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Endogenous time preference, investment and development traps

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Contents

Pertti Haaparanta* and Mikko Puhakka **

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Abstract

We introduce endogenous time preference via investment in patience (farsightedness) in an overlapping generations growth model to study development traps. There is no investment in patience, if the economy is very poor, while if it is wealthy enough there is always such investment. We explore the conditions for the existence of the development trap, and study in detail a robust example of an economy with traps. It does not exist, if the economy's total factor productivity is large enough. Our results illustrate the complementarity between physical investment and investment in farsightedness. Our model may also explain why economic growth is affected by initial conditions. In addition we show that increased international capital mobility does not necessarily help economies to escape from development traps.

JEL classification: I30, O11, O16
Keywords: development trap, overlapping generations

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Pertti Haaparanta and Mikko Puhakka

Endogenous time preference, investment and development traps

Tiivistelmä

Eri maiden per capita tuotannoissa on suuria ja pysyviä eroja. Köyhyysloukuille, joissa talous on jäänyt "huonoon" tasapainoon vaikka parempiakin olisi olemassa, on kehitetty monia selityksiä. Tutkimuksemme esittää yhden selityksen. Tutkimme nimittäin köyhyysloukkujen olemassaoloa limittäisten sukupolvien kasvumallissa, jossa taloudenpitäjät voivat vaikuttaa diskonttaustekijäänsä esimerkiksi investoimalla terveyteensä tai johonkin muuhun tekijään, joka vaikuttaa positiivisesti heidän tulevaisuuden arvostukseensa. Tällaista investointia ei tapahdu hyvin köyhissä talouksissa, mutta rikkaissa talouksissa taloudenpitäjät haluavat aina tehdä sellaisen investoinnin. Tutkimme niitä ehtoja, joiden vallitessa köyhyysloukut ovat olemassa. Esitämme yksityiskohtaisen esimerkin, jonka avulla valaisemme monikäsitteisiä tasapainoja, joista yksi on köyhyysloukku. Jos talouden kokonaistuottavuus on tarpeeksi suuri, se ei voi joutua loukkuun. Tutkimustuloksemme heijastavat sitä, että tavalliset investoinnit ja investoinnit "tulevaisuuden arvostukseen" täydentävät toisiaan. Mallimme saattaa myös selittää sen, miksi taloudellinen kasvu riippuu alkulähtökohdista. Näytämme lisäksi, että pääomien kasvava kansainvälinen liikkuvuus ei välttämättä auta taloutta pakenemaan köyhyysloukusta.

Asiasanat: köyhyysloukku, limittäiset sukupolvet

1 Introduction

There is a large and persistent disparity in observed per capita output levels in different economies. E.g. Jones (1997), McGrattan and Schmitz (1998) and Parente and Prescott (2000) document these facts, and discuss possible explanations for the phenomenon. A multitude of theoretical explanations have been put forward to explain, why these differences in per capita output levels persist. Azariadis (1996, 2001) surveys theoretical explanations for the development (poverty) traps. These traps are situations, where an economy can end up in a bad equilibrium even though better equilibria are available. Graham and Temple (2003) have argued that empirically development trap is a significant factor in explaining the international income differences and their persistence.

In this paper we present another mechanism to generate development traps. In the previous work surveyed by Azariadis the mechanism underlying the multiplicity of equilibria is the endogeneity of time preference due to the influence of consumption on the intertemporal marginal rate of substitution.[1] The formal framework is thus based on recursive utility functions e.g. as explored in Becker and Boyd (1997) (see also Das, 2003). In our model, in addition to investing in physical capital, economic agents can invest in patience, i.e. they can spend resources to decrease the rate of time preference. We use this idea in a growth model to generate development traps. This mechanism has also been used by Becker and Mulligan (1994, 1997). Recently Stern (2000) has utilized the same idea in an optimal growth model.[2] The idea is closely related, but not identical, to the idea in recent "psychological economics" that people can make conscious (and costly) decisions to overcome the "weakness of will" created by time inconsistent preferences (e.g. Benabou and Tirole 2002). This has obvious implications for savings and growth (Harris and Laibson, 2003).

We argue that the possibility for people to invest in farsightedness in addition to productive capital may explain why there exist development traps. It may also explain why economic growth is affected by initial conditions. By investment in farsightedness we mean such things as investment in personal health or better nutrition, which prolong life

[1] Fisher (1977) argued that the rate of time preference increases the wealthier consumers become**.**

[2] In contrast to Stern we focus on the multiplicity of equilibria, and concentrate solely on each generation's investment to reduce their own time preference. In his model it is not possible to distinguish between intergenerational altruism and each generation's efforts to manipulate their own time preference.

and increase the weight people assign for their future welfare. In a similar fashion, investment in activities that help to understand culture and social traditions (e.g. investment in understanding modern art) may improve perseverance.[3]

Chakraborty's (2004) overlapping generations model with endogenous mortality (in fact, discount factor) generates development traps. One possible interpretation of our model is that it has endogenous mortality, but without perfect annuity markets and government provided health services.[4] In his model public provision yields a direct link via wage taxes from the current capital stock to the rate of time preference, while the link in our model comes from consumer's optimal choice of saving and investment in patience.

At the face value, our attempt is perhaps futile: some of the existing empirical evidence seems to be against our theory. Mokyr (1990, p.155-156) rejects outright Boulding's hypothesis that increased life expectancy was a major driving force behind the growth of innovative activities leading to the First Industrial Revolution. He points out that there is no evidence for such a link between innovations and increased life expectancy. Furthermore, Braudel (1978) remarks that the life expectancy varied very much between socioeconomic groups.

Recently Chakraborty (2004) and Artadi and Sala-i-Martin (2003), however, have argued that mortality can be an important source for stagnation in Africa. Similarly we think that increased farsightedness may be an important part of the growth process. Growth may induce investment in farsightedness, which again may increase accumulation of productive capital. And if growth has this cumulative element, it is easy to understand why the economy might end up in a development trap.

There is quite a bit of evidence supporting our view. Stark (1995, ch. 2) shows evidence that life expectancy and per capita income are internationally positively correlated. Correlation, of course, does not say anything about causation, and we, in fact, argue that they are interrelated. Deaton (2003) provides a survey of these issues confirming the role of income in improving individual health. Schultz (2003) also reviews the evidence on the close association between sustained total factor productivity and reduced poverty with improvements in child nutrition, adult health, and schooling (i.e. three different types of investments in human capital). Also closely supporting our argument is the fact that the income elasticity of public spending on health is higher in countries with high per capita in-

[3] Becker and Mulligan (1997) provide other similar examples.

come than in countries with low income (World Development Indicators, World Bank 1998, p 91).

A rough look at the data brings up similar related findings. We have taken the five richest (Iceland, Ireland, Luxembourg, Norway, and USA) and the five poorest countries (Burundi, Congo Democratic Republic, Malawi, Sierra Leone, and Tanzania) in terms of per capita GDP in PPP terms in 2001 (World Development Indicators 2003), and looked at various indicators of health. In 2001 the average child immunization rate (DPT) was among the poorest countries 67 per cent while among the richest it was 93 per cent (WDI 2003).[5] Finally, the average maternal mortality rate (per 100 000 live births) during 1995-2001 was 9.2 in the richest countries and 1324 among the poorest countries (WDI 2003 Social Indicators Datasheets).[6]

In his survey Deaton (2003) concludes that the social environment is crucial for the individual health and for the overall health of nations. In economic history there is more micro level evidence on the possible importance of the mechanism we propose.[7] We want to argue that the exact mechanism creating development traps is the complementarity between investment in physical capital and investment in patience. Complementarity implies that income must be at a high enough level for investment in patience to take place, or that multiple equilibria, with one equilibrium being the development trap, exist.

2 Investment in patience and saving decision

We consider an overlapping generations economy with two period lives, no population growth and perfect foresight. We assume that the young consumer can affect the rate of

[4] Both of these aspects are usually missing in the poor countries.

[5] In Ireland the immunization rate was, however, below the rates in Malawi and Tanzania.

[6] A potentially interesting application of our model is to Russia. As is well known transition has everywhere included a period of falling real GDP. In Russia the decline has continued for a longer time and been deeper than in most of the other countries. At the same time the life expectancy at birth has declined. The adult mortality rate (both for men and women) increased dramatically in the first half of the 1990's and has been high since then (World Development Indicators 2003, Table 2.20). Our model can be used to see the continued decline of income and increase in mortality as different aspects of the same phenomenon.

[7] E.g. Thompson (1988) argues that in the 19th century Britain the possibility to get their children positions in government offices improved, the middle classes began to exercise birth control. This was necessary, because otherwise they would not have been able to provide proper education for their children (especially because the cost of education was increasing) and at the same time take care of children's welfare. This was naturally a new investment opportunity highlighting an increasing weight put on children's welfare.

time preference by his own choices e.g. by investing in better health. Thus $\beta(x) \equiv [(1+\rho(x)]^{-1}$, where ρ is the rate of time preference and x is the amount invested. To focus on investment in patience alone we assume away all effects coming from changing wealth distributions. Consequently the agent born at t has the following lifetime utility function,

(1) $$v(c_1^t, c_2^t, x_t) = u(c_1^t) + \beta(x_t)u(c_2^t).$$

The periodic utility function, $u(c)$, is assumed to be strictly increasing and concave, and to fulfill the Inada conditions: $u'(c) > 0$, $u''(c) < 0$, $\lim_{c\to 0} u'(c) = \infty$ and $\lim_{c\to\infty} u'(c) = 0$. c_1^t and c_2^t denote consumption in youth and in old age. Consumers supply inelastically one unit of labor in their youth.

To focus sharply on the patience investment we assume the discount factor function to have the following simple form:

$$\beta(0) = \beta_1 > 0 \ , \ \beta(\bar{x}) = \beta_2 > 0 \text{ and } 1 > \beta_2 > \beta_1 .$$

This form of discounting means that consumer must invest at least $\bar{x}$ to patience for the future to have an added importance. This specification simplifies considerably the analysis of the relationship between physical and patience investments.

Consumer's periodic budget constraints are

(2) $$c_1^t + s_t + x_t = w_t$$

(3) $$c_2^t = R_{t+1}s_t.$$ [8]

w_t is the wage rate, s_t denotes saving, and R_{t+1} is the interest factor from period t to period $t+1$. The lifetime budget constraint is then

(4) $$c_1^t + x_t + \frac{c_2^t}{R_{t+1}} = w_t .$$

The consumer's decision problem is

(PC) $$\max_{\{c_1^t, c_2^t, x_t\}} \{u(c_1^t) + \beta(x_t)u(c_2^t)\}$$

subject to (4) or to (2) and (3).

[8] In principle we could have set the price of x to differ from unity. We can interpret there to be a linear "technology", which transforms patience investment (x) into "output". Thus the price of x is unity.

This yields the saving function $s_t = s(w_t, R_{t+1}; \beta_i)$ ($i = 1,2$), which for a given level of patience investment is obtained from the Euler equation

(5) $$u'(w_t - x_i - s_t) = R_{t+1}\beta_i u'(R_{t+1}s_t),$$

where x_i is either zero or $\bar{x}$.

Consumer invests in patience either nothing or $\bar{x}$. He will invest $\bar{x}$, if that decision yields him higher utility. Thus, in consumer's optimum $x = \bar{x}$, if total utility is at least as high as not investing anything in patience, i.e.

(6) $$\Delta(w_t, R_{t+1}) \equiv u(w_t - \bar{x} - s_t^2) + \beta_2 u(R_{t+1}s_t^2) - u(w_t - s^1) - \beta_1 u(R_{t+1}s_t^1) \geq 0,$$

where s_t^i, ($i = 1,2$), is the appropriate optimal saving decision.[9] The indirect indifference curve, $\Delta(w, R) = 0$, gives all the wage and interest factor combinations such that consumer is indifferent in investing in patience or not.

We first note that if the wage income is very small, less than or equal to the required patience investment, $\bar{x}$, consumer will not invest anything in patience. On the other hand if that income is so large that the proportion of $\bar{x}$ to the wage is small, he will always invest in patience. This argument is formalized in

Proposition 1. There is a wage level, $\underline{w}$ ($> \bar{x}$), below which consumers do not invest anything in patience, i.e. $\Delta(w, R) < 0$ for all $w < \underline{w}$. Furthermore, $\lim_{w \to \infty} \Delta(w, R) > 0$.

Proof: For all $w \leq \bar{x}$, consumer cannot invest anything in patience, because he does not have enough income. Consider now a situation with a large enough wage level, i.e. where $w \approx w - \bar{x}$, and denote the optimal saving without patience investment as s^1. Since $\beta_2 > \beta_1$, we have $\Delta(w, R) \geq u(w - \bar{x} - s^1) + \beta_2 u(Rs^1) - u(w - s^1) - \beta_1 u(Rs^1)$ = $(\beta_2 - \beta_1)u(Rs^1) + u(w - \bar{x} - s^1) - u(w - s^1) > 0$. By continuity of the utility function and the respective saving functions there must be at least one wage level, say $\underline{w}$, which is greater than $\bar{x}$ such that $\Delta(\underline{w}, R) = 0$. Q.E.D.

[9] If the utilities are equal we assume that he invests in patience.

We can make even a stronger statement: the wage level $\underline{w}$ in Proposition 1 is unique. This follows from the following lemmas.

Lemma 1. The first period consumption by a more impatient consumer always exceeds the consumption by a patient consumer, $c_1^{\beta 1} > c_1^{\beta 2}$, and thus $u'(c_1^{\beta 1}) < u'(c_1^{\beta 2})$.

Proof: We differentiate equation (5) (without subscripts) to get $\partial s / \partial \beta > 0$. Assume now that $c_1^{\beta 1} < c_1^{\beta 2}$. It then follows from the budget constraints that $w - x - s^{\beta 2} > w - s^{\beta 1}$, which implies $s^{\beta 1} > s^{\beta 2} + x$. The last statement contradicts the fact that $\partial s_t / \partial \beta > 0$, and thus we must have $c_1^{\beta 1} > c_1^{\beta 2}$. The second claim follows from the strict concavity of the periodic utility function. Q.E.D.

Lemma 2. $\Delta_w(w, R) > 0$.

Proof: Taking into account the Euler conditions and using the envelope theorem we differentiate $\Delta(w, R)$ to get $\Delta_w(w, R) = u'(c_1^{\beta 2}) - u'(c_1^{\beta 1})$. Since the utility function is strictly concave, it follows from Lemma 1 that this partial derivative is positive. Q.E.D.

Next we will find out those combinations of the wage rate and the interest factor such that consumer is indifferent between types, i.e. we want to find out the slope of the indirect indifference curve, $\Delta(w, R) = 0$. We drop subscripts in (6), take into account the appropriate Euler conditions, and totally differentiate to obtain

(7) $$\left\{u'(c_1^{\beta 2}) - u'(c_1^{\beta 1})\right\} dw = \left\{\beta_1 s^1(w, R) u'(c_2^{\beta 1}) - \beta_2 s^2(w, R) u'(c_2^{\beta 2})\right\} dR .$$

Superscripts βi ($i = 1,2$) refer to consumer's type. It is not clear from (7), what the slope of the indifference curve is with a general utility function because of the ambiguity of the sign of the term on the right-hand side. Obviously we can get technical conditions e.g. for the downward sloping indifference curve by inspecting equation (7), but those conditions do not seem to have a nice economic interpretation. Thus we study (7) by assuming that the lifetime utility function has constant intertemporal elasticity of substitution ($1/\sigma$), i.e. $u(c) = c^{1-\sigma} / (1-\sigma)$. We also assume that $1/\sigma > 1$ so as to make saving an increasing function of the interest factor.[10]

Solving for saving and consumption we get

[10] Our emphasis in this paper is on the dynamics created by investment in patience, and thus we want to keep the rest of the model as standard as possible.

(8) $$s^1 = \frac{1}{1+\beta_1^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}} w, \qquad c_1^{\beta 1} = \frac{\beta_1^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}}{1+\beta_1^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}} w$$

(9) $$s^2 = \frac{1}{1+\beta_2^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}} (w-\bar{x}), \quad c_1^{\beta 2} = \frac{\beta_2^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}}{1+\beta_2^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}} (w-\bar{x}).$$

Next we compute the arguments on the right-hand side of (7) to obtain

(10) $$\beta_1 s^1 u'(c_1^{\beta 1}) = \frac{\beta_1 w^{1-\sigma}}{R^{\sigma}\left[1+\beta_1^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}\right]^{1-\sigma}}, \ \beta_2 s^2 u'(c_1^{\beta 2}) = \frac{\beta_2 (w-\bar{x})^{1-\sigma}}{R^{\sigma}\left[1+\beta_2^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}\right]^{1-\sigma}}.$$

We get the following lemma.

Lemma 3. For a utility function with constant intertemporal elasticity, the indifference curve ($\Delta(w,R)=0$) has a negative slope, i.e. $\beta_1 s^1(w,R)u'(c_2^{\beta 1}) - \beta_2 s^2(w,R)u'(c_2^{\beta 2})$ is negative at points of indifference.

Proof: At points where $\Delta(w,R)=0$ $\beta_2 u(c_2^{\beta 2}) > \beta_1 u(c_2^{\beta 1})$ by Lemma 1. This inequality can be written as $\frac{\beta_2}{\beta_1} > \left[\left(\frac{1+\beta_2^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}}{1+\beta_1^{-\frac{1}{\sigma}} R^{1-\frac{1}{\sigma}}}\right)\left(\frac{w}{w-\bar{x}}\right)\right]^{1-\sigma}$. But, using equation (10), the inequality $\beta_1 s^1 u'(c_1^{\beta 1}) < \beta_2 s^2 u'(c_1^{\beta 2})$ is exactly the same. Q.E.D.

We have given conditions for describing the behavior of the consumer in a situation, where he must decide, whether to invest in patience or not. Figure 1 describes an indifference curve. It follows from Proposition 1 and Lemma 2 that the area above the curve is the one, where consumer wants to invest in patience.

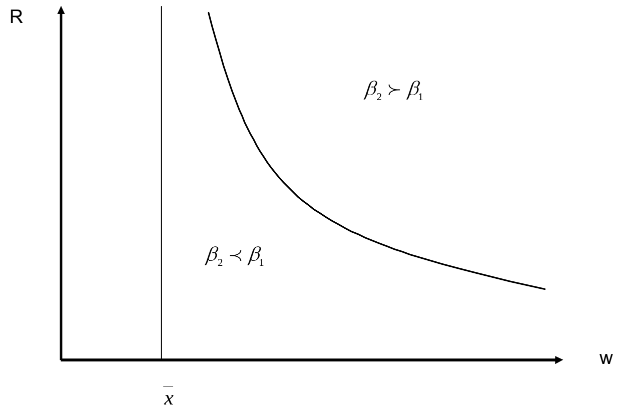

Figure 1.

The production side of our model is standard. The firms have a constant returns to scale technology, $AF(K_t, L_t)$, to transform capital (K_t) and labor (L_t) into output. A denotes total factor productivity. There is no capital depreciation. This technology can be expressed in factor intensive form to give $F(K_t, L_t)/L_t = Af(k_t)$, where k_t (= K_t / L_t) is the per capita level of capital. The per capita production function has the standard properties: $f' > 0$ and $f'' < 0$. Furthermore, we assume $\lim_{k \to 0} f'(k_t) = \infty$ and $\lim_{k \to \infty} f'(k_t) = 0$.

3 Equilibrium and development trap

Next we define the competitive equilibrium.

Definition. A sequence of a price system and a feasible allocation,

$\{R_t, w_t, c_1^t, c_2^{t-1}, x_t, k_t\}_{t=1}^{\infty}$ is a competitive equilibrium, if

(i) given the price system, consumers and firms solve their decision problems and

(ii) markets clear for all t = 1,2,...,T,...

Market clearing conditions are

(11a) $c_1^t + c_2^{t-1} + k_{t+1} + x_t = Af(k_t) + k_t$

(11b) $s_t = k_{t+1}$

(11c) $Af'(k_t) = r_t$

(11d) $$Af(k_t) - k_t Af'(k_t) = w_t .$$

(11a) is the resource constraint for all t, and (11b) is the asset market clearing condition, where today's savings of the young are used as capital in the next period. Equations (11c) and (11d) in turn are the marginal productivity conditions, which determine the evolution of factor prices, r_t and w_t.

Using the market clearing conditions (11b), (11c) and (11d), and the saving function we can express the fundamental dynamical equation as follows

(12) $$k_{t+1} = s\left[1 + Af'(k_{t+1}), Af(k_t) - k_t Af'(k_t); \beta_i\right].$$

This means that equilibria can also be described as a sequence of capital stocks, $\{k_s\}_{s=0}^{\infty}$, such that (12) holds. When the discount factor is constant, and there is no investment in patience, the properties of (12) are well known since Diamond (1965).[11]

To isolate the effects of patience investment in the most transparent way, we assume that the dynamics of (12) without patience investment is such that there is one non-trivial stable stationary equilibrium. E.g. Cobb-Douglas technology with constant returns to scale and logarithmic preferences will result in such equilibrium. We also assume that dynamics with patience investment is "standard". In that case there are two nontrivial steady states, the one with a lower level of capital being unstable. The dynamics in the latter case is described in Figure 2.

[11] See Galor and Ryder (1989), and also de la Croix and Michel (ch. 1, 2002) for precise analyses of equation (12) without investment in patience.

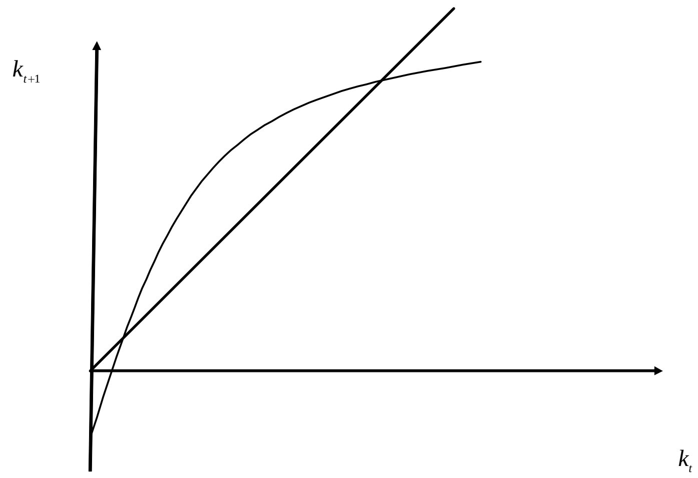

Figure 2.

Equations (11c) and (11d) define the factor price frontier, which is downward sloping. This means that we can describe the indifference curve, $\Delta(w_t, R_{t+1}) = 0$, also as a relation between the capital stocks, k_t and k_{t+1}. It follows from the factor price frontier that this relation is also downward sloping. We denote this curve by $\Gamma(k_t, k_{t+1}) = 0$. We denote the respective utilities along the capital paths as $V(k_t, k_{t+1}; \beta_i)$. For a given level of k_{t+1}, k_t is bigger above the curve, and thus is the wage rate. According to Proposition 1 and Lemma 2 consumer prefers to invest in patience above the curve.

Azariadis (1996, p.450-451) defines poverty traps as "…nonergodic equilibrium growth paths that contain several attractors, e.g. steady states, balanced growth paths, or asymptotic distributions of world income. We call the lowest of these attractors a "poverty trap" or a "low-level development trap"." In our model the simplest case of a poverty trap is a situation, where there are two stable steady states, e.g. as those described in Figure 3. $\underline{k}$ is the level of capital, which corresponds to the wage level $\underline{w}$. Both stationary equilibria, k_1^s and k_2^s, are stable. If $k_0 < \underline{k}$, the economy goes towards the lower steady state equilibrium (development trap), and if $k_0 \geq \underline{k}$ the economy converges toward an equilibrium with a higher level of capital stock, k_2^s.

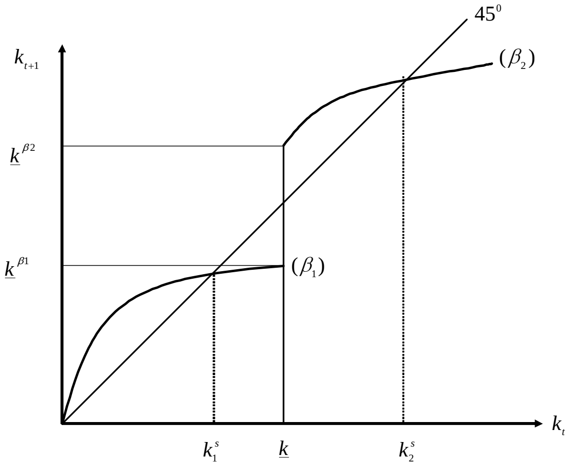

Figure 3.

Next we elaborate conditions under which we can get the situation described in Figure 3. For the existence of a development trap the indifference curve, $\Gamma(k_t, k_{t+1}) = 0$, must lie between the steady states described in Figure 3. E.g. if we have a situation, where indifference curve cuts the curve describing dynamics under patience investment (denoted by (β_2) above the steady state, k_2^s, we cannot have a poverty trap, since the only steady state in the economy will then be k_1^s.

We describe the construction of a poverty trap in Figure 4. Denote by $\hat{k}$ a level of capital stock such that $\Gamma(\hat{k}, \hat{k}) = 0$. From Figure 4 we see that to get a poverty trap we need to have $k_1^s < \hat{k} < k_2^s$. By inspecting the Figure we note that $\Gamma(k_t^{''}, k_{t+1}^{''\beta 1}) = \Gamma(k_t^{'}, k_{t+1}^{'\beta 2}) = 0$. If the initial capital stock, k_0, fulfills $k_0 < k_t^{'}$, consumer does not want to invest anything in patience. If $k_0 > k_t^{''}$, consumer wants to invest in patience. What happens, if $k_t^{'} < k_0 < k_t^{''}$? From Figure 4 we conclude that $\Gamma(k_t^{''}, k_{t+1}^{''\beta 2}) > 0$ and $\Gamma(k_t^{'}, k_{t+1}^{'\beta 1}) < 0$. By the continuity of the utility function this, in particular, means that there must be a three **t**uple, ($\underline{k}, \underline{k}^{\beta 1}, \underline{k}^{\beta 2}$), such that $k_t^{'} < \underline{k} < k_t^{''}$ and $V(\underline{k}, \underline{k}^{\beta 1}; \beta_1) = V(\underline{k}, \underline{k}^{\beta 2}; \beta_2)$**.** The allocations, which are indifferent, are perhaps described more clearly in Figure 3 above.

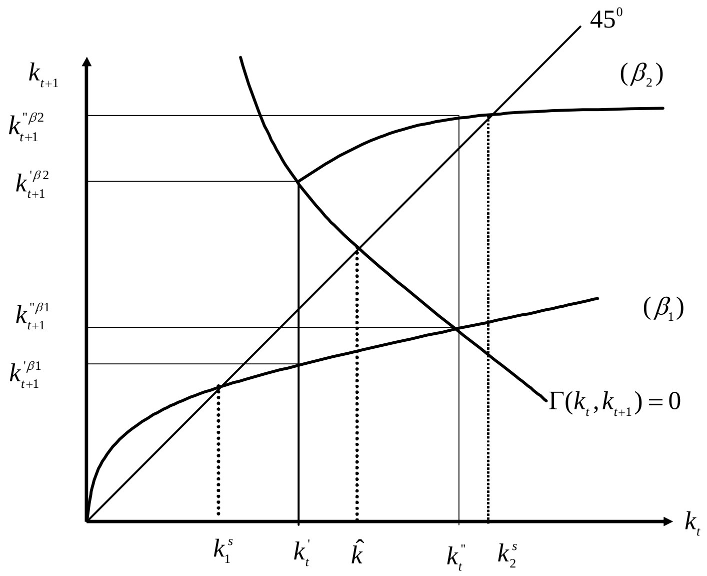

Figure 4.

4 Multiple equilibria and development trap: An example

To investigate equilibria more closely we now turn to the following example: $u(c) = \ln(c)$, and $f(k) = Ak^{\alpha}$, where $1 > \beta_2 > \beta_1 > 0$, $1 > \alpha > 0$ and $A > 0$. The saving functions are

(13) $$s(R_{t+1}, w_t; \beta_1) = \frac{\beta_1}{1+\beta_1} w_t \text{, when } \beta = \beta_1$$

(14) $$s(R_{t+1}, w_t; \beta_2) = \frac{\beta_2}{1+\beta_2}(w_t - \bar{x}) \text{, when } \beta = \beta_2 .$$

Note that saving is an increasing function of the discount factor. The saving functions lead to the following equilibrium dynamics for the capital stock

(15) $$k_{t+1} = \frac{\beta_1}{1+\beta_1}(1-\alpha)Ak_t^{\alpha} \text{, when } \beta = \beta_1$$

(16) $$k_{t+1} = \frac{\beta_2}{1+\beta_2}(1-\alpha)Ak_t^{\alpha} - \frac{\beta_2}{1+\beta_2}\bar{x} \text{, when } \beta = \beta_2 .$$

Equation (16) has a steeper slope than (15), and it has two steady states, if $\bar{x}$ is not too large. The relevant parts of these equations are depicted in Figure 3 above. Given the equilibrium sequence of capital stocks, $\{k_t\}_{t=1}^{\infty}$ with a given level of initial capital, k_0, we can calculate the resulting utility levels under a particular equilibrium sequence. Using a general periodic utility function, and the Cobb-Douglas technology we can express the relation, $\Gamma(k_t, k_{t+1}) = 0$, as

$$(17)\, u\left[(1-\alpha)Ak_t^{\alpha} - k_{t+1} - \bar{x}\right] + \beta_2 u\left[k_{t+1} + \alpha A k_{t+1}^{\alpha}\right] - u\left[(1-\alpha)Ak_t^{\alpha} - k_{t+1}\right] - \beta_1 u\left[k_{t+1} + \alpha A k_{t+1}^{\alpha}\right] = 0$$

Given (17) we explore the effects of the change in total factor productivity on the location of the curve, $\Gamma(k_t, k_{t+1}) = 0$, and thus on the possibility of obtaining poverty traps.

Proposition 2. With a Cobb-Douglas technology the curve, $\Gamma(k_t, k_{t+1}) = 0$, shifts downwards, when the level of total factor productivity, A, is increased.

Proof: We fix the level of the future capital stock, and totally differentiate equation (17) with respect to A and k_t to get $\left\{\left[u'(c_1^{\beta 2}) - u'(c_1^{\beta 1})\right](1-\alpha) + (\beta_2 - \beta_1)u'(c_2)\alpha k_{t+1}^{\alpha}\right\}dA$ $= \left\{\left[u'(c_1^{\beta 1}) - u'(c_1^{\beta 2})\right](1-\alpha)A\right\}dk_{t+1}$, where $c_2 = k_{t+1} + \alpha A k_{t+1}^{\alpha}$. Given Lemma 1, and the fact that $\beta_2 > \beta_1$, we conclude that the term in front of dA is positive and the term in front of dk_{t+1} negative. Thus the curve, $\Gamma(k_t, k_{t+1}) = 0$, shifts downwards, when the total factor productivity is increased. Q.E.D.

This Proposition means that it is harder to get a poverty trap the larger is the total factor productivity parameter.[12]

Next we look for a particular combination, $\{k_t, k_{t+1}\}$, of capital stocks (i.e. also a particular combination of the wage level, w_t, and the interest factor, R_{t+1}) such that consumer is indifferent between investing nothing in patience and investing the amount $\bar{x}$. We take into account the periodic budget constraints: $c_1^t + s_t + x_t = w_t$, $c_2^t = R_{t+1}s_t$, the equilibrium relation, $s_t = k_{t+1}$, and the pricing relations: $Af'(k_t) = r_t$ and $Af(k_t) - Ak_t f'(k_t) = w_t$. Given the functional forms the pricing relations yield: $\alpha A k_t^{\alpha-1} = r_t$ and $(1-\alpha)Ak_t^{\alpha} = w_t$. If combinations $\left\{\underline{k}, \underline{k}^{\beta 1}\right\}$ and $\left\{\underline{k}, \underline{k}^{\beta 2}\right\}$ (consult Figure 3 above) are such that consumer is indifferent, then those points are the solutions for the following three equations:

[12] Schultz (2003) argues that improving health and schooling improves total factor productivity. Proposition 2 tells that there can be a reverse causation, too. This circular causation could be another source for a development trap.

(18)

$$\ln\left[(1-\alpha)A\underline{k}^{\alpha} - \underline{k}^{\beta 1}\right] + \beta_1 \ln\left[\underline{k}^{\beta 1} + \alpha A(\underline{k}^{\beta 1})^{\alpha}\right] = \ln\left[(1-\alpha)A\underline{k}^{\alpha} - \underline{k}^{\beta 2} - \bar{x}\right] + \beta_2 \ln\left[\underline{k}^{\beta 2} + \alpha A(\underline{k}^{\beta 2})^{\alpha}\right]$$

(19) $$\underline{k}^{\beta 2} = \frac{\beta_2}{1+\beta_2}(1-\alpha)A\underline{k}^{\alpha} - \frac{\beta_2}{1+\beta_2}\bar{x}$$

(20) $$\underline{k}^{\beta 1} = \frac{\beta_1}{1+\beta_1}(1-\alpha)A\underline{k}^{\alpha}.$$

Equation (18) gives the indifference of investing and not investing in patience. (19) and (20) indicate that we are picking the capital points from the appropriate capital accumulation curves (see Figure 3).

We use the following numbers to perform the numerical calculation: $\beta_1 = 1/2$, $\beta_2 = 3/4$, $\alpha = 1/3$, $\bar{x} = 0.01$ and $A = 2.7$. We get the following capital stocks as solutions: $\underline{k}^{\beta 1} = .495445$, $\underline{k}^{\beta 2} = .632715$, and $\underline{k} = .56303$. The steady states calculated for both cases are: when $\beta = 1/2$, $k_1^s = .464758$, and when $\beta = 3/4$, $k_2^s = .671115$ (only the larger (stable) steady state is reported). The steady state per capita outputs in a poorer (y_p^*) and wealthier (y_r^*) economies are: $y_p^* = 2.091409$ and $y_r^* = 2.363902$. The more patient economy has 1.13029 times higher GDP per capita. In addition to showing the existence of development traps, this example indicates the complementarity between physical and patience investments.

To show the effect of changes in total factor productivity we consider an example, where $A = 2.75$. We get the following capital stocks as solutions: $\underline{k}^{\beta 1} = .489542$, $\underline{k}^{\beta 2} = .625125$, and $\underline{k} = .514055$. The steady states are: when $\beta = 1/2$, $k_1^s = .477728$, and when $\beta = 3/4$, $k_2^s = .690023$ (only the larger (stable) steady state is reported). The steady state per capita outputs in a poorer (y_p^*) and wealthier (y_r^*) economies are: $y_p^* = 2.14977$ and $y_r^* = 2.43008$. In this example the more patient economy has 1.13039 times higher GDP per capita. The results indicate that with higher TFP the level of the capital stock needed to get development trap is reduced as indicated on Proposition 2. In fact, if $A = 2.8$, there is no development trap. The impacts of higher TFP on capital stock and GDP per capita are magnified, if it is accompanied by investment in patience.

5 Development trap and capital mobility

As an application of our model consider the impacts of capital mobility on the escape from development traps. Factor price frontier (FPF) does not depend on the preferences and thus not, on the fact of economy being in the trap. The FPF can be superimposed in the same figure with the indirect indifference curve (c.f. Figure 1 above).[13]

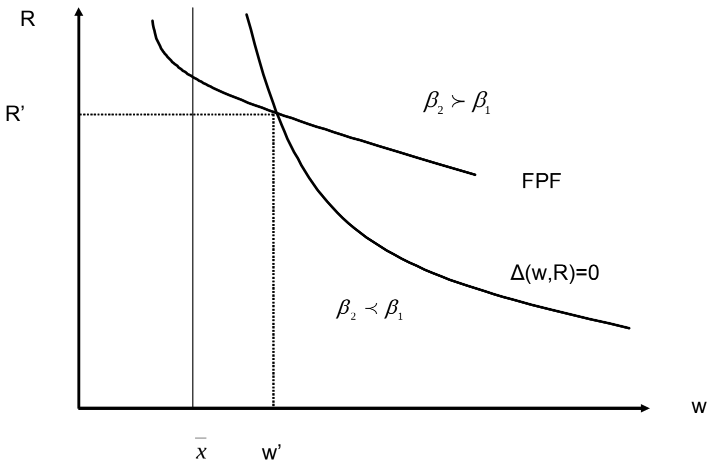

Figure 5.

The slope of the $\Delta(w,R)=0$ -curve depends only on consumer preferences and the slope of the FPF depends only on technology. Hence, either one of these curves can be steeper than the other one. The curves can even intersect at more than one point. In Figure 5 we describe a situation, where FPF is assumed to be flatter than the indifference curve. Initially the economy is at the point, where $R = R'$ and $w = w'$. The situation is such that the consumer is indifferent between being of type β_1 or β_2. Furthermore, assume that the domestic interest factor (R') without capital mobility is higher than the world factor, which is usually the case in developing countries. Then it is natural that capital mobility reduces the interest rate. Since the economy must always lie on the FPF curve, we can see from

[13] Note that the FPF is in w_t, R_t -space while the indifference curve is in w_t, R_{t+1} -space. In what follows we assume that with capital mobility the interest factor is determined by the world market and is constant (with possibly a constant risk premium). Along the FPF unit cost of production equals the unit value of production (= 1) due to perfect competition. Thus, reduction in one factor price must be accompanied by an increase in the return of the other factor. With constant-returns-to-scale technology unit costs depend only on factor prices, not on the level of production.

Figure 5 that the increased capital mobility will definitely switch the economy away from the trap. The reduction in the interest factor increases the wage rate (from FPF) so much that the current young have resources, and are willing, to invest in patience.

The conclusion from Figure 5, however, is not general. In Figure 6 we describe a situation, where FPF is steeper than the indifference curve. Initially the economy is now at the point, where $R = R''$ and $w = w''$. Again capital mobility reduces the interest rate. We conclude from Figure 6 that the increased capital mobility will definitely switch the economy back to the trap.

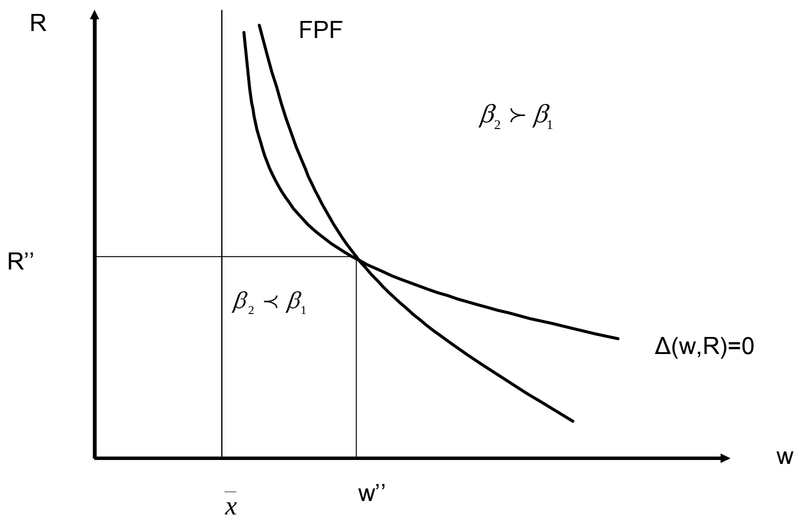

Figure 6.

We collect the previous discussion in Proposition 3.

Proposition 3. The increased international capital mobility does not necessarily help economies to escape from the development trap.

One must be careful in interpreting the fact that higher capital mobility might lead the country into the development trap. With lower interest rates induced by the capital mobility it is clear that investment by firms and hence, output per capita, will increase. What happens is that all of the new investment is financed by foreign borrowing as domestic saving declines. Domestic wages increase but otherwise the increased output will go to the foreign investors. The main point is that liberalization of capital mobility can increase the current account deficit drastically. In general it is known that capital account liberalization increases current account deficit (see e.g. Edwards 1989). But in many cases the deficits have increased very sharply. This is known as the capital inflows problem (see Buffie 1985 and 2001, ch. 8, and Obstfeld 1985). Usually it is explained by the imperfect credibility of the reform programs. Our model provides a new (but complementary) explanation: Private savings can drop sharply when capital account is liberalized.

Our model can also explain why capital account liberalization can reduce current account deficit by increasing private saving despite the reduction in the interest rate. The implication is that in cross-country studies it may be difficult to get any statistically significant estimate of the interest elasticity of saving unless one can properly control for the possible jumps in saving rates.

The points just raised are strengthened since it is straightforward to see that the factor price frontier can cut the indifference curve at least in two points. This means that the impacts of capital mobility can be highly nonlinear. A minor liberalization e.g. can move the economy to the trap, but a substantial liberalization can help the economy to escape it again. In an open economy the factor price frontier shifts up with an increase in total factor productivity. This means that an increase in TFP with a given degree of capital mobility helps the economy to get out of the trap.

6 Conclusions

We have presented a growth model with endogenous time preference to generate development traps. In addition to investing in physical capital, economic agents can invest in patience (or farsightedness) to decrease the rate of time preference.

We have shown that there is no investment in patience, if the economy is very poor. If the economy is wealthy enough there is always investment in patience. We have constructed a robust example of an economy with multiple stable steady states, i.e. development traps. Development trap is not possible, if the economy's total factor productivity is large enough. In particular, our results illustrate the complementarity between physical investment and investment in farsightedness. This prediction of our model seems to conform to stylized empirical observations, since better nutrition, health etc. correlate strongly with the level of an economy's output. Our model may also explain why economic growth is affected by initial conditions.

In addition we have applied our model to show that increased international capital mobility does not necessarily help economies to escape from development traps. The possibility that the economy can drop back to the trap after liberalization is in our model equivalent to a sudden and large increase in current account deficit due to a sharp decline in private saving.

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