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Local Communities in front of Big External Investors: An Opportunity or a Risk?

By **Angelo Antoci**, University of Sassari
Paolo Russu, University of Sassari
Elisa Ticci, European University Institute

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Keywords: Foreign Direct Investments, Environmental Negative Externalities, Structural Changes, Poverty Alleviation

JEL Classification: F21, F43, D62, O11, O13, O15, O41, Q20

Address for correspondence:

Angelo Antoci
DEIR, University of Sassari
via Torre Tonda 34
07100 Sassari
Italy
E-mail: angelo.antoci@virgilio.it

Corso Magenta, 63, 20123 Milano (I), web site: www.feem.it, e-mail: working.papers@feem.it

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Angelo Antoci[*], University of Sassari
Paolo Russu, University of Sassari
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Abstract

In the current age of trade and financial openness, local economies in developing countries are becoming increasingly exposed to external investments. The objective of the proposed two-sector model with environmental externalities is to provide an insight into the interaction between external investors and local communities with a focus upon the different strategies and income sources available to each category. In this context, analysis suggests that environmental regulations and incentives offered in order to attract external capital investment (whether foreign or national) may have an un-uniform impact on the two typologies of actors.

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1 Introduction

Processes of global integration of economies, urbanization and industrialization and the growing demand for raw materials and commodities have increased the exposure of rural economies to external influences and investments. External investments may take the form of foreign direct investments (FDI) or domestic capital flows deriving from urban or richer areas. In both cases, the inflow of capital is usually regarded as beneficial for local economic growth and poverty reduction. Many governments offer significant inducements to attract foreign investors and international financial institutions provide policy makers with suggestions as to the most efficient policies and measures to attract foreign investments. Furthermore, both neoclassical and endogenous economic growth

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[*] Corresponding author; address: DEIR, University of Sassari, via Torre Tonda 34, 07100 Sassari, Italy. E-mail: angelo.antoci@virgilio.it

theories have highlighted different ways in which external capital inflows can stimulate economic growth. Credit constraints may be relaxed via new investments and capital inflows, thus increasing domestic capital stock and facilitating the accumulation of financial capital (Brems 1970). In economies with sufficient absorptive capacity, mergers, acquisitions and greenfield investments may generate spill-over effects on local firms in the form of dissemination of new technology, skills, managerial and marketing practices, access to wider distribution networks, incentive to operate on a more competitive scale, acquisition of greater capacity to penetrate export markets and development of upstream and downstream links between local entrepreneurs and new investors (Findlay 1978, Lall 1978, Blomstrom and Wang 1992, De Mello 1997, Markusen and Venables 1999, Barrios et al. 2003). Other potentially positive effects produced by FDI include creation of employment, infrastructure development, expansion of tax base, fiscal revenues and foreign exchange earnings (Janeba 2004, Amiti and Wakelin 2003, Li and Liu 2005). This may result in economic acceleration which, in turn, may sustain a process of poverty reduction. Suitable conditions required to produce such beneficial results for host economies have been discussed at length in economic literature. Empirical findings and theoretical arguments have underscored the key role of institutional and legal contexts, the degree of the competition or complementarity with local activities, the extent of the technological gap, the level of human capital and development of host economies, the development of financial markets and receptiveness to trade, as well as the role of investment regulations and labor intensity in investment sectors (Blomstrom et al. 1994, Balasubramanyam et al. 1996, Borenzstein et. al. 1998, Lim 2001, Alfaro et al. 2004). In addition, the sectorial composition of FDI has been regarded as a further factor which influences the growth of the host economy. If the impact of FDI on the primary sector is considered to be limited or even negative, more far reaching positive connections and spill-overs are expected in the case of capital flow into the manufacturing sector (UNCTAD 2001, Aykut and Sayek 2007, Chakrabortya and Nunnenkamp 2008). All these conditions, identified in economic literature as being relevant in shaping the effects of growth of external capital flows, may explain the considerable degree of heterogeneity in the empirical research with regard to the nexus between FDI and output growth.

Less attention has been dedicated to the potentially negative impacts of external capital investments notwithstanding the findings of some authors that in certain countries foreign investments can harm local firms and have negative effects on economic growth in the short term (Saltz 1992, Aitken and Harrison 1999, Djankov and Hoekman 2000, Damijan et al. 2001, Konings 2001, Agosin and Machado 2005, Herzer et. al. 2008). Moreover a number of studies suggest that there may be a minimum level of absorptive capacity below which productivity spill-overs from FDI are negligible or negative and that it is only above this threshold that FDI generates positive effects (Barrios et al. 2005, Girma 2005). One of the explanations put forward to account for such findings is that of a possible negative competition impact which may dominate positive spill-overs resulting in the crowding-out of domestic activities. However, most of these studies have focused on intra-industry and vertical competition, while the impact of externalities across sectors has been often overlooked.

The objective of this paper is to develop a unified model which incorporates both the positive and the negative effects of external investment on local communities. We focus on a scenario which includes some of the factors neglected by the literature, but excludes others which have already been widely discussed. The model considers inter-industry linkages, including environmental externalities and incorporating direct positive impact of external capital flows, but it excludes other positive indirect effects. More precisely, the potential effect of poverty-reduction of external capital flows operates through the labor market by creating new labor opportunities and raising labor demand. Positive spill-overs on host economies are, instead, excluded and local and new activities are not connected by inward or forward linkages. Local and new activities are characterized by different production functions, that is, they belong to different sectors and they are not competitors[1]. In these cases, external investments might be attracted by low labor costs, public incentives, high endowments or the low cost of natural resources rather than by complementarities with local firms. Secondly, we introduce the analysis of a type of externality which has not received much attention in the debate on FDI impact on domestic firms, namely environmental damage. In the proposed model, local activities cause environmental damage but external investors also cause negative externalities on natural resources which are used by local firms for production. Finally, it is worth emphasising that although in the literature on FDI is a recognised term of reference, in this model we use the term "external" to refer not just to foreign investors, but also national entrepreneurs whose capital derived from a source outside the local economy.

This scenario reflects some characteristics of several developing countries where national economies can be profoundly segmented and regionally differentiated in terms of economic development, access to capital markets and dependence on natural resources. In some areas, local borrowing and investment capacity is more limited than in other regions, human activities can be profoundly dependent on environmental dynamics and natural systems are not just amenities but also a means of subsistence or valuable economic services and assets. In such settings, external investors usually hold the large majority of man-made capital stock. Moreover, environmental externalities and resource degradation can have a dramatic impact on local activities even if national accounting and household surveys cannot capture them because the effects involve only a circumscribed region or just informal activities or simply because environmental services encounter problems of measurement. Indeed, all over the world increasing struggle of local communities against external agents which threaten their environment suggest that such interaction may not be insignificant. Most cases of grassroots protests are against environmental degradation caused by extractive, fishery and agriculture activities of large firms. Case stud-

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[1] Note that the main transmission channels of spill-overs are usually expected to be more active within the same industry than across sectors.

ies of struggles by poor communities to gain control over natural resources and to deal with injustice and environmental degradation created by big companies, for instance, have been documented, among others, by Ghai and Vivian (1992)[2], Lee and So (1999)[3], Martines-Alier (2002)[4]. In some cases, the impact has been so devastating as to provoke worldwide media interest. For example, both international press and international organizations (UNDP 2006) have acknowledged that oil and gas exploration and exploitation, urbanization and industrialization are pushing the Niger Delta towards ecological disaster with dramatic consequences on social stability and on the life of the indigenous population, nearly 60 per cent of whom depend on the natural environment for their livelihood (UNDP 2006). Since the late Eighties, the impact on poverty and deforestation produced by large mechanized agriculture, livestock and timber activities has been analyzed by De Janvry and Garcia (1988), Heath and Binswanger (1996), Leonard (1989). More recently, Chomitz (2008) has reviewed other examples of the displacement of forest dwellers and the loss of assets caused as a result of more wealthy players looking after their own interests. In other cases, local communities are negatively affected by processes of industrialization and urbanization. China provides some of the most symbolic examples of rural communities harmed by environmental externalities and disenfranchisement from natural resource use caused by the arrival of new manufacturing firms. Heavy damages to agriculture and fishery sectors, other than health hazards, caused by Chinese industrialization have been documented, amongst others, by Economy (2004) and World Bank (2007). By way of example, it is estimated that every year 1.8 percent of the value of Chinese agricultural output is damaged by acid rains, and, as recently as 2003, fishery pollution accidents caused losses to commercial fishery amounting to more than 500 million USD (World Bank 2007), without taking into account the impact of chronic water pollution and effects on self-consumption of fish. Moreover, UNDP (2005) reported that between 1987 and 2001, non agricultural projects are estimated to have brought about land expropriation of 40-50 million Chinese farmers (whether legally or illegally).

Finally, even if no consensus has been reached in literature on the "pollution

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[2] This study investigates the action of grassroots movements against the owners of trawlers in Kerala, and logging contractors and energy companies in Hymalayan region.

[3] Lee and So explore the proliferation of grassroots movements against investment- and trade- induced problems in South Asia which, according to the authors, are often caused by multinational corporations which extract raw materials or move their production plants in this region.

[4] Martines-Alier describes the actions of Oilwatch, a south-south network concerned about the loss of biodiversity and forests, soil and water pollution, violations of human rights and indigenous territorial rights caused by oil and gas extraction in tropical countries. He also deals with the growing social resistance against export oriented commercial shrimp farming in several Asian and Latin American countries. In many cases, the expansion of legal or illegal shrimp ponds has caused the eviction of small scale fishermen and the destruction of coastal mangrove forests to the detriment of local communities. Finally he considers struggles against mining activities responsible for depletion and contamination of water, air and soil pollution.

havens hypothesis"[5], empirical evidence [6] increasingly suggests that the adoption of cleaner technologies and changes towards less environmentally intensive consumption explain only a part of the reduction in the pollution intensity of production systems in Northern countries. In fact the growth and composition of imports have also significantly contributed to pollution reductions of high income countries. The flip-side of these processes is the absorption of environmentally intensive industries by the developing countries. In addition, with the fast economic growth of large and intensely populated emerging economies (such as India, China, Brazil), the possibility for such countries to rely on changes in level and composition of imports to reduce pollution may be restricted in the future. All these factors suggest that the development process of today's developing countries cannot be viewed in isolation from environmental pressures exerted by external forces. This paper is a step towards the analysis of the role of these forces for poverty reduction.

The article is organized as follows. Sections 2 and 3 present the model; section 4 investigates some possible dynamics that may emerge from the model; section 5 contains comparative statics results and highlights their implications in terms of welfare; section 6 draws conclusions.

2 The proposed model

We consider a small open economy with three factors of production: labor, a renewable natural resource and physical capital. In this economy, agents belong to two different communities: "External Investors" (I-agents) and "Local Agents" (L-agents). Both communities are constituted by a continuum of identical individuals and the size of each community is equal to 1. The I-agents are endowed with physical capital which can be invested in the economy in question or elsewhere. We assume that they do not face credit constraints and their availability of physical capital is "unlimited". Therefore they will continue to invest their capital in the economy as long as the return on capital generated is higher than in other economies. I-agents also hire labor force and undertake all their potential work - represented by a fixed amount of entrepreneurial activity - in what we call "capitalistic sector" or "market sector". The asset of the L-agents is laborforce and they have to choose how to distribute such asset between two

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[5] The pollution havens effect is the delocalization of polluting industries to countries with more lenient environmental controls and regulations as response to an increase in domestic regulatory stringency. For a survey on this topic see Brunnermeier and Levinson (2004).

[6] Using data on U.S. regulations and trade with Canada and Mexico for 130 manufacturing industries from 1977 to 1986, Levison and Taylor (2008), for instance, find that an 1% increase in PAC predicts a 0.4% increase in net imports from Mexico and a 0.6% increase from Canada and for the industries whose PAC increased most, the rise in net imports due to increased pollution costs represents a considerable fraction of the increase in total trade volumes over the period. Ghertner and Fripp (2007) analyze US trade data for 1998-2004 reaching similar conclusions: the US has partially shifted the environmental impact of its consumption to other countries through trade. Other direct and indirect evidences on outsourcing of dirty industries are provided by Suri and Chapman, (1998), Fischer-Kowalski and Amann (2001), Cole (2004).

activities: working as employees for External Investors in the capitalistic sector or direct exploitation of the natural resource. Let us say that "local sector" denotes production of the Local Agents. Given that L- and I- agents' investments in physical capital follow different mechanisms and rules, we assume that the capital market is completely segmented and it is accessible only by the External Investors, while Local Agents can invest only their savings. We assume that the production functions of the two sectors satisfy Inada conditions, are concave, increasing and homogenous of degree 1 in their inputs. The production function of the representative L-agent is given by:

$$Y_L = K_L^{\alpha} E^{\beta} L^{1-\alpha-\beta}$$

where:

E is the stock of a free access environmental resource;

L is the amount of time that the representative L-agent spends on local sector production;

K_L is the physical capital accumulated by the representative L-agent;

$\alpha > 0$, $\beta > 0$, $\alpha + \beta < 1$ hold.

The L-agent's total amount of time is normalized to 1 and leisure is excluded, thus $1 - L$ represents the L-agent's labor employed by the representative I-agent as wage work. The production function of the representative External Investor is represented by a Cobb-Douglas function:

$$Y_I = K_I^{\gamma} (1 - L)^{1-\gamma} \tag{1}$$

where K_I denotes the stock of physical capital invested by the representative I-agent in the economy. The I-agents choose their labor demand $1 - L$ and the stock of physical capital K_I which they invest in the economy in order to maximize their profits:

$$Y_I - w(1 - L) - rK_I$$

where w and r are, respectively, the wage and the interest rate, considered as exogenously determined by each I-agent. However, the wage w is endogenously set in the economy by the labor market equilibrium condition (we exclude the import of labor from other economies), while r is an exogenous parameter. We assume that K_I inflow is potentially unlimited. Therefore the dynamics of the same are not linked to I-agents' savings but only to productivity of K_I (which, in turn, depends on L and K_I).

This is a stylized scenario, but it can represent the main differences between capital accumulation dynamics which have their origin in the choices of local populations and those generated by the choices of external investors who enter small economies dominated by primary activities. The use of labor intensive techniques, employment of family labor and constraints in access to credit markets are often key features of the production activity of local communities. External investors, in contrast, usually manage more capital intensive activities based on employment of wage labor. Their companies or firms are able to gain access to national and international capital markets; they therefore rely on financing sources coming from outside the economy and their ability to accumulate physical capital is in no way comparable to local population's accumulation potential. In addition, we assume that their production is characterized by a higher degree of mobility because it relies on wage labor which is also available in other economies and on physical capital that can be employed elsewhere [7]. Therefore they invest in a economy only if their investment is remunerative and they can defend themselves against a reduction in labor or capital return in the local economy by moving their capital to other markets. On the other hand, without loss of plausibility, we assume that two productive inputs employed by the local sector, namely labor and the natural resource, constitute capital which is less mobile than physical. Consequently, local producers can rely on fewer strategies than external investors in order to confront reduction in labor or capital productivity. They can only choose the level of their savings and the allocation of their labor between the two sectors. More precisely, we assume that the representative L-agent solves the following maximization problem:

$$\max_{L,C_L} \int_0^{\infty} (\ln C_L)\, e^{-\delta t} dt \tag{2}$$

subject to:

$$\dot{K}_L = K_L^{\alpha} E^{\beta} L^{1-\alpha-\beta} + (1-L)w - C_L$$

where the positive parameter δ represents the subjective interest rate. The representative local agent invests all his savings remaining after financing his consumption C_L in physical capital. His resources come from self-employment in the local sector ($K_L^{\alpha} E^{\beta} L^{1-\alpha-\beta}$) and from wage labor in the capitalistic sector ($(1-L)w$).

The dynamics of E are described by a logistic function modified by human intervention:

$$\dot{E} = E(\overline{E} - E) - \epsilon \overline{Y}_L - \eta \overline{Y}_I$$

$\overline{Y}_L$ and $\overline{Y}_I$ are the aggregate values of Y_L and Y_I, respectively and ϵ and η are positive parameters measuring the environmental impact caused, respectively, by the aggregate production of L and I-agents. The positive parameter $\overline{E}$ represents the carrying capacity of the environmental resource.

Each economic agent considers to be negligible the effect of his choices on the dynamics of E and does not internalize it. That is, $\overline{Y}_L$ and $\overline{Y}_I$ are considered to be exogenous and this implies that the evolution of E is taken as given in problem (2). As a result, they behave without taking into account the shadow value of the natural resource and nobody has an incentive to preserve or restore the same. Consequently, the resulting dynamics are not optimal. However, the

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[7] In the real world, capital demobilization faces some constraints and it is often observed that flows of direct productive investment are more stable than portfolio flows and bank lending. However, in this model we compare local and external producers and we consider that the degree of freedom in location choices is much higher for external investors than for local small producers.

trajectories under such dynamics are Nash equilibria, in the sense that no agent has an incentive to modify his choices along each trajectory generated by the model for so long as others do not modify theirs.

Working under the assumption that each typology of agents consists of a continuum of identical individuals of size 1, (ex post) aggregate outputs $\overline{Y}_L$ and $\overline{Y}_I$ coincide with pro-capite values Y_L and Y_I, respectively.

Problem (2) will be analyzed with the following restrictions on variables and parameters: K, $E > 0$; α, β, γ, δ, ϵ, η, r, $\overline{E} > 0$; $\alpha + \beta < 1$.

3 Dynamics generated by the model

The dynamics generated by the model are obtained by applying the *Maximum Principle* to the maximization problem of the representative L-agent, under the equilibrium condition in the labor market. The current value Hamiltonian function associated to problem (2) is (see Wirl 1997):

$$H = \ln C_L + \lambda \left[K_L^\alpha E^\beta L^{1-\alpha-\beta} + (1-L)w - C_L \right]$$

where λ is the co-state variable associated to K_L. By applying the Maximum Principle, the dynamics of the economy are described by the equations:

$$\dot{K}_L = \frac{\partial H}{\partial \lambda} = K_L^\alpha E^\beta L^{1-\alpha-\beta} + (1-L)w - C_L \tag{3}$$

$$\dot{\lambda} = \delta\lambda - \frac{\partial H}{\partial K_L} = \lambda \left[\delta - \alpha K_L^{\alpha-1} E^\beta L^{1-\alpha-\beta} \right] \tag{4}$$

with the constraint:

$$\dot{E} = E(\overline{E} - E) - \epsilon \overline{Y}_L - \eta \overline{Y}_I \tag{5}$$

where C_L and L satisfy the following conditions[8]:

$$\frac{\partial H}{\partial C_L} = \frac{1}{C_L} - \lambda = 0 \tag{6}$$

$$\frac{\partial H}{\partial L} = \lambda \left[(1-\alpha-\beta) K_L^\alpha E^\beta L^{-\alpha-\beta} - w \right] = 0, \text{ i.e. } w = (1-\alpha-\beta) K_L^\alpha E^\beta L^{-\alpha-\beta} \tag{7}$$

At the same time, the representative I-agent chooses the level of labor demand $1 - L$ and physical capital K_I employed in the capitalistic production in order to maximize her profit function:

$$\Pi_I = K_I^\gamma (1-L)^{1-\gamma} - w(1-L) - rK_I \tag{8}$$

This gives rise to the following first order conditions:

$$\frac{\partial \Pi_I}{\partial (1-L)} = (1-\gamma) K_I^\gamma (1-L)^{-\gamma} - w = 0 \tag{9}$$

---

[8] Notice that, in our context, $C_L > 0$ and $1 > L > 0$ always hold.

$$\frac{\partial \Pi_I}{\partial K_I} = \gamma K_I^{\gamma-1}(1-L)^{1-\gamma} - r = 0 \tag{10}$$

3.1 Labor market equilibrium

The labor market is perfectly competitive and wages are flexible. I- and L-agents take w as given, but the wage rate and labor allocation between the two sectors continue to change until the labor demand is equal to labor supply. The labor market equilibrium condition is given by:

$$(1-\gamma)K_I^{\gamma}(1-L)^{-\gamma} = (1-\alpha-\beta)\, K_L^{\alpha} E^{\beta} L^{-\alpha-\beta} \tag{11}$$

By equation (10) we have:

$$K_I = \left(\frac{\gamma}{r}\right)^{\frac{1}{1-\gamma}} (1-L) \tag{12}$$

and substituting K_I in (11) we obtain:

$$L = \Gamma \left(K_L^{\alpha} E^{\beta}\right)^{\frac{1}{\alpha+\beta}} \tag{13}$$

where:

$$\Gamma := \left[\frac{1-\alpha-\beta}{(1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}}\right]^{\frac{1}{\alpha+\beta}}$$

Function (13) identifies the labor market equilibrium value L^* of L if the right side of (13) is lower than 1; otherwise, the equilibrium value of L is 1, that is:

$$L^* = \min\left\{1,\, \Gamma \left(K_L^{\alpha} E^{\beta}\right)^{\frac{1}{\alpha+\beta}}\right\} \tag{14}$$

The economy is specialized in the production of the L-sector if $L^* = 1$. Note that condition 9 excludes the specialization in the production of the capitalistic sector (i.e. $L^* > 0$ always). Therefore two cases are distinguished, the case *without specialization* (in the local sector) and the case *with specialization.*

3.2 Case without specialization

If $\Gamma \left(K_L^{\alpha} E^{\beta}\right)^{\frac{1}{\alpha+\beta}} < 1$, then L-agents spend a positive fraction of their time endowment working in the capitalistic sector and condition (13) identifies the value of L. Moreover, the following proposition holds:

Proposition 1 *The equilibrium wage rate is constant and is given by* $w = (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}$.

Proof. By substituting (13) in (7) we obtain:

$$\begin{aligned} w &= (1-\alpha-\beta)\, K_L^{\alpha} E^{\beta} L^{-\alpha-\beta} = \\ &= (1-\alpha-\beta)\, K_L^{\alpha} E^{\beta} \left[\Gamma \left(K_L^{\alpha} E^{\beta}\right)^{\frac{1}{\alpha+\beta}}\right]^{-\alpha-\beta} = \\ &= (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} \end{aligned}$$

■

In such a context, the dynamic system (3)-(5) can be expressed as follows:

$$\begin{aligned}
\dot{K}_L &= \Gamma\left[T^{-\alpha-\beta}-(1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}\right]\left(K_L^{\alpha}E^{\beta}\right)^{\frac{1}{\alpha+\beta}}+(1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}-\frac{1}{\lambda} \qquad (15)\\
\dot{E} &= E(\overline{E}-E)+\Gamma\left[\eta\left(\frac{r}{\gamma}\right)^{\frac{\gamma}{\gamma-1}}-\epsilon\Gamma^{-\alpha-\beta}\right]\left(K_L^{\alpha}E^{\beta}\right)^{\frac{1}{\alpha+\beta}}-\eta\left(\frac{r}{\gamma}\right)^{\frac{\gamma}{\gamma-1}} \qquad (16)\\
\dot{\lambda} &= \lambda\left[\delta-\frac{\alpha\Gamma^{1-\alpha-\beta}\left(K_L^{\alpha}E^{\beta}\right)^{\frac{1}{\alpha+\beta}}}{K_L}\right] \qquad (17)
\end{aligned}$$

3.3 Case with specialization

If $\Gamma\left[K_L^{\alpha}E^{\beta}\right]^{\frac{1}{\alpha+\beta}} \geq 1$, then the L-agents spend all their time endowment working in the L-sector, that is $L^* = 1$, and the dynamic system (3)-(5) becomes:

$$\dot{K}_L = K_L^{\alpha}E^{\beta} - \frac{1}{\lambda} \qquad (18)$$

$$\dot{E} = E(\overline{E}-E) - \epsilon K_L^{\alpha}E^{\beta} \qquad (19)$$

$$\dot{\lambda} = \lambda\left(\delta - \alpha K_L^{\alpha-1}E^{\beta}\right) \qquad (20)$$

4 Analysis of dynamics: existence and stability of stationary states

4.1 Preliminary results

A stationary state $P^* = (E^*, K_L^*, \lambda^*)$ of the dynamic system (3)-(5) is a solution of the system $\dot{K}_L = 0$, $\dot{E} = 0$, $\dot{\lambda} = 0$. From equation $\dot{\lambda} = 0$, in the case without specialization, we obtain:

$$\left(K_L^{\alpha}E^{\beta}\right)^{\frac{1}{\alpha+\beta}} = \frac{\delta K_L}{\alpha\Gamma^{1-\alpha-\beta}} \qquad (21)$$

Substituting (21) in (13), we get:

$$L^* = \Gamma\frac{\delta K_L}{\alpha\Gamma^{1-\alpha-\beta}} = \frac{K_L}{\alpha\delta^{-1}\Gamma^{-\alpha-\beta}} \qquad (22)$$

Consequently $L^* < 1$ if and only if $K_L < \alpha\delta^{-1}\Gamma^{-\alpha-\beta}$. This implies that the stationary states without specialization lie, in the plane (E, K_L), below the straight line:

$$K_L = \overline{K}_L := \alpha\delta^{-1}\Gamma^{-\alpha-\beta} \qquad (23)$$

while those with full specialization lie above it.

It is easy to check that, below $\overline{K}_L$, the stationary states (without specialization) are given by the intersections between the two following curves:

$$K_L = f(E) := \Omega E \tag{24}$$

$$K_L = g(E) := \frac{\eta \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} - E(\overline{E} - E)}{\Lambda} \tag{25}$$

where:

$$\Omega := \left(\alpha \delta^{-1} \Gamma^{1-\alpha-\beta}\right)^{\frac{\alpha+\beta}{\beta}} \tag{26}$$

$$\Lambda := \frac{\delta \left[\eta(1-\alpha-\beta) - \epsilon(1-\gamma)\right]}{\alpha(1-\gamma)} \tag{27}$$

Notice that:

$$\Lambda > 0 \quad if \quad \epsilon < \epsilon_\Lambda := \eta \frac{1-\alpha-\beta}{1-\gamma} \tag{28}$$

While, above $\overline{K}_L$, the stationary states (with specialization) are given by the intersections between the following two curves:

$$K_L = f_1(E) := \left(\frac{\alpha}{\delta}\right)^{\frac{1}{1-\alpha}} E^{\frac{\beta}{1-\alpha}} \tag{29}$$

$$K_L = g_1(E) := \frac{\alpha}{\delta\epsilon} E(\overline{E} - E) \tag{30}$$

4.2 Multiplicity of stationary states

The following propositions deal with the problem of the existence and numerosity of the stationary states of the dynamic system (3)-(5).

Proposition 2 *The dynamic system (3)-(5) admits at most four stationary states: A and B with $L^* < 1$, A_1 and B_1 with $L^* = 1$.*

Proof. The graph of $g(E)$ is a parabola while the graph of $f(E)$ is a straight line, consequently $f(E)$ and $g(E)$ have at most two intersections. Analogously, both $f_1(E)$ and $g_1(E)$ are concave, however the difference $f_1(E) - g_1(E) = E\left[\left(\frac{\alpha}{\delta}\right)^{\frac{1}{1-\alpha}} E^{\frac{\alpha+\beta-1}{1-\alpha}} + \frac{\alpha}{\delta\epsilon}E - \frac{\alpha}{\delta\epsilon}\overline{E}\right]$ has at most two zeros with $E > 0$. ■

By the symbol A_1 (respectively, B_1) we shall refer to the stationary state $P^* = (E^*, K_L^*, \lambda^*)$ with specialization satisfying the condition $f_1'(E^*) < g_1'(E^*)$ (respectively, $f_1'(E^*) > g_1'(E^*)$); analogously, by the symbol A (respectively, B) we shall refer to the stationary state without specialization satisfying the condition $sign\,(\Lambda) = sign\,[f'(E^*) - g'(E^*)]$ (respectively, $sign\,(\Lambda) = sign\,[g'(E^*) - f'(E^*)]$).

To express the next proposition, we have to define the following threshold values (see the proof of the proposition):

$$
\begin{aligned}
\overline{E}_1(\epsilon,\eta) \quad &: \quad = 2\sqrt{\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}\eta} - \Omega\frac{\delta(1-\alpha-\beta)}{\alpha(1-\gamma)}\eta + \Omega\frac{\delta}{\alpha}\epsilon && (31)\\
\overline{E}_2(\epsilon) \quad &: \quad = \frac{\overline{K}_L}{\Omega} + \frac{\delta\Omega}{\alpha}\epsilon && (32)\\
\overline{E}_3(\epsilon) \quad &: \quad = \left(2-\frac{\beta}{1-\alpha}\right)\left[\frac{\left(\frac{\alpha}{\delta}\right)^{\frac{\alpha}{1-\alpha}}}{\left(1-\frac{\beta}{1-\alpha}\right)^{\frac{1-\alpha-\beta}{1-\alpha}}}\right]\epsilon^{\frac{1-\alpha}{2(1-\alpha)-\beta}} && (33)\\
\epsilon_T \quad &: \quad = \left(\frac{\delta}{\alpha}\right)^{\frac{2-\beta}{\beta}}\frac{1-\alpha}{1-\alpha-\beta}\overline{K}_L^{\frac{2(1-\alpha)-\beta}{\beta}} && (34)\\
\eta_T \quad &: \quad = \left(\frac{\overline{K}_L}{\Omega}\right)^2\left(\frac{r}{\gamma}\right)^{\frac{\gamma}{1-\gamma}} && (35)
\end{aligned}
$$

Proposition 3 *The stationary states of the dynamic system (3)-(5) are (see Figure 1)*[9]*:*

1) A, B, A_1 and B_1 if and only if (iff):

$$\eta < \eta_T, \quad \epsilon > \epsilon_T, \quad \overline{E}_3(\epsilon) < \overline{E} < \overline{E}_2(\epsilon)$$

2) A and B iff:

$$\eta < \eta_T, \quad \epsilon < \epsilon_T, \quad \overline{E}_1(\epsilon,\eta) < \overline{E} < \overline{E}_2(\epsilon)$$

or

$$\eta < \eta_T, \quad \epsilon > \epsilon_T, \quad \overline{E}_1(\epsilon,\eta) < \overline{E} < \overline{E}_3(\epsilon)$$

3) A_1 and B_1 iff:

$$\eta < \frac{1-\gamma}{1-\alpha-\beta}\epsilon_T \qquad \epsilon > \epsilon_T, \quad \overline{E}_3(\epsilon) < \overline{E} < \overline{E}_1(\epsilon)$$

or

$$\eta > \frac{1-\gamma}{1-\alpha-\beta}\epsilon_T \qquad \epsilon_T < \epsilon < \epsilon_\Lambda, \quad \overline{E}_3(\epsilon) < \overline{E} < \overline{E}_2(\epsilon)$$

4) A and B_1 iff:

$$\overline{E} > \overline{E}_2(\epsilon)$$

No stationary state exists in the remaining cases.

---

[9] For simplicity, in this classification, we do not take into account the "non robust" cases corresponding to an equality condition on parameter values (for example, the cases in which $\eta = \eta_T$, $\epsilon = \epsilon_T$ or $\overline{E} = \overline{E}_3(\epsilon)$).

Proof. Notice that: a) $f(E)$ and $f_1(E)$ do not depend on the parameter $\overline{E}$ (see (24) and (29)); b) if the value of the parameter $\overline{E}$ increases, the graph of $g(E)$ moves up (in the plane (E, K_L)) in the case $\Lambda < 0$ and moves down in the case $\Lambda > 0$; c) if the value of the parameter $\overline{E}$ increases, the graph of $g_1(E)$ moves up.

The classification given in this Proposition, based on the values of the parameters $\overline{E}$, ϵ, η and represented in the plane $(\epsilon, \overline{E})$ (see Figure 1), can be easily checked considering that the thresholds values defined in formulas (31)-(35) are characterized by the following properties (which can be easily proved):

1) given ϵ and η, the function $\overline{E}_1(\epsilon, \eta)$ (see (31)) indicates the value of the parameter $\overline{E}$ such that the curves $f(E)$ and $g(E)$ are tangent;

2) given ϵ, the function $\overline{E}_2(\epsilon)$ (see (32)) indicates the value of the parameter $\overline{E}$ such that the curves $f(E)$ and $g(E)$ have an intersection point along the horizontal line $K_L = \overline{K}_L$ ($\overline{K}_L$ is defined in (23)[10];

3) given ϵ, the function $\overline{E}_3(\epsilon)$ (see (33)) indicates the value of the parameter $\overline{E}$ such that the curves $f_1(E)$ and $g_1(E)$ are tangent;

4) the tangency point between the curves $f_1(E)$ and $g_1(E)$ lies above the horizontal line $K_L = \overline{K}_L$ if and only if the condition $\epsilon > \epsilon_T$ (see (34)) is satisfied;

5) the tangency point between the curves $f(E)$ and $g(E)$ lies below the horizontal line $K_L = \overline{K}_L$ if and only if the condition $\eta < \eta_T$ (see (35)) is satisfied;

6) $\epsilon_\Lambda < \epsilon_T$ holds (remember that $\Lambda > 0$ iff $\epsilon < \epsilon_\Lambda$, see (28)) if and only if $\eta < \overline{\eta} := \dfrac{1-\gamma}{1-\alpha-\beta}\epsilon_T$, where $\overline{\eta} > \eta_T$ always holds;

7) the graphs of $\overline{E}_1(\epsilon, \eta)$ and $\overline{E}_2(\epsilon)$, in the plane $(\epsilon, \overline{E})$, are two parallel straight lines; they coincide for $\eta = \eta_T$ while $\overline{E}_1(\epsilon, \eta)$ lies below $\overline{E}_2(\epsilon)$ for $\eta \neq \eta_T$;

8) the function $\overline{E}_3(\epsilon)$ is strictly concave in ϵ, its graph lies below the straight line $\overline{E}_2(\epsilon)$ and is always tangent to it for $\epsilon = \epsilon_T$. ■

Remember that the parameter $\overline{E}$ represents the carrying capacity of the environmental resource E while the parameters ϵ and η measure, respectively, the environmental impact caused by the aggregate production of L-agents and I-agents. Figure 1 shows the regions, in the plane $(\epsilon, \overline{E})$, corresponding to cases 1-4 of the above proposition. Notice that:

i) case 1 (that in which the stationary states are A, B, A_1, B_1) can be only observed for low enough values of η and high enough values of ϵ, that is for $\eta < \eta_T$ and $\epsilon > \epsilon_T$ respectively (see Figure 1.a);

ii) case 2 (that in which the stationary states are A, B) can be only observed for low enough values of η, that is for $\eta < \eta_T$ (see Figure 1.a);

iii) for $\eta > \eta_T$, only case 3 (that in which the stationary states are A_1, B_1) and case 4 (that in which the stationary states are A, B_1) can occur;

iv) case 3 can be only observed in the context $\Lambda > 0$ if the value of η is high enough, that is for $\eta > \dfrac{1-\gamma}{1-\alpha-\beta}\epsilon_T$ (see Figure 1.c);

---

[10] Notice that, in such a case, the intersection point between $f(E)$ and $g(E)$ coincides with that between $f_1(E)$ and $g_1(E)$.

v) if, given ϵ and η, the value of $\overline{E}$ is high enough, then only case 4 can be observed (see Figures 1.a-1.c).

4.3 Stability

Let $P^* = (E^*, K^*, \lambda^*)$ be a stationary state of the dynamic system (3)-(5). The stability properties of P^* depend on the signs of the real parts of the eigenvalues associated to the Jacobian matrix J evaluated at P^*. We shall say that P^* is *saddle-point stable* if J has two eigenvalues with negative real parts, i.e. if P^* has a 2-dimensional stable manifold. As a matter of fact, under the perfect foresight assumption, if the stationary state has a 2-dimensional stable manifold, given the initial values $E(0)$ and $K(0)$ of the state variables E and K, L-agents are able to fix the initial value $\lambda(0)$ of the jumping variable λ so that the growth trajectory starting from $(E(0), K(0), \lambda(0))$ approaches P^*. Therefore the stationary state can be reached by growth trajectories. If the stationary state has less than two eigenvalues with negative real parts, then given the initial values $E(0)$ and $K(0)$, a value $\lambda(0)$ does not (generically) exist so that the growth trajectory starting from $(K(0), E(0), \lambda(0))$ approaches the stationary state.

The following proposition concerns the stability properties of the stationary states A_1 and B_1 in the regime with specialization (i.e. $L^* = 1$).

Proposition 4 *In the regime with specialization, we have that:*

1) If $f_1'(E^*) < g_1'(E^*)$ (that is, P^* is of the type A_1), then P^* has two eigenvalues with strictly positive real parts and one with strictly negative real part.

2) If $f_1'(E^*) > g_1'(E^*)$ (that is, P^* is of the type B_1), then P^* is saddle-point stable or it has three eigenvalues with strictly positive real parts; a sufficient condition for saddle-point stability is:

$$E^* > \frac{\overline{E}}{2} - \frac{\delta(1-\alpha)}{2\alpha}$$

Proof. See Appendix A ■

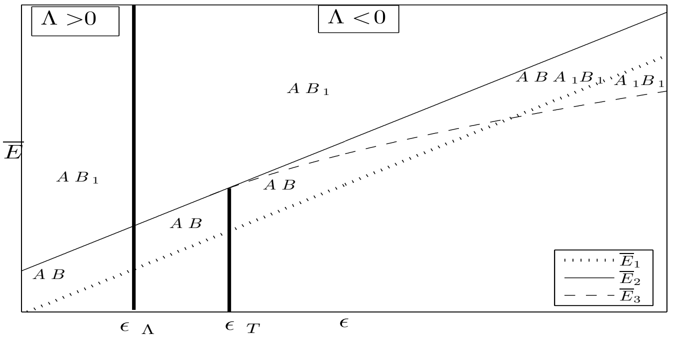
The following proposition deals with the stability properties of the stationary states A and B in the regime without specialization (i.e. $L^* < 1$).

Proposition 5 *In the regime without specialization, we have that:*

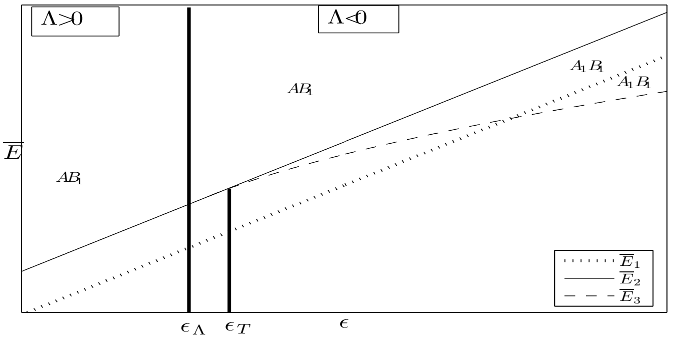
1) If sign (Λ) = sign $[f'(E^*) - g'(E^*)]$ (that is, P^* is of the type A), then P^* has two eigenvalues with strictly positive real parts and one with strictly negative real part.

2) If sign (Λ) = sign $[g'(E^*) - f'(E^*)]$ (that is, P^* is of the type B), then P^* is saddle-point stable or it has three eigenvalues with strictly positive real parts; a sufficient condition for saddle-point stability is:

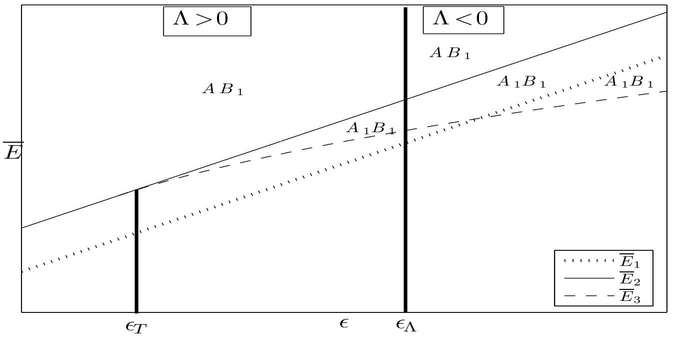
$$E^* > \frac{\overline{E}}{2} - \frac{\beta\delta}{2\alpha(\alpha+\beta)}$$



(a) $\eta < \eta_T$



(b) $\eta_T < \eta < \overline{\eta} = \dfrac{1-\gamma}{1-\alpha-\beta}\epsilon_T$



(c) $\eta > \overline{\eta}$

Figure 1: Threshold values in the plane $(\epsilon, \overline{E})$ and existing stationary states.

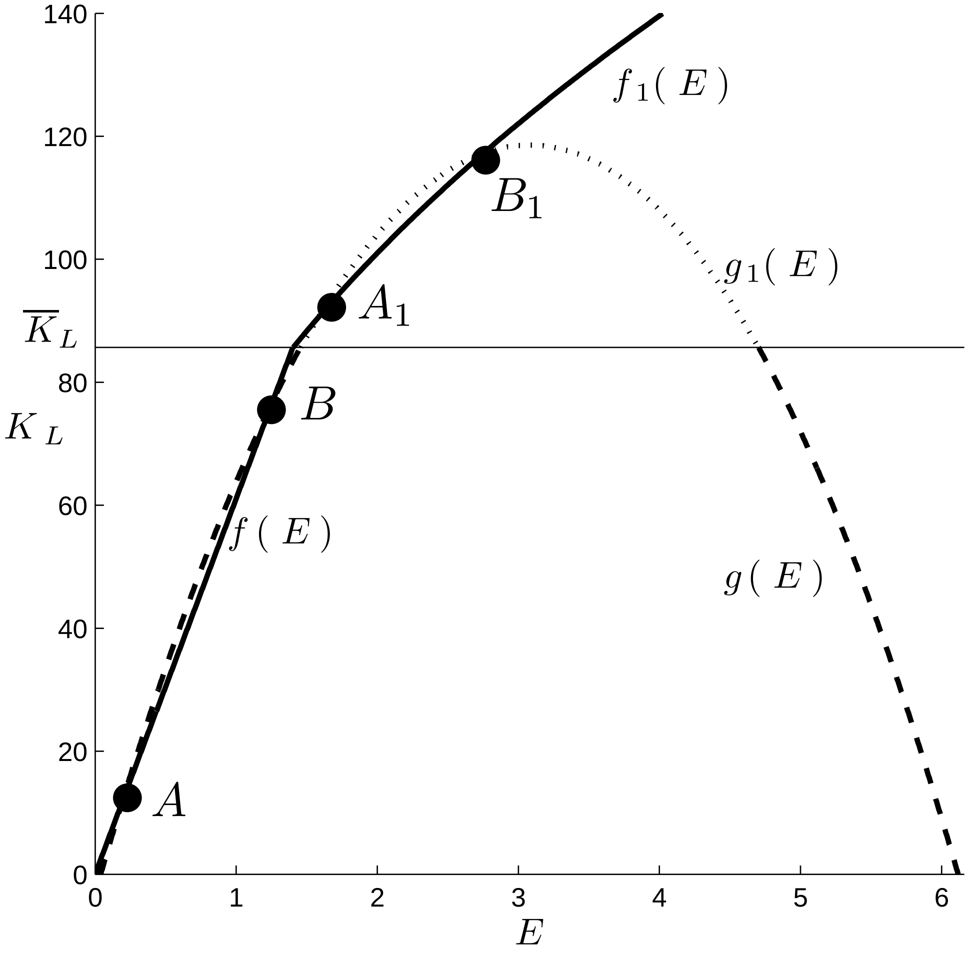


Figure 2: Numerical example in which four stationary states exist; the values of parameters are: $\alpha = 0.25$, $\beta = 0.35$, $\gamma = 0.15$, $\delta = 0.01$, $\epsilon = 2$, $\eta = 0.1$, $r = 0.01$, $\overline{E} = 6.2$.

Proof. See Appendix B ■

A numerical example in which four stationary states A, B, A_1 and B_1 exist and both B and B_1 are saddle-point stable is obtained posing $\alpha = 0.001$, $\beta = 0.003$, $\gamma = 0.01$, $\delta = 0.08$, $\epsilon = 0.5$, $\eta = 0.2$, $r = 0.01$, $\overline{E} = 1.4245$. In such an example, the coordinates of B and B_1 are, respectively, $(K_L^*, E^*, L^*) = (0.0115, 0.535, 0.93)$ and $(K_L^*, E^*, L^*) = (0.01243, 0.8115, 1)$, and the corresponding eigenvalues are $(-2.1546, -0.1645, 2.3654)$ and $(-2.4888, -0.2003, 2.5688)$.

When both B and B_1 are saddle-point stable, a bi-stable regime occurs and dynamics is path dependent in that the economy may reach B or B_1 according to the initial values of the state variables K_L and E. Joining together the above stability results and those concerning the existence of the stationary states, we can observe that:

i) a bi-stable regime can occur only if $\eta < \eta_T$ and $\epsilon > \epsilon_T$ (i.e. when all the stationary states A, B, A_1, B_1 exist; see Figure 1.a);

ii) the case in which B is the unique saddle-point stable stationary state can occur only if $\eta < \eta_T$ (i.e. when only the stationary states A, B exist; see Figure 1.a);

iii) if, given ϵ and η, the value of $\overline{E}$ is high enough, then B_1 becomes the unique saddle-point stable stationary state (see Figures 1.a-1.c).

5 Comparative statics

The following proposition helps to identify the most significant conditions that are verified in correspondence with the stationary states of dynamics; the asterisk indicates the stationary state values of the variables.

Proposition 6 *The following conditions hold at the stationary states of the dynamic system (3)-(5):*

$$L^* = \min\left\{1,\ \frac{\delta}{\alpha}\Gamma^{\alpha+\beta}K_L^*\right\} \tag{36}$$

$$K_I^* = \max\left\{0,\ \left(\frac{\gamma}{r}\right)^{\frac{1}{1-\gamma}}(1-L^*)\right\} = \max\left\{0,\ \left(\frac{\gamma}{r}\right)^{\frac{1}{1-\gamma}}\left(1-\frac{\delta}{\alpha}\Gamma^{\alpha+\beta}K_L^*\right)\right\} \tag{37}$$

$$C_L^* = \frac{\delta}{\alpha}K_L^* + \frac{r(1-\gamma)}{\gamma}K_I^* \tag{38}$$

Furthermore, in the context $L^* < 1$ (stationary states A and B), the following condition holds:

$$C_L^* = (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} + \frac{\delta(\alpha+\beta)}{\alpha}K_L^* \tag{39}$$

Proof. Formula (36) has been proved in subsection 3.1 (see (14)) while formula (37) follows from (12) and (36). To prove (38), let us remember that $\dot{K}_L = 0$ holds for (see (3)):

$$C_L = K_L^\alpha E^\beta L^{1-\alpha-\beta} + w(1-L) \tag{40}$$

and $\dot{\lambda} = 0$ holds for (see (4)):

$$\delta = \alpha K_L^{\alpha-1} E^\beta L^{1-\alpha-\beta} \tag{41}$$

Multiplying both sides of (41) by K_L we get $\frac{\delta}{\alpha} K_L = K_L^\alpha E^\beta L^{1-\alpha-\beta}$; substituting in (40) and taking into account formulas (37) and $w = (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}$, we can write:

$$\begin{aligned} C_L &= \frac{\delta}{\alpha} K_L + (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} (1-L) = \\ &= \frac{\delta}{\alpha} K_L + \frac{r(1-\gamma)}{\gamma} K_I \end{aligned}$$

Finally, formula (39) is obtained by substituting (37) in (38):

$$C_L^* = (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} + \frac{\delta}{\alpha}\left[1 - (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} \Gamma^{\alpha+\beta}\right] K_L^* = (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} + \frac{\delta(\alpha+\beta)}{\alpha} K_L^*$$

■

Notice that the value of K_L evaluated at the stationary state B_1 is higher than that evaluated at B (when both B_1 and B exist) because B_1 lies above the line (see (23)) $K_L = \overline{K}_L := \alpha\delta^{-1}\Gamma^{-\alpha-\beta}$ while B lies below it. Therefore, from (38) and (39), it follows that:

Proposition 7 *When both the stationary states B_1 and B exist, then L-agents' welfare (measured by C_L) evaluated in B_1 is higher than that evaluated in B*[11].

The following propositions investigate the impact of a change in parameters (in particular, we focus our analysis on $\overline{E}$, ϵ, η, r) on the values of K_L^*, K_I^*, E^*, L^*, Y_I^* and C_L^* evaluated at B, the stationary state without specialization that can be saddle-point stable. By the symbols $x \uparrow$ and $x \downarrow$ we shall indicate, respectively, an increase and a decrease in the parameter or variable x.

Proposition 8 $\overline{E} \uparrow$ *(remember that $\overline{E}$ represents the carrying capacity of the environmental resource) implies $E^* \uparrow$, $K_L^* \uparrow$, $L^* \uparrow$, $C_L^* \uparrow$ and $K_I^* \downarrow$.*

Proof. See Appendix C ■

Proposition 9 $\epsilon \uparrow$ *or* $\eta \uparrow$ *(remember that ϵ and η represent, respectively, the environmental impact of L-agents and I-agents) imply $E^* \downarrow$, $K_L^* \downarrow$, $L^* \downarrow$, $C_L^* \downarrow$ and $K_I^* \uparrow$.*

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[11] We do not consider the stationary states A_1 and A because they cannot be saddle-point stable.

Proof. See Appendix C ■

The comparative statics carried out on ϵ and η pinpoints the consequences of considering environmental dynamics. The results show that a lower environmental regulation, which translates into higher levels of ϵ or η, tends to stimulate a labor movement towards the external sector, whose productive performances have not worsened by environmental degradation. The local community faces a reduction in return in the context of self-employment and is pushed towards wage employment, partially substituting self-employed labor with wage labor. In such a context, the expansion of external capital inflows does not help local agents. On the contrary, their welfare declines. A symmetrically opposed effect is produced by an increase in $\overline{E}$, which translates into an increase in the welfare of L-agents and a reduction in the investments of I-agents.

Proposition 10 *If* $\Lambda > 0$ *(i.e.* $\epsilon < \epsilon_\Lambda$*), then* $r \uparrow$ *always implies* $E^* \uparrow$ *and* $K_L^* \uparrow$*. If* $\Lambda < 0$ *(i.e.* $\epsilon > \epsilon_\Lambda$*), then:*

1) $r \uparrow$ *implies* $E^* \uparrow$ *if:*

$$\eta > \frac{\epsilon(1-\gamma)(1-\alpha-\beta)^2}{\beta + (1-\alpha-\beta)^3} \tag{42}$$

2) $r \uparrow$ *implies* $E^* \downarrow$ *if:*

$$\eta < \left[-\frac{P}{2} + \frac{1}{2}\sqrt{P^2 + \frac{4(1-\gamma)}{1-\alpha-\beta}} \right]^{\frac{1}{2}}$$

where:

$$P := \frac{\alpha\beta(1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{2(1-\gamma)}}}{\delta\Omega(1-\alpha-\beta)^2}$$

3) $r \uparrow$ *implies* $K_L^* \uparrow$ *if and only if:*

$$\frac{1-\alpha-\beta}{\beta} E(\overline{E} - 2E) - \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} < 0$$

Furthermore, (42) is a sufficient condition to have $K_L^* \uparrow$*.*

Proof. See Appendix C ■

Remember that, according to Proposition 6, K_L is positively correlated with L^* and negatively correlated with K_I^*; furthermore:

$$\frac{\partial C_L^*}{\partial r} = \frac{\delta}{\alpha}(\alpha+\beta)\frac{\partial K_L^*}{\partial r} - \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} \frac{\gamma}{r}$$

This implies that the condition $\frac{\partial K_L^*}{\partial r} > 0$ is necessary but not sufficient to obtain $\frac{\partial C_L^*}{\partial r} > 0$.

Figure 4) shows a graphical representation of the results of some numerical exercises. A reduction in r can be interpreted as a reduction in external agents' opportunity cost of capital investment in the economy. These exercises of comparative statics highlight a novel requirement such that capital inflows can drive a process of poverty reduction and environmental sustainability. In all scenarios a decline in r leads to a labor reallocation towards the modern sector, resulting in an expansion of this sector and a diminution of the subsistence sector. The effects on the welfare of local agents, however, depend on the relation between parameters representing environmental impacts generated by the two sectors (ϵ and η): the expansion of external investments due to a decline in r results in a poverty reduction (i.e. an increase in C_L^*) only if the capitalistic sector does not cause too much pollution, namely if it produces relatively low environmental externalities in comparison to the subsistence activities where the difference between ϵ and η is adjusted for the ratio between labor productivity in the two sectors. Moreover, this economic transition leads to an increase in environmental sustainability (i.e. an increase in E^*) only if ϵ is sufficiently large with respect to η (Λ is sufficiently negative).

6 Concluding remarks

An improvement in the investment climate is one of the main objective of most local and national governments all over the world. The promotion of incentives and of opportunities for firms to invest and to create jobs is regarded as a crucial strategy in order to stimulate economic growth and to reduce poverty. The economic doctrine has underscored both the need to mobilize domestic resources and to attract external capitals and several international organizations[12] have suggested measures for promoting domestic investments and improving investment climate. In poor economies, however, inflows of external investments are seen by policy makers as the main solution to tackle scarcity of domestic capitals and to escape a poverty trap of low investments - low growth - poverty perpetuation. Expansion of modern activities, prompted by the arrival of external investors, are considered to be the way forward in terms of economic expansion and diversification of the local economy. Many countries, therefore, have focused their efforts on reforms and inducements which aim to promote modern and big companies usually financed by external capitals. The proposed model has enabled us to discuss the impact of these policies on an underdeveloped economic system based on primary activities. In our simplified economy, policies for attracting external investors can be identified by parameter r which stands for I-agents' opportunity cost to invest physical capital in the local economy. A reduction in r, for example, can represent interventions that benefit external investors such as more favorable taxation, regulation, provision of services

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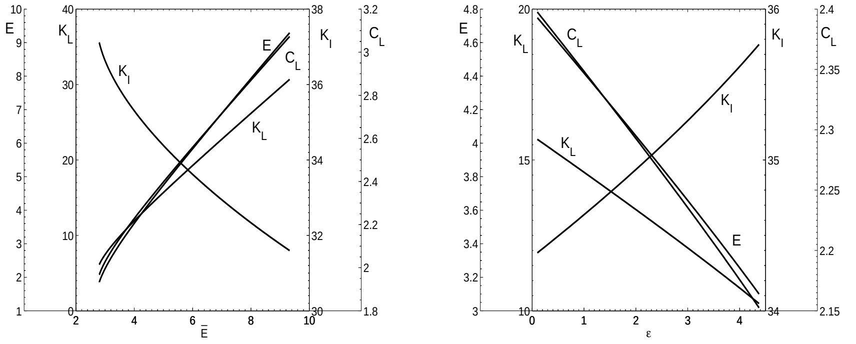
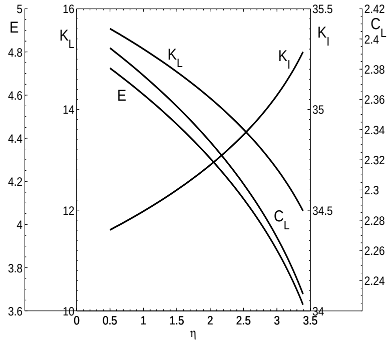
[12] The World Development Report 2005, for example, points out that climate investment improvements are driving factors in boosting economic expansion and combating poverty and it recommends the promotion of domestic investments and support of small and rural firms (World Bank 2005).



(a) $\epsilon = 0.1$, $\eta = 1$

(b) $\overline{E} = 5$, $\eta = 1$



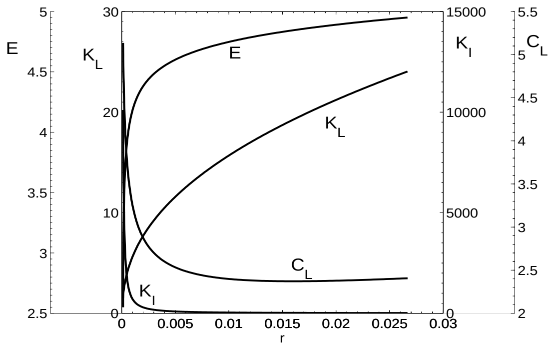
(c) $\overline{E} = 5$, $\epsilon = 0.1$

Figure 3: Values of K_L^*, K_I^*, E^*, L^*, Y_I^* and C_L^* evaluated at B, varying the parameters $\overline{E}$, ϵ and η; the other parameters are fixed at the values: $\alpha = 0.1$, $\beta = 0.35$, $\gamma = 0.2$, $\delta = 0.01$, $r = 0.01$.

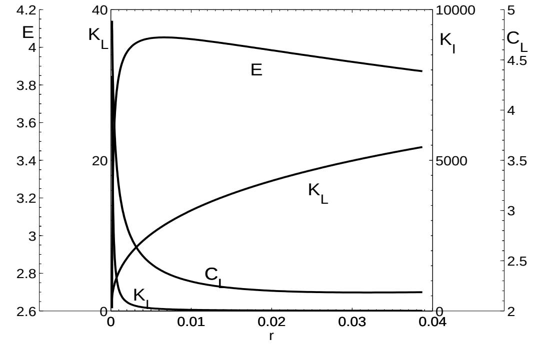
and infrastructures, political climate and the enforcement of property rights or, more intuitively, a reduction in r can be considered as a subsidy for I-agents.

In this context a decline in the opportunity cost of external capital investment prompts a process of diversification: the economy reaches a stationary state associated with the expansion of the capitalistic sector driven by higher levels of physical capital and labor employment, while investment in the subsistence sector decreases. The impact on environmental preservation and welfare of local communities, however, is not always positive. Indeed, if the modern sector is much more environmentally demanding by comparison with the local sector, the equilibrium value of natural capital declines and C_L^* decreases. In conclusion, the model shows that new scenarios may emerge when environmental dynamics are included in the discussion on the interaction between local and external producers. In particular, the increasing exposure of local economies to external forces and investments can cause perverse consequences when incoming actors invest in contaminating industries and enter economies characterized by a high dependence on primary activities and, consequently, by an acute vulnerability to environmental degradation or to exclusion from the use of natural resources. In this case, not only is the promotion of external investments not very effective in the struggle against poverty and environmental degradation, but it may actually exacerbate these problems. These conclusions, however, have to be evaluated in the lights of some important remarks. Firstly, in our model, positive externalities and backward or forward linkages between the two sectors are excluded. The inclusion of these channels of interaction between the two sectors may, in fact, limit or downsize the results obtained by this model. Our objective, however, was to focus on factors that tend to be neglected in the discussion of investment incentives, namely the environmental externalities of human activities and agents' heterogeneity in terms of vulnerability to depletion of natural resources.

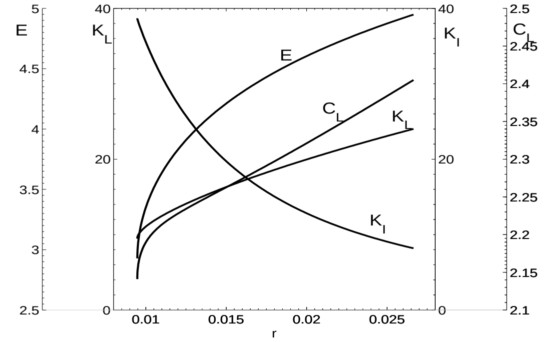
Secondly, in the context in question, L-agents cannot, by assumption, employ wage labor. Therefore this is a short-medium term model because, if in the long run the economy reaches a sufficiently high level of K_L, this assumption cannot hold and the local sector could undertake a process of expansion limited only by the endowment of natural capital but not by labor scarcity.



(a) $\epsilon = 0.1$, $\eta = 1$, $\Lambda > 0$



(b) $\epsilon = 2$, $\eta = 1$, $\Lambda < 0$



(c) $\epsilon = 0.1$, $\eta = 5$, $\Lambda > 0$

Figure 4: Values of K_L^*, K_I^*, E^*, L^*, Y_I^* and C_L^* evaluated at B, varying the parameter r; the other parameters are fixed at the values: $\alpha = 0.1$, $\beta = 0.35$, $\gamma = 0.2$, $\delta = 0.01$, $\overline{E} = 5$.

7 Appendix A

This Appendix and Appendix B are built on Wirl's results (1997). The Jacobian matrix $J_1(P^*)$, evaluated at a stationary state with specialization $P^* = (E^*, K^*, \lambda^*)$, can be expressed as follows:

$$J_1(P^*) = \begin{pmatrix} \delta & \frac{\beta\delta}{\alpha}\frac{K_L^*}{E^*} & \frac{1}{(\lambda^*)^2} \\ -\delta\epsilon & \overline{E} - 2E^* - \frac{\beta\delta\epsilon}{\alpha}\frac{K_L^*}{E^*} & 0 \\ \delta(1-\alpha)\frac{\lambda^*}{K_L^*} & -\alpha\beta\delta\frac{\lambda^*}{E^*} & 0 \end{pmatrix}$$

The eingenvalues of $J_1(P^*)$ are the roots of the following characteristic polynomial:

$$P_1(z) = z^3 - tr(J_1)z^2 + Mz - |J_1|$$

where:

$$tr(J_1) = \overline{E} + \delta - 2E^* - \frac{\beta\delta\epsilon}{\alpha}\frac{K_L^*}{E^*}$$

$$M = \delta(\overline{E} - 2E^*) - \frac{\delta^2(1-\alpha)}{\alpha}$$

$$|J_1| = \frac{\delta}{\lambda^*}\left[\frac{\beta\delta\epsilon}{\alpha}\frac{1}{E^*} - (1-\alpha)\frac{\overline{E} - 2E^*}{K_L^*}\right] \tag{43}$$

It easy to check that the determinant $|J_1|$ can be expressed as follows:

$$|J_1| = \frac{\epsilon\delta^2(1-\alpha)}{\alpha\lambda^* K^*}\left[f_1'(E^*) - g_1'(E^*)\right]$$

where f_1' and g_1' are the derivatives of f_1 and g_1 evaluated at E^*. Therefore, $|J_1| \gtreqless 0$ for $f_1'(E^*) - g_1'(E^*) \gtreqless 0$. Since, at the stationary state A_1, the condition $f_1'(E^*) < g_1'(E^*)$ holds, A_1 is either a saddle with two eingenvalues with strictly positive real parts or a sink; however, A_1 cannot be a sink in that, by (43), $|J_1| > 0$ implies $tr(J_1) > 0$.

At the stationary state B_1, the condition $f_1'(E^*) > g_1'(E^*)$ holds; therefore B_1 is either a saddle with two eingenvalues with strictly negative real parts or a source. Wirl (1997) finds that $M < 0$, i.e. $E^* > \frac{1}{2}\left(\overline{E} - \frac{\delta(1-\alpha)}{\alpha}\right)$, is a sufficient condition for the saddle-point stability of B_1. This completes the proof.

8 Appendix B

The Jacobian matrix $J(P^*)$, evaluated at a stationary state without specialization $P^* = (E^*, K^*, \lambda^*)$, can be expressed as follows:

$$J(P^*) = \begin{pmatrix} \delta & \dfrac{\beta\delta\Omega}{\alpha} & \dfrac{1}{(\lambda^*)^2} \\ \dfrac{\alpha\Lambda}{\alpha+\beta} & \overline{E} - 2E^* + \dfrac{\beta\Lambda\Omega}{\alpha+\beta} & 0 \\ \dfrac{\beta\delta}{\alpha+\beta}\dfrac{\lambda^*}{K^*} & -\dfrac{\beta\delta}{\alpha+\beta}\dfrac{\lambda^*}{E^*} & 0 \end{pmatrix}$$

The eingenvalues of $J(P^*)$ are the roots of the following characteristic polynomial:

$$P_1(z) = z^3 - tr(J)z^2 + Mz - |J|$$

where:

$$tr(J) = \delta + \frac{\beta\Lambda\Omega}{\alpha+\beta} + \overline{E} - 2E^* \tag{44}$$

$$M = \delta(\overline{E} - 2E^*) - \frac{\beta\delta}{(\alpha+\beta)K^*\lambda^*} \tag{45}$$

$$|J| = -\frac{\beta\delta\Lambda}{(\alpha+\beta)K^*\lambda^*}\left(\Omega + \frac{\overline{E} - 2E^*}{\Lambda}\right) \tag{46}$$

It is easy to check that the determinant $|J|$ can be expressed as follows:

$$|J| = \frac{\beta\delta}{(\alpha+\beta)K^*\lambda^*}\Lambda\left[g'(E^*) - f'(E^*)\right]$$

where f' and g' are the derivatives of f and g evaluated at E^*. Therefore, $|J| \gtrless 0$ for $\Lambda\left[g'(E^*) - f'(E^*)\right] \gtrless 0$. Since, at the stationary state A, the condition $\Lambda\left[g'(E^*) - f'(E^*)\right] < 0$ holds, A is either a saddle with two eingenvalues with strictly positive real parts or a sink. However, as in Appendix A, we can easily exclude the attractivity of A. Notice that $\overline{E} - 2E^* > 0$ always holds in A (see (25) and the definition of A); this implies that $tr(J) > 0$ if $\Lambda > 0$ (see (44). If $\Lambda < 0$, then $|J| < 0$ if and only if $\Omega\Lambda + \overline{E} - 2E^* > 0$ (see (46)), which implies $tr(J) > 0$ (see (44).

At the stationary state B, $|J| > 0$ holds; therefore B is either a saddle with two eingenvalues with strictly negative real parts or a source. Wirl (1997) finds that a positive determinant and a negative coefficient M are sufficient conditions for saddle-point stability. Notice that, if $\Lambda > 0$, the condition $\overline{E} - 2E^* < 0$ holds (see (25) and the definition of B) and consequently $M < 0$. In case $\Lambda < 0$, from (21) and $\dot{K}_L = 0$, we obtain:

$$\frac{1}{\lambda^*} = \frac{\alpha+\beta}{\alpha}\delta K^* + (1-\gamma)\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}$$

Substituting in (45) and remembering that $K_L^\star < \overline{K}_L = \alpha\delta^{-1}\Gamma^{-\alpha-\beta}$, we can write:

$$M = \delta\left[\overline{E} - 2E^* - \frac{\beta}{\alpha}\delta - \frac{\beta(1-\gamma)(\frac{\gamma}{r})^{\frac{\gamma}{1-\gamma}}}{(\alpha+\beta)K^*}\right] < \delta\left[\overline{E} - 2E^* - \frac{\beta\delta}{\alpha(\alpha+\beta)}\right] \tag{47}$$

Therefore, a sufficient condition for saddle-point stability is:

$$E^* > \frac{\overline{E}}{2} - \frac{\beta\delta}{2\alpha(\alpha+\beta)}$$

This completes the proof.

9 Appendix C

Let us rewrite equations (24) and (25) as follows:

$$\begin{aligned} F(K_L, E) =& K_L - \Omega E = 0 & (48)\\ G(K_L, E) =& K_L - \frac{\eta\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} - E(\overline{E} - E)}{\Lambda} = 0 & (49) \end{aligned}$$

Differentiating equations (48) and (49) with respect to the parameter $y = \overline{E}$, ϵ, η, r we obtain:

$$\begin{pmatrix} 1 & -\Omega \\ 1 & \frac{\overline{E} - 2E}{\Lambda} \end{pmatrix} \begin{pmatrix} \frac{\partial K_L}{\partial y} \\ \frac{\partial E}{\partial y} \end{pmatrix} = \begin{pmatrix} \frac{\partial F}{\partial y} \\ \frac{\partial G}{\partial y} \end{pmatrix} \tag{50}$$

9.1 Proof of Proposition 8

Posing $y = \overline{E}$, the system (50) becomes:

$$\begin{aligned} \frac{\partial K_L}{\partial \overline{E}} =& \Omega \frac{\partial E}{\partial \overline{E}} \\ \frac{\partial K_L}{\partial \overline{E}} + \frac{\overline{E} - 2E}{\Lambda}\frac{\partial E}{\partial \overline{E}} =& -\frac{E}{\Lambda} \end{aligned}$$

Therefore $sign\left(\frac{\partial K_L}{\partial \overline{E}}\right) = sign\left(\frac{\partial E}{\partial \overline{E}}\right)$ and $\frac{\partial E}{\partial \overline{E}} = \frac{E}{\Lambda\left[g'(E) - f'(E)\right]} > 0$ (remember that $\Lambda\left[g'(E) - f'(E)\right] > 0$ at the stationary state B). The part of the Proposition concerning the effects of an increase in $\overline{E}$ (and, consequently, in K_L) on the values of L, C_L and K_I can be easily checked by applying Proposition 6.

9.2 Proof of Proposition 9

Posing $y = \eta$, the system (50) becomes:

$$\begin{aligned}\frac{\partial K_L}{\partial \eta} &= \Omega \frac{\partial E}{\partial \eta}\\ \frac{\partial K_L}{\partial \eta} + \frac{\overline{E} - 2E}{\Lambda}\frac{\partial E}{\partial \eta} &= \frac{\delta}{\alpha \Lambda^2}\left[\frac{1-\alpha-\beta}{1-\gamma}E(\overline{E}-E) - \epsilon \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}\right]\end{aligned}$$

Therefore:

$$sign\left(\frac{\partial K_L}{\partial \eta}\right) = sign\left(\frac{\partial E}{\partial \eta}\right) \tag{51}$$

and:

$$\frac{\partial E}{\partial \eta} = \frac{\frac{\delta}{\alpha \Lambda^2}\left[\frac{1-\alpha-\beta}{1-\gamma}E(\overline{E}-E) - \epsilon \left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}\right]}{f'(E) - g'(E)} \tag{52}$$

which, substituting $E(\overline{E}-E) = \eta\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} - \Omega\Lambda E$ (equation obtained by equalizing the right sides of formulas (24) and (25)), can be rewritten as follows:

$$\frac{\partial E}{\partial \eta} = \frac{\frac{\delta}{\alpha \Lambda}\left[\frac{\delta}{\alpha}\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}} - \frac{1-\alpha-\beta}{1-\gamma}\Omega E\right]}{f'(E) - g'(E)}$$

Being $K_L = \Omega E < \overline{K}_L$, where $\overline{K}_L = \frac{\delta(1-\gamma)}{\alpha(1-\alpha-\beta)}\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}$ (see (23)), the expression in square brackets is strictly positive; therefore $\frac{\partial E}{\partial \eta} < 0$; this implies, by (51), that $\frac{\partial K_L}{\partial \eta} < 0$ holds. The part of the Proposition concerning the effects of an increase in η on the values of L, C_L and K_I follows from Proposition 6. The comparative statics results about the parameter ϵ can be easily checked following the same steps.

9.3 Proof of Proposition 10

For simplicity, we define $\Theta := \eta\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}$. Posing $y = r$, the system (50) becomes:

$$\begin{aligned}\frac{\partial K_L}{\partial r} - \Omega\frac{\partial E}{\partial r} &= \frac{\partial \Omega}{\partial r}E\\ \frac{\partial K_L}{\partial r} + \frac{\overline{E} - 2E}{\Lambda}\frac{\partial E}{\partial r} &= \frac{1}{\Lambda}\frac{\partial \Theta}{\partial r}\end{aligned}$$

where:

$$\frac{\partial\Theta}{\partial r} = -\frac{\gamma}{r(1-\gamma)}\Theta < 0 \tag{53}$$

$$\frac{\partial\Omega}{\partial r} = \frac{\gamma(1-\alpha-\beta)}{\beta r(1-\gamma)}\Omega > 0 \tag{54}$$

The solution of such system is:

$$\frac{\partial K_L}{\partial r} = \frac{\partial\Omega}{\partial r}E + \frac{\partial E}{\partial r}\Omega \tag{55}$$

$$\frac{\partial E}{\partial r} = \frac{\frac{1}{\Lambda}\frac{\partial\Theta}{\partial r} - \frac{\partial\Omega}{\partial r}E}{f'(E) - g'(E)} \tag{56}$$

Notice that, if $\Lambda > 0$, then $\frac{\partial E}{\partial r} > 0$ always holds[13]. If $\Lambda < 0$, then $\frac{\partial E}{\partial r} > 0$ holds if and only if:

$$E < \frac{\frac{1}{\Lambda}\frac{\partial\Theta}{\partial r}}{\frac{\partial\Omega}{\partial r}} \tag{57}$$

Substituting formulas (53) and (54) in (57), the inequality (57) can be expressed as:

$$E < \frac{\alpha\beta(1-\gamma)\Theta}{\delta\Omega(1-\alpha-\beta)\left[\epsilon(1-\gamma)-\eta(1-\alpha-\beta)\right]}$$

Remembering that, in B, $K_L = \Omega E < \overline{K}_L = \frac{\delta(1-\gamma)}{\alpha(1-\alpha-\beta)}\left(\frac{\gamma}{r}\right)^{\frac{\gamma}{1-\gamma}}$ holds (see (48) and (23)) and solving the inequality:

$$\frac{\overline{K}_L}{\Omega} < \frac{\alpha\beta(1-\gamma)\Theta}{\delta\Omega(1-\alpha-\beta)(\epsilon(1-\gamma)-\eta(1-\alpha-\beta))}$$

we obtain the sufficient condition for $\frac{\partial E^*}{\partial r} > 0$ given in the Proposition.

The sufficient condition for $\frac{\partial E^*}{\partial r} < 0$ is obtained by following similar steps. Remember first that, for $\overline{E} = \overline{E}_1$ (see Appendix A), the curves $f(E)$ and $g(E)$ are tangent; it is easy to check that, at the tangent point, $E = \sqrt{\Theta}$ holds. This implies that, for $\overline{E} > \overline{E}_1$, $E > \sqrt{\Theta}$ holds at the stationary state B.

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[13] Remember that, at the stationary state B, $sign\,(\Lambda) = sign\,[g'(E^*) - f'(E^*)]$ holds.

Therefore, the sufficient condition for $\dfrac{\partial E^*}{\partial r} < 0$ is obtained solving the following inequality[14]:

$$\sqrt{\Theta} \geq \frac{\dfrac{1}{\Lambda}\dfrac{\partial \Theta}{\partial r}}{\dfrac{\partial \Omega}{\partial r}}$$

which can be rewritten as:

$$\eta + \frac{\alpha\beta(1-\gamma)\sqrt{\Theta}}{\delta\Omega(1-\alpha-\beta)^2}\sqrt{\eta} - \frac{\epsilon(1-\gamma)}{1-\alpha-\beta} \leq 0$$

Let us now consider the variations in K_L, L and K_I generated by an increase in r. Remember that, according to Proposition 6, K_L is positively correlated with L and negatively correlated with K_I. Consequently, we have only to analyze the sign of $\dfrac{\partial K_L}{\partial r}$. Notice that, by (55), $\dfrac{\partial E}{\partial r} > 0$ implies $\dfrac{\partial K_L}{\partial r} > 0$; therefore, if $\Lambda > 0$, then $\dfrac{\partial K_L}{\partial r} > 0$. If $\Lambda < 0$, the inequality $\dfrac{\partial K_L}{\partial r} > 0$ can be written as follows (we use formulas (55), (53) and (54)):

$$\frac{\partial K_L}{\partial r} = \frac{\gamma}{r(1-\gamma)}\frac{\Omega}{\Lambda}\left[\frac{1-\alpha-\beta}{\beta}E\left(\overline{E}-2E\right)-\Theta\right]$$

Therefore, $\dfrac{\partial K_L}{\partial r} > 0$ if and only if:

$$\frac{1-\alpha-\beta}{\beta}E(\overline{E}-2E)-\Theta < 0$$

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[14] $\dfrac{\partial E}{\partial r} < 0$ holds if and only if the opposite of condition (57) is satisfied.

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