r_t$ , the growth equation for  $x_t$  is given by:-  $x_{t+1} = x_t [1 + \gamma(x_t) f_t]$  where  $f_t = \frac{1}{N} \sum_{i=1}^N f_{it}$ .

The output per unit of efficient labor is produced according to a neoclassical production function which we specify as:-  $f(k_t) = \alpha k_t^{1-\alpha}$  where  $\alpha \in (0, 1)$  and  $k_t$  is the capital to effective labor ratio. Effective aggregate labor is given by  $N L(t) = [N - \sum_{i=1}^N r_{it}] x_t$  so that  $k_t = \frac{K_t}{N L(t)}$

$K(t) [N - \alpha - \delta] x(t) + \dots$  where  $K(t)$  denotes the aggregate physical capital stock. The rental rate on physical capital and the wage are given by, respectively  $r(t) = \alpha k(t)^{\alpha-1} w(t) = (1 - \alpha)k(t)^{\alpha}$ . There is also an expenditure loan market with gross rate of interest denoted  $R(t)$ . Arbitrage equates the rate of return on renting physical capital with the rate of return on consumption loans via  $R(t) = r(t + 1) + 1 - \delta$ , where  $\delta$  is the net decrease rate on physical capital. This paper assumes  $S = 1$ . All agents in this economy have the same preferences,  $U = \ln c(t) + \beta \ln c(t + 1)$ . Furthermore, all agents face the similar lifetime budget constraint:  $c(t) + \frac{1}{R(t)} [1 + \beta y(x(t)) r(t)] w(t + 1)$

### Equilibrium point under perfect prescience

In this part, the paper supposes that agents have ideal prudence. Join the first order circumstances with the budget restraint, and making employ of the definitions for  $w(t)$  and  $R(t)$ , the individual young agent's best probable savings choice can be written as:

$$s(t) = (1 - \delta)x(t)(1 - \alpha)k(t)^{\alpha} - [1 + \beta y(x(t)) \delta] x(t)(1 - \alpha)k(t + 1).$$

Young agents are equally endowed with  $x(t)$ , and under perfect foresight they all make the same choices for  $\delta(t)$ , which we call  $r(t)$ . Thus, aggregate saving is given by  $S(t) = Ns(t)$ .

The market clearing condition is that  $K(t + 1) = S(t)$ . Some manipulation yields

$$k(t + 1) - g(t + 1) = (1 - r(t)) \alpha (1 - \alpha) k(t)^{\alpha} - [1 + \beta y(x(t)) r(t)] [g(t + 1) - \alpha (1 - \alpha) k(t)^{\alpha}]$$

where  $g(t + 1) = [1 + \beta y(x(t + 1)) r(t + 1)] x(t + 1)$ . We now consider steady states of this system.

First, suppose that  $r(t) = 0 \forall t$ . In this case,  $x(t)$  must be constant for all  $t$ . It follows from (1) that in this case  $\frac{1}{R} = \frac{1}{1 + \beta y(x) \delta}$

The pair  $(r, k)$  is the low income steady state of our system. Next, suppose that  $r(t) = 0$ . In this case,  $x(t)$  is growing so that for  $t$  large enough  $\beta y(x(t)) \delta \rightarrow 1$ , and furthermore arbitrage requires that  $R = \alpha k^{\alpha}$ . Then and it follows from (1) that  $r$  must solve

$$- [ (1 - r) \alpha (1 - \alpha) ] \frac{1}{R} = \frac{1}{R} [ 3\alpha - 2\alpha r + 1 ]$$

The quadratic in  $r$ , but only one of the two roots is feasible with  $r \in [0, 1)$ , and this is the root where we can prefer for  $r \sim 1$ . The pair  $(r \sim, k \sim)$  comprises the elevated income stable status in this system. It is simple to show that the low income steady state is locally stable in the perfect foresight dynamics, and that the high income steady state is saddlepath stable. Azariadis and Drazen (1990) argued that original circumstances would decide which stable state a state might eventually achieve, and that given a adequately varied set of original conditions, an viewer might see country in determinedly low as well as persistently high expansion equilibrium. They argued that this forecast equal elements of the present global circumstances.

### **Testing Economic Theories for the present study**

An experiment is a procedure carried out to verify, refute, or establish the validity of a hypothesis. Experiments provide insight into cause-and-effect by demonstrating what outcome occurs when a particular factor is manipulated. Experiments vary greatly in goal and scale, but always rely on repeatable procedure and logical analysis of the results. There also exist natural experimental studies. It is important, as economic theories are hypothetical to explain human behaviour in natural economic environments.

“The logic is as follows. General theories must apply to simple special cases. The laboratory technology can be used to create simple (but real) economies. These simple economies can then be used to test and evaluate the predictive capability of the general theories when they are applied to the special cases. ...

Although we have remarkably large number of theories exist in economics. Hence, the main purpose of an experiment is to reduce the number by determining which do not work in the simple cases (Charles Plott, 1991). Predictive capability of a theory is the ability of a system to predict certain ocean phenomena is the predictive capability of the system for those phenomena. It considers all sources and reductions of errors (initial and boundary

conditions, model, data, etc.) and their evolution this methodological position is used by many economists.

### Model, Expectations and Suggestions

In this paper, the researcher will concentrate on the study of the asymptotic behavior of the equilibrium of an A–D economy. The latter are given by all the non-negative sequences  $\{x_t, k_t, r_t\}_{t=0}^{\infty}$ , with  $0 \leq \tau \leq 1$ , which are produced by repeating the dynamical system (1) from some original condition  $(x_0, k_0)$ .

$$[x_{t+1}(2-\tau+1)]k_{t+1} = s[f(k_{t+1}), w(k_t)x_t(1-\tau), w(k_{t+1})x_{t+1}] \quad (1a) \quad x_{t+1} = x_t [1 + \tau(x_t)\tau] \quad (1b)$$

$f(k_{t+1})w(k_t) \geq w(k_{t+1})\gamma(x_t)$ , (with  $=$  when  $\tau > 0$ ). (1c) The notation is the usual:  $x$  is the aggregate stock of human capital,  $k$  is the physical to human capital ratio,  $\tau$  is the percentage of accessible time that the young generation invests in education,  $f(k)$  is a strictly concave neoclassical production function fulfilling Inada-type conditions on the boundaries,  $s(R, y, y)$  denotes saving as a function of the normal rate of return  $R = f'(k)$ , current income  $y$  and future income  $y$ , it is increasing in  $(R, y)$  and decreasing in  $y$ ,  $w(k)$  is the wage rate equal to  $[f(k) - kf'(k)]$  and, finally, the gross rate of human capital accumulation is given by  $1 + \gamma(x)\tau$ . It is assumed that  $\gamma$  is non-negative and monotone non-decreasing with  $\hat{\gamma} = \max \{\gamma(x); x \geq 0\} = \gamma(x)$  for all  $x \geq \hat{x}$  and, further, that  $s(R, y, y)$  is increasing in all arguments and linearly homogeneous in  $(y, y)$  for any given  $R$ . We consider first the no-training equilibrium. This is the object of Proposition 1 in the A–D paper. My modified version is:

### Suggestion

1. Under the maintained assumptions there exists a level  $x > 0$  for the stock of human capital and a level  $k > 0$  for the physical stock such that all the triplets  $(x, k, 0)$  with  $0 \leq x \leq \hat{x}$  are fixed points of (1). Denote the set composed of all such triples as  $K$ . Points in  $K$  are



“asymptotically stable” in the following sense: if  $\{x, kt, 0\}_{t=0}^{\infty}$  is an equilibrium then  $(x, kt, 0) \rightarrow (x, k, 0)$ . Proof Set  $\tau = 0, x_t = x$  and  $k_t = k$  for all  $t$  in (1). Then (1.b) can be dropped and (1.a) reduces to  $2k/w(k) = s[f(k), 1, 1]$ . The latter has a unique solution  $k > 0$  because  $f$  strictly concave implies that  $2k/w(k)$  is strictly increasing and  $s[f(k), 1, 1]$  is strictly decreasing in  $k$ . Now let  $f(k) = \gamma$ , and set  $x = \operatorname{argmax}\{x: \gamma(x) \leq \gamma\}$ . Such an  $x$  exists and is non-negative; clearly all the triples  $(x, k, 0)$  with  $0 \leq x \leq x$  are no-training stationary states because they satisfy inequality (1.3). A local analysis of (1.a) and (1.b) shows that all the equilibrium paths  $\{x_t, k_t, r_t\}_{t=0}^{\infty}$  with  $\tau = 0$  and  $x_t = x \in [0, x]$  for all  $t$ 's larger than some finite  $t$  will converge to  $(x, k, 0)$ .

Notice what this result does not say: it does not say that there exists an open neighbourhood of  $K$  in  $\mathbb{R}^3$  such that all equilibria beginning within such a neighbourhood will converge to a point in  $K$ . In other words the proposition does not imply that the no-training equilibria are dynamically stable, at least not in the usual sense. The reason is simple: potentially the model described by (1.a)–(1.c) has multiple equilibrium paths departing from a common initial condition. It is a third order system for which only two initial conditions,  $(x_0, k_0)$ , are available: the initial value  $\tau_0$  is chosen in equilibrium by looking forward to the future value of  $k_1$ . This is a typical situation in which, depending on individual expectations, different values of  $k_1$  may be selected, each one of them consistent with a distinct equilibrium sequence. While the complexity of the model makes it quite hard to work out explicit examples, it should be clear why one is prevented from proving a strong stability result. A better understanding of the dynamic behavior of the model can be obtained by the following geometrical construct. Denote as  $NT$  the subset of  $\mathbb{R}^2$  composed of all the pairs  $(x, k)$  satisfying  $f(k) \geq \gamma(x)$ , clearly  $K \subset NT$  as in Figure 1. Trajectories starting within  $NT$  and which also remain within  $NT$  can only move along vertical lines to keep the initial value of  $x_0$  constant. As the arrows indicate, this implies that orbits beginning in the shaded subsets

of NT cannot remain in NT and, a-fortiori, cannot converge to K while those starting in the area I indicated as B(K) may converge to K if they remain in B(K). Nevertheless there may exist equilibria beginning in B(K) and leaving it after a finite number of periods: these are “optimistic” equilibria along which at time t a value  $k_{t+1}$  is selected which is feasible from  $k_t$  and such that  $(x_t, k_{t+1})$  is not in NT anymore. Notice that, on the other hand, there may exist equilibria that start outside both B(K) and NT and that jumps into B(K) at a finite and remain there forever: these are “pessimistic” equilibria along which physical capital is accumulated and the incentives for investing in education disappears. From a qualitative point of view the economic phenomena I am describing are not much different from those already encountered in other models with externalities; see e.g. Boldrin (1990), Boldrin-Kiyotaki-Wright (1991), Matsuyama (1991), Mortensen (1991), etc. I shall now move on to the second type of stationary equilibria studied by A–D: these are equilibria departing from initial conditions  $(x_0, k_0)$  where  $x_0 \geq \hat{x}$ , (so that  $\gamma(x_0) = \hat{\gamma}$ ), and  $k_0$  is large enough to make it feasible to select accumulation sequences satisfying (1.c) with equality. A stationary equilibrium will then be a balanced growth along which  $x_{t+1} = (1 + \hat{\gamma}r^*)x_t$ ,  $k_t = k^*$  and  $\tau = \tau^* > 0$  for all t. With regard to their existence one can prove the following:

**Suggestion 2.** Let  $k$  be the stationary value defined in Proposition 1 and denote with  $k^*$  the solution to  $f(k) = \hat{\gamma}$ . Then: (i) if  $k > k^*$  a value  $\tau^* \in (0, 1)$  exists such that when  $x_0 \geq \hat{x}$   $x_0(1 + \hat{\gamma}\tau^*)^t, k^*, \tau^*$  is an equilibrium with initial condition  $(x_0, k^*)$ . (ii) if  $k < k^*$  then no such value of  $\tau$  exists in  $[0, 1]$ . Evidence it is rather simple. In case (ii) concavity of  $f$  implies that  $k^*/w(k^*) > k/w(k)$  and  $f(k) > \hat{\gamma}$  are both true. Then one has the following sequence of inequalities:

$$2k^*/w(k^*) > 2k/w(k) = s[f(k), 1, 1] > s[\hat{\gamma}, 1, 1].$$

On the other hand a stationary equilibrium exists if there is a value of  $\tau$  between zero and one which solves (\*)  $(2 - \tau)k^*/w(k^*) = s[\hat{\gamma}, (1 - \tau)/(1 + \hat{\gamma}\tau), 1]$  The previous inequalities

imply, though, that the left hand side of (\*) is strictly above the right hand side of (\*) at both  $\tau = 0$  and  $\tau = 1$ . By comparing the slopes of the two functions one can also see that the same is true for all the other admissible value of  $\tau$  and therefore equilibrium does not exist. In case (1) one needs again a solution to (\*). It is easy to see that the right hand side is now larger than the left hand side for  $\tau = 0$  and smaller than at  $\tau = 1$ . At least one stationary value of  $\tau$  will therefore exist.

To study the dynamic stability of the stationary point  $(k^*, \tau^*)$  one has to overcome the same difficulties illustrated earlier for the no-training equilibrium: multiple solutions to system (1) are possible for a given initial circumstance in a neighbourhood of  $(k^*, \tau^*)$  and therefore a general statement is not possible. Moreover, a close inspection of the young agents maximization problem shows that centre solutions with  $0 < \tau < 1$  and  $s(R, y, y) > 0$  are very “tenuous” and it is hard to characterize the subset of  $v\sigma\pi\mu\tau(\omega, \lambda, \lambda+1) \in \mathbb{R}^3$  at which they are realized, let alone showing that the latter is an attracting set for the dynamical system (1). It is true, though, that a linearization of (1.a) and (1.c) with respect to  $k$  and  $\tau$  in a neighbourhood of  $(k^*, \tau^*)$ , (and with  $x_{t+1} = x_t(1 + \hat{\gamma}\tau^*)$ ), shows that the latter has the local structure of a saddle, as A–D already pointed out in their article. This leaves the question of stability open: a saddle point is dynamically “stable” only if there are compelling economic reasons for which, at any given initial condition, the equilibrium path lies on the stable manifold. This is the case in most models of intertemporal optimization because one can show that all the paths different from the stable manifold violate either a feasibility condition or the transversality condition. There is no transversality condition to be imposed in the present contest. Therefore one would have to prove that, for a given pair  $(x, k_0)$  with  $x \geq \hat{x}$  and  $k_0$  near  $k^*$ , the only value of  $\tau_0$  that induces a feasible orbit under repeated iterations of (1.a)–(1.c) is the one that puts  $(k_0, \tau_0)$  on the stable manifold of  $(k^*, \tau^*)$ . This seems quite hard to prove given the full generality of the model, even if it

might be possible for some particular cases. I should also note that examples for which only the no-training steady state exists are very easy to construct as the reader will easily figure out with some algebraic manipulation of the following economy:  $u(c_1, c_2) = \ln(c_1) + \ln(c_2)$ ;  $f(k) = k^\alpha$ ;  $\gamma(x) = (\beta + 1)x / (1 + x)$  for  $0 \leq x \leq \beta$  and  $\gamma(x) = \beta$  otherwise.

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