REAL OPTION VALUE AND POVERTY TRAP

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ABSTRACT. In recent years concerns about poverty traps have risen to the forefront of policy. Accordingly, the decision on investing or waiting in specific sectors or locations of poor countries is in part assigned to the government of that country. We study the optimal timing of a foreign direct investment (FDI) where the returns are stochastic and the cost irreversible. A model of real option value compares the benefits and costs of a risky FDI with those of a riskless official development assistance (ODA). Once FDIs take place, the local government can shift ODAs towards different sectors or locations to hinder poverty. We show that with uncertainty and irreversibility, the policy decision has an opportunity value that must be included as a part of the full value of the FDI. This option value is highly sensitive to uncertainty over the future returns, so that changing actual economic conditions in poor countries can have a large impact on the poverty trap. Simulations show that this option value can be significant to explain the prevalence of hysteresis, that is the tendency of a poor country to persist in poverty.

1. Introduction. Traditionally poverty trap is modelled in static framework of coordination failure. However, this setting overlooks some dynamic aspects of poverty traps related to the persistence of poverty. Our goal in this paper is to frame this issue. Precisely, we present a model of real option value which quantifies both benefits and costs of foreign direct investment (FDI) and official development assistance (ODA) in poor countries. We show that, with uncertainty and irreversibility, when the decision to accept a FDI is in part assigned to the government of the poor country, the policy decision has an opportunity value that must be included as a part of the full value of the developing strategy. Specifically, our aim is to calculate the trigger value that makes optimal to accept the risky FDI renouncing to the riskless ODA. This trigger value can explain the prevalence of hysteresis that is the tendency of a poor country to persist in poverty well beyond the disappearance of its cause.

The standard framework in which economists evaluate poverty traps is a cost-benefit analysis. Consider, for example, a fiscal incentive given to households to overcome poverty. By altering relative prices, this policy would impose an expected

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flow of costs on society in excess of the government fiscal costs it generates. Presumably, it also yields an expected flow of benefits. In fact, households would consume more goods, fewer diseases should occur, an improvement in social conditions should happen, and the damage caused by poverty would be correspondingly reduced. The standard framework would recommend this policy if the present value of the expected flow of benefits exceeds the present value of the expected flow of costs.

This standard framework ignores however three important features of most poverty problems, and the policies designed to respond to them. First, there is almost always uncertainty over the future costs and benefits of adopting a particular policy. Second, there are usually important irreversibilities associated with investment policy. Third, policy adoption is rarely “a now or never” proposition. In most cases it is feasible to the policy maker to delay action and wait for new information, or at least begin with incremental policies that are limited in their scope and impact.

Policies designed to poverty reduction involves two kinds of irreversibilities, and they work in opposite directions. First, policies aimed at reducing poverty can impose sunk costs on society. These sunk costs can take the form of investments. For example, firms might have to scrap existing capital stock and invest in more efficient ones. In this case, such sunk costs create an opportunity value of adopting a policy now, rather than postponing the decision to better evaluate its economic consequences. Second, in a poor country, the policy decision of the local government can be partially or totally irreversible. For example, the damage to social system from a wrong policy can be permanent. This means that adopting a specific policy “now” rather than “waiting” has a sunk cost, i.e., an opportunity value, which biases traditional cost-benefit analysis against policy adoption. Therefore, it may be desirable for the government to postpone a decision now, even if the traditional analysis declares it to be economic.

In this paper we attempt to rationalize this issue. We assume that, in poor countries, there is always uncertainty over the future, and over the costs and benefits of policy adoption. We focus on how irreversibilities and uncertainty interact in affecting the timing and design of policy. In this scenario, recipient government must be capable of properly assessing the costs and benefits of alternative strategies aimed at bringing the country out of the poverty trap.

This paper has several objectives. First, we review the models of poverty trap to show that one novel explanation of it is obtainable from models of option value applied to policy decisions. This is the main contribution of the present paper to the literature on poverty traps. A second objective is to show that the real option value must be included as a part of the full cost of the foreign investment project. Accordingly, the local government can swap from ODAs to FDIs when the value of the foreign investment exceeds the opportunity cost of the aid by an amount equal to the opportunity of keeping the option alive. Finally, we will show that the option value of a policy is highly sensitive to uncertainty over the future returns of the foreign investment project, so that changing economic conditions in poor countries (and around the world) can have a large impact on poverty trap.

The paper is organized as follows. After some stylized facts, section 3 surveys theoretical and empirical models on poverty trap. Section 4 provides the main intuition of our explanation using a simple two periods model. Then, section 5 formalizes our idea in a continuous time framework. Section 5 concludes.
2. **Some stylized facts.** Official development assistance (ODA) is defined as government aid designed to promote the economic development and welfare of developing and poor countries. Aid may be provided bilaterally, from donor to recipient, or channelled through multilateral development agencies. Aid includes grants, “soft” loans and the provision of technical assistance. Typically, aids aimed at economic infrastructure are targeted at countries with good governance and mature economic institutions, while countries that lack such capacities receive aid in the form of social-sector assistance. We refer to this aid as traditional ODA.

![Development aid stable in 2017 as refugee costs ease](image)

**Figure 1.** Source: [62] DAC statistics

In developing countries ODA amounts to more than 50% of total resource receipts by year (see [62]). In some countries the amount is even higher (for example, Afghanistan 70%, Central African Republic 94%, Democratic People’s Republic of Korea 67%). As said, ODA has numerous developmental objectives premised on a long-standing assumption that aid reduces poverty. Nevertheless, its effectiveness continues to be debated in development economics research area, because many aid-dependent countries have long remained at the top of the poverty rankings ([2]; [10]).

Empirically, there is no clear consensus about the effectiveness of ODA in poverty reduction (see [23], [28], [58]). We can characterize the aid-poverty literature into three broad strands. The first is skeptical about aid and concludes that aid is ineffective, causing the “Dutch Disease” and labels aid as harmful (e.g. [58], [65]). The first strand is skeptical about aid and concludes that aid is ineffective, causing the “Dutch Disease” and labels aid as harmful (e.g. [58], [65]). The first strand is skeptical about aid and concludes that aid is ineffective, causing the “Dutch Disease” and labels aid as harmful (e.g. [58], [65]).
second concludes that aid is effective in poverty reduction (e.g. [68], [44], [45]. The third one assumes an intermediate position that aid effectiveness in poverty reduction is liable on recipient country characteristics (e.g., [29], [72], [73]). While there is no coherent evidence that ODA has a harmful impact on economic performance and poverty, ODA impact tends to vary substantially depending on the type of policy intervention, location of the recipient country, and the sector to which aids are channeled ([61], [30] [15]). In any case, a likely relationship between development aid and economic growth in recipient countries is hardly been progressive. In many cases, foreign aid is more harmful than helpful to the recipient economy [30].

In its place, the effects of foreign direct investment (FDI) on poverty reduction in developing and poor countries have been recognized as a crucial mechanism for economic growth. Typically, FDI is an investment made by a firm in one country into business interests located in another country. In developing countries FDI amounts to less than 1% of total resource receipts by year [62]. Nevertheless, a large body of literature explores whether FDI is accompanied by poverty reduction in recipient countries [75]. Benefits accruing from FDI are generally assumed to include the creation of employment, technology and knowledge spillover, and competitive business environments leading to production efficiency, all of which tend to reduce poverty [43]. However, these benefits are contingent on the absorptive capacity of the recipient country [76]. For example [4] find that FDI significantly reduced poverty in 21 countries.

![Figure 2. Source: UNCTAD (2014). Inward and outward foreign direct investment flows, annual, 1970-2012.](image)

According to [3] FDIs are often subject to uncertainty about returns and irreversibility about costs. Specifically, returns may be associated to high transaction costs very difficult to revert should the uncertainty about returns be resolved with a
negative outcome [69]. In this scenario, risk aversion may lead to the perpetuation of poverty, by inducing suboptimal, risk-averse behavior [74]. Further, given the structural and institutional weakness of poor countries, uncertainty and irreversibility can raise “the value of the wait-and-see option [and] induce the postponement of the FDI decision” (see [3] p. 86).

In such a scenario, the difficulty starts when decision makers try to identify what investment policy is, or should be. Indeed, “a huge range of stakeholders, problems, institutions, legal instruments, and administrative tools are captured in that concept. So, even if policy makers can identify a destination”, it can be difficult to know where and when to start [38].

A common mistake is that poor countries often set up investment policies to respond to the challenges posed by the type of FDI and ODA they are already receiving. But, a poor country also needs to identify the opportunities for receiving benefits from other types of FDI the country needs in order to develop. Many policy makers in poor countries face however difficulties in investment policy formulation. Further, the expected benefits from new projects are not automatic. Designing and implementing appropriate investment policies depends on the nature of the investment program: on its cost, riskiness and irreversibility. Different features call for different policy mixes. So, the crucial question is: Do policy makers in poor countries rely on a specific framework when FDI is risky and irreversible?

The strategic value of the FDI has two different aspects. On the one hand, it can boost foreign firms to postpone the decision to invest in developing countries [66], [20]. On the other hand, it can alter the returns and costs perceived by policy makers in beneficiary countries by determining the choice between FDI and ODA. As far as we know, this latter aspect is not emphasized enough in the literature. Nonetheless, most governments regard attracting FDI as a priority, particularly in developing and transitional economies [46]. “It is given such emphasis not just because it boosts capital formation but because of its potential to enhance the quality of the capital stock ... [Further] If spillovers occur, they provide an external benefit from FDI, one that [host] governments are hoping to secure when they offer inducements” [47].

Therefore, the interplay between foreign firms and local governments can shed new light on the issue of the poverty trap. Specifically, when a poor country benefits from ODA at the present, the FDI can be seen as a real option value affecting the decision of the local government to accept or reject a new foreign investment program. In such a context, the policy makers’ perception, about returns, risks and irreversibility, becomes a key determinant of the timing of the investment policy. Thus, there is a need to come up with a framework sophisticated enough to differentiate different types of investment, and at the same time be simple enough to be practical for policy making.

Accordingly, in what follows we present a model of investment decision where the decision on committing or waiting, in specific sectors, regions or locations is in part assigned to the government of the poor country. Any investment strategy has different payoffs. But, the point here is that waiting for a while can enable the government of the recipient country to avoid potential sunk costs related to the uncertain investment programs while maintaining the benefits provided by the ODA. This choice generates a positive value of waiting which can fuel the poverty trap. In fact, the decision to postpone the acceptance of a FDI – even when its current return is larger than the one of the ODA – may appear optimal to the policy
makers to be surer that the current state of the economy is not transitory. Many examples of this kind of binary choice occur in developing countries. When policy makers are considering to accept a FDI realize that other developing countries can accept similar projects. As the others enter, returns and benefits may reduce and disappear hereafter. Or, the price of the underlying assets (i.e. commodities) can be so volatile that the appreciation rate of the FDI can be less than the current value of ODA. All these elements encourage local governments to be cautious and to postpone the investment decision by preferring traditional ODAs to FDIs, which are certainly less remunerative but also safer and reversible.

3. Literature. The seminal paper by [5] highlights the possibility of low growth traps with multiple equilibria for economies exhibiting similar initial conditions. They define the poverty trap as a “self-reinforcing mechanisms that act as barriers to the adoption of more productive techniques and so cause poverty to persist” ([5], [7]).

Then [6] examines the reasons why similar countries do not always converge towards the same steady state as predicted by the standard Solow model. He identifies many possible reasons of poverty traps, such as subsistence consumption, limited human capital, demographic transitions when fertility is endogenous, and political economy problems generated by coordination failures. Also [8] puts emphasis on ‘misbehaving governments’ and incomplete markets, while [68] and [71] focus on how the limited access to financial markets can constraint the ability of poor countries to finance risky investments, feeding the poverty trap.

The current debate also provides dynamic models with multiple equilibria and poverty traps [56] (see [7], [16], and [49] for excellent overviews on the topic). Multiple equilibria are determined by the existence of critical thresholds. For values of the parameters above the threshold the system lead to positive asset accumulation. But, below the threshold the decumulation of assets prevails, pushing the economy in the poverty trap. Increasing returns to scale (see [67] [55], [5], [34], [39]), spatial agglomeration economies with technological effects at regional scale ([50], [40]), indivisibility and irreversibility of investments ([54], [9], [41], [77]) and the trade-offs between stability and economic growth can generate multiple equilibria [12].

Other mechanisms at the core of the poverty traps are related to the coordination failures. Often these failures are the result of poor contract enforcement mechanisms and asymmetric information with high transaction costs and risk exposure [11]. The central pillar is the idea that the poor economy may fail to achieve coordination among complementary activities. For example, some investments are not undertaken because complementary investments do not exist in the poor country. As a consequence, the coordination failure leads to an equilibrium with an outcome which is Pareto inferior for all agents. Examples include the paper by [31], [59], [60], [51], [18], [24], [21].

Poverty traps may also operate at macro level or micro level ([13], [49], [42], [14]. Some authors ([12], [13]; [19]) highlight the presence of thresholds (the so-called Micawber thresholds) and bifurcations. Some others, stress the question related to risk aversion which may lead to the perpetuation of poverty, by inducing suboptimal, risk-averse behavior [53]. However, this point has been recently questioned by [74] which show, using a specific experimental framework, that students in poorer countries are more risk tolerant than students in richer countries.
Durlauf’s research [33]-[34] has enriched the modelling of poverty traps by adding spatial dimensions. In this view, an agent’s outcome depends upon the composition of the various groups of which he is a member over the course of his life. Thus, the decision to acquire an higher education in order to skip poverty strongly depends on the prior existence of other educated members in a group. This interdependence of behavior induces “neighborhood effects”, which generate different types of aggregation and alternative steady states.

Further, poverty traps can be induced by the presence of specific institutions, [16] defines institutions as conventions in which members of a population act in ways that maximize payoffs given the actions taken by others. [64] points out that the formation of “institutional traps” is one of the main obstacles for improving economic performance in poor country. An institutional trap is defined as a stable yet inefficient equilibrium where agents choose a norm of behavior (an institution) among several options. It is usually implied that multiple equilibria prevail in the system, and that an institutional trap is Pareto dominated.

A poverty trap can also be caused by strategic complementarity between human capital and R&D in an evolutionary game approach [1], [70]. The assumption of rationality is dropped in favor of an assumption that agents adhere to the rules of their strategy, perhaps complemented by additional behavioral rules, such as imitation.

While the poverty trap is well portrayed as a low-level equilibrium point, the “big push” argument to move away from that situation advises that poor countries need huge amount of resources to move towards a higher path of economic development. Accordingly, the ‘big push’ argument portrays foreign aid as the fundamental means to complement domestic savings and to raise economic growth [68].

Notice that the poverty traps also occur whenever a strict relationship among national income, subsidies and investment projects prevails. For country whose level of income is extremely low, the rate of return from investing (in food, in education and business) can be so low that it cannot invest enough to improve its initial economic condition. Thus, it tends to become poorer and poorer. However, over a given income threshold the investment can be productive, driving the poor country out the poverty trap ([10], [49]). In this view, foreign aid is expected to serve as a means of transferring capital from advanced economies to developing ones. Aid would stimulate social and economic reforms by providing funds for investment projects such as infrastructure, technologies and education (see [36], [37] [17], [22], [23], [25], [26], [45], [52]).

An additional but crucial question is why international aids are efficient in some countries, but fail in some others. It is well known that subsidies are key instruments to escape from poverty traps. This is the case of middle income countries, such as Mexico, South Africa and Brazil [48]. However, it can happen that an economy with foreign subsidies may reduce its capability to increase productivity and economic growth. In this vein, [48] develops the “paradox of social protection” where cash transfer programs can generate an intertemporal trade-off between the well-being of the poor today versus their well-being in the future. So, if agents do not anticipate social protection benefits, the paradox of social protection emerges.

Viewed from this perspective the poverty trap is ubiquitous. However, one problem with existing models is that they do not blend three important characteristics of most poverty traps. First, the FDIs may be partially or completely irreversible. Second, there is uncertainty over the future returns from investments as FDIs. Third,
the policy maker of the recipient country may have some leeway about the timing of acceptance of a FDI. These characteristics determine the optimal choice of the policy maker. As we will see, small frictions in costs and benefits can produce a zone of inaction between the value of ODA and the (expected) returns from FDIs which can fuel the poverty trap.

As far as we know, our paper is nearest in spirit to that of [2] where poverty traps are induced by high aid volatility, and to that of [27] where poverty traps are determined by agents’ decisions on whether to invest in a risky asset or in a safe one. However, while [27] shows that agents sufficiently above the poverty line will invest in the risky project, we will show the opposite. That is, we explain why in a poor country the “optimal” strategy of the policy maker is to maintain the *status quo* even when the returns of FDIs are higher than the safe one from ODAs. The reason is that the opportunity to invest is like a real option: waiting a little longer to see how costs and returns evolve has value for the policy maker (see [57], [63], [32], [33]).

4. **A basic model.** Let’s assume that government of a poor country receives, at the current time, an ODA for a specific sector, region or location [30], [15]. Let’s indicate with $S$ the (discounted) value of the ODA. Then, assume that the government can manage with foreign firms for a FDI to be allocated in the same sector, region or location. The cost of it is irreversible. Its return is uncertainty. But its expected value is higher than the one of ODA.

Now, let’s assume that if the FDI takes place the government of the recipient country has the opportunity to shift the existing ODA towards alternative sectors or locations. How will the policy makers manage to take such a decision?

Let’s indicate with $\rho > 0$ the appropriate interest rate of the FDI. Given the current operating profit $\pi_0$ provided by the FDI, the ratio $\frac{\pi_0}{\rho}$ measures the discounted value of the future expected flow of net operating revenues per unit time. This is where the uncertainty comes in. The government knows the current value $\pi_0$, but also knows that this value can change in the future because of uncertainty of returns and irreversibility of costs. However, the FDI strategy does not generally disappear for ever if not taken immediately, so that the government’s decision is not only whether to manage in order to accept or refuse the FDI, but also when to take such a decision if any.

To formalize the problem, let’s indicate with $H$ the value of current return that would make the policy maker indifferent between either to accept the FDI or maintaining the ODA. We can write

$$H = \rho S$$

This means that if $\frac{H}{\rho} - S > 0$ the FDI takes place, whereas it is refused if $\frac{H}{\rho} - S < 0$. But what happens if the policy maker can wait for a while and re-evaluate the decision in the next period? Now, the menu of choices is wider. To explain the point, let’s assume that in the next period the return is $\pi_u > H$ and that it will remain at this level for ever. This implies that the net present value of the FDI will be positive for the time to come. Conversely, assume that $\pi_d < H$. In this case, the net worth of the FDI is zero and the policy maker will prefer not to accept the FDI. Therefore, waiting for a certain period can be an optimal choice for the policy maker to avoid the risk of a downsize of returns. This strategy can generate a positive value of waiting which fuel the poverty trap.
To be concrete, let’s indicate with $\pi_0$ the return of the FDI at the current time. In the next period it can increase ($\pi_u$) or decrease ($\pi_d$). Its expected return is

$$E(\pi) = (q)\pi_u + (1 - q)\pi_d$$

where $q > 0$ is the probability associated with the best scenario. To simplify the problem assume now that the discount rate is equal to zero, and that $\pi_d < S < \pi_u$ to avoid arbitrage opportunity. If the FDI takes place at time 0 its Net Present Value (NPV) is

$$E(\text{NPV}_0) = -S + \pi_0 + E(\pi)$$

because the policy maker shifts the ODA, whose value is $S$, towards an alternative sector, region or location. Alternatively, the NPV of the deferred strategy at time 1 is

$$E(\text{NPV}_1) = q(\pi_u - S)$$

because the policy makers will take the FDI in the next period only if the return is $\pi_u$. Thus, from the point of view of the local government the optimal decision will depend on the comparison between the NPV of the two alternatives that is on the difference

$$E(\text{NPV}_1) - E(\text{NPV}_0) = (1 - q)(S - \pi_d) - \pi_0$$

Equation (5) has the following meaning. For the policy makers the mix between uncertainty and irreversibility generate a positive value of waiting: it is equal to the potential loss $(1 - q)(S - \pi_d)$ eluded postponing the acceptance of the FDI minus the loss of the current net return $\pi_0$. In other words, $\pi_0$ is the “opportunity cost” of holding the right to accept the FDI in the next period.

Therefore, equation (5) says that the local government will only act to make the FDI viable at the current time if $E(\text{NPV}_1) - E(\text{NPV}_0) < 0$ that is when $\pi_0 > (1 - q)(S - \pi_d)$. By continuity, maintaining the ODA remains better than accept the foreign investment project for value of the potential loss $(1 - q)(S - \pi_d)$ slightly in excess of $\pi_0$. In this scenario, the FDI is not launched and the poverty trap will be perpetuated.

5. **The option value.** To generalize our result, let’s suppose that the FDI is an infinitely lived project that produces a continuous flow of return $\pi$ over an infinite time horizon. The corresponding return rate has a nonzero growth rate $\alpha > 0$, with a proportional variance per unit of time equal to $\sigma^2$. The change $d\pi$ over an interval of time evolves according to the random dynamics

$$d\pi = \alpha \pi dt + \sigma \pi dz$$

where $dz \sim N[0, dt]$ is the increment of a Wiener process. Notice that if $\sigma = 0$,then $\pi_t = \pi_0 e^{\alpha t}$ and the value of the FDI at time $t$ is $V(\pi) = (\pi_t e^{\alpha t} - S) e^{-\rho t}$, where $\alpha < \rho$ to assure convergence. But, with uncertainty the decision of the policy maker depends on the random behavior of the net return whose mean value and variance are $E(d\pi) = \alpha \pi dt$ and $E(d\pi)^2 = \sigma^2 \pi^2 dt$, respectively.

From the point of view of the recipient government the option value of the FDI approaches to zero if the return approach to zero because the probability that $\pi$ will climb the trigger value, say $H$, in the far future is very small. In this scenario, the discounted value of the foreign investment project is quite irrelevant, and the
local policy makers will prefer to maintain the ODA – whose current value is $S$ – instead of swapping to the FDI. However, higher returns should raise the value of the foreign investment opportunity, and for values of $\pi$ close to the trigger value $H$ the option value of the FDI approaches the net worth of the live project in $H$.

For what value of $\pi$ is it optimal to swap from the ODA to the FDI? To compute this trigger value, let’s indicate with $V(\pi)$ the value of the FDI. Since the foreign project yields no profits up to time the investment is undertaken, the only return it provides during the waiting period is its capital appreciation. In equilibrium it must be equal to the (instantaneous) appropriate return rate $\rho$

$$\rho = \frac{E (dV)}{V dt}$$

(7)

Equation (7) can be rewritten as

$$\rho V dt = E (dV)$$

(8)

It says that the total expected return of the FDI, $\rho V dt$, is equal to the expected rate of capital appreciation $E (dV)$. Using Ito’s lemma, the right hand side of (8) can be written as

$$E (dV) = V' (\pi) E (d\pi) + \frac{1}{2} V'' (\pi) E (d\pi)^2$$

(9)

$$= V' (\pi) \alpha \pi dt + \frac{1}{2} V'' (\pi) \sigma^2 \pi^2 dt$$

(10)

Substituting in (8) for $E (dV)$ and simplifying we get the Bellman equation

$$\frac{1}{2} V'' (\pi) \sigma^2 \pi^2 + \alpha \pi V' (\pi) - \rho V = 0$$

(11)

This equation is a standard second-order differential equation whose solution can be expressed as a linear combination of any two independent solutions. Trying with the function $A \pi^x$ we get the quadratic equation

$$Q (x) \equiv \frac{1}{2} x (x - 1) \sigma^2 \pi^2 + \alpha x - \rho = 0$$

(12)

where

$$x_{1,2} = \frac{1}{2} - \frac{\alpha}{\sigma^2} \pm \sqrt{\left[ \left( \frac{\alpha}{\sigma^2} \right) - \frac{1}{2} \right]^2 + \frac{2 \rho}{\sigma^2}}$$

(13)

with $x_1 > 1$ and $x_2 < 0$. So the general solution can be written as

$$V (\pi) = A \pi^{x_1} + B \pi^{x_2}$$

(14)

where $A$ and $B$ are constants to be determined. Then, $V (\pi)$ must satisfy the following boundary conditions

$$V (0) = 0$$

(15)

$$V (\pi^*) = \frac{\pi^*}{\rho} - S$$

(16)

$$V' (\pi^*) = \frac{1}{\rho}$$

(17)

where $\pi^*$ is the trigger value of profit where the policy maker is indifferent between the ODA and the FDI. However, in our problem, the boundary condition (15) implies that $B = 0$, leaving the solution $V (\pi) = A \pi^{x_1}$. The system above evaluated in $\pi^* = H$ reduces to
\[ AH^x = \frac{H}{\rho} - S \]  
\[ xAH^{x-1} = \frac{1}{\rho} \]  
(18)  
(19)

Solving for \( H \) we get

\[ H = \frac{x}{x - 1}\rho S \]  
(20)

and

\[ A = \frac{H^* - S}{(H^*)^x} = \frac{(x - 1)^{x-1}}{(x)^x \rho^x S^{x-1}} > 0 \]  
(21)

where since \( x > 1 \) we have \( \frac{x}{x-1} > 1 \) and \( \frac{H^*}{\rho} > S \). Therefore, the mix uncertainty and irreversibility drives a wedge between the critical values \( \frac{H^*}{\rho} \) and \( S \). It is this wedge that fuels the poverty trap.

Figure 3. Source: Own elaboration. Values of Waiting and Investing.
To provide an intuitive explanation of the solution look at figure (3). The upward sloping straight line represents the current value \( \pi - S \) of the FDI as a function of \( \pi \), if the government accepts to start immediately with the FDI renouncing to the ODAs. Note that after the value \( \pi = p \) the FDI has a positive net present value, but the policy maker of the recipient country still prefer the ODA to the investment. The convex function \( A\pi^x \) describes the value of the FDI as a function of \( \pi \). For \( \pi < H \) the curved line is above the straight line meaning that the policy maker prefers the real option to the lived FDI. But, the option value approach to zero if the return is low, and raises rapidly as it approaches the trigger value \( \pi = H \). In figure (3) \( H > p \) and the curved line \( A\pi^x \) is tangential to the straight line \( \pi - S \). Thus, for the policy maker the optimal switching strategy requires that the two curves must be tangent at \( H \). This is the reason why the boundary condition (17) is called smooth pasting condition whereas the condition (16) is called matching condition. Importantly, the optimal trigger value \( H \) is higher than \( p \) implying that the government prefers to postpone the acceptance of the FDI even when the NPV of the investment is positive and higher than the value \( S \) of the ODA. It is this shadow value between \( p \) and \( H \) that fuel the poverty trap.

One final aspect must be noted. From the inspection of figure (3) emerges that the convex curve \( A\pi^x \) lies above the straight line to the right of \( H \). This does not mean that the “waiting strategy” is optimal when \( \pi > H \). Indeed, the expression \( A\pi^x \) ceases to have a concrete interpretation once \( \pi \) climbs above the trigger value \( H \). It is only a speculative bubble which would “promise” an ever increasing payoff without participating to any actual FDI.

5.1. Option value and poverty trap. With these information we can provide a novel explanation of the “poverty traps”. The mix uncertainty and irreversibility can be a plausible self-reinforcing mechanism that acts as barrier to the immediate adoption of FDI in specific regions, sectors or locations of poor countries. This interaction determines endogenously the mechanism at the core of the perpetuation of the inefficient status quo called hysteresis.

How does a higher uncertainty affect the poverty trap? To give an answer to this question, let’s write the positive root of the equation (12)

\[
x = \frac{1}{2} - \frac{1}{\sigma^2} + \sqrt{\left(\frac{1}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}} > 1
\]  

(22)

Differentiating \( x \) with respect to \( \sigma \) we get \( \frac{\partial x}{\partial \sigma} < 0 \). Therefore, an increase in \( \sigma \) decreases \( x \), and raises the ratio \( \frac{x}{x - 1} > 1 \). In other words, the greater is the uncertainty over the payoff \( \pi \), the larger is the wedge between \( H \) and \( \rho S \), and the larger is the excess of return the policy maker will require to renounce to the safe asset (ODA) in favor of a (risky) irreversible FDI. Notice that equation (20) also says that higher is the value \( S \), higher is the trigger value \( H \) where the policy maker finds optimal to switch from the waiting strategy (the real option) to the FDI. In other words, a high level of ODA tends to raise the option value of the possible investment program, and consequently to reduce the incentive to take the FDI.

Figure (4) plots \( V(\pi) \) as a function of \( \pi \). Assume initially that \( S = 1, \alpha = 0.06, \rho = 0.08 \) and \( \sigma = 0.2 \). Given these parameter values, \( x = 1.23 \) and \( A = 12.42 \).

The option value of the investment program is \( V(\pi) = 12.42\pi^{1.23} \), and the net present value of the “invest now” strategy is \( \frac{\pi}{0.08} - 1 \). Figure (4) shows the option value \( V(\pi) \) for these parameters, but also for \( \sigma = 0.3 \). In each case, the tangency
point of $V(\pi)$ with the straight line gives the critical value $H$. Note that when $\pi < H$ then $V(\pi) > \frac{\pi}{h} - S$ which implies that $\frac{\pi}{h} < V(\pi) + S$. Hence, the value of the FDI is smaller than its full cost, the direct cost $S$ plus the opportunity cost $V(\pi)$. Finally, note that $V(\pi)$ increases when $\sigma$ raises. Therefore, the greater uncertainty reduces the incentive of the local government to leave the ODA in favor of the foreign investment strategy.

Figure 4. Source: Own elaboration. Real option value for $\sigma = 0.2$ and 0.3.

Figure (5) shows how $V(\pi)$ and $H$ depend on $\alpha$, the profit growth rate. Observe that an increase in $\alpha$ from 0.06 to 0.08 results in an increase in $V(\pi)$ and hence an increase in the trigger value $H$. The reason is that as $\alpha$ becomes larger the expected rate of $V$ raises and hence the expected appreciation in the value of the FDI raises. In other words, for the local government it is optimal to wait rather than to start with the FDI now, given the higher option value.

Figure 5. Source: Own elaboration. Real option value for $\alpha = 0.06$ and 0.08.
6. Conclusions. In this paper we have shown that the poverty trap can be treated as a real option. When there is uncertainty about returns and irreversibility about costs of FDIs, the policy makers of a poor country can prefer to maintain ODA’s – in a specific region, location, or sector – instead of taking the FDIs, postponing any possible commitment to the future. This happens because, from the government’s perspective, the full cost of any FDI is given by the sum of the ODA shifted from the initial region, sector or location towards alternative destinations of the same country plus the opportunity value of the risky and irreversible FDI. If the current return of the alternative investment program is in the range between these two extreme values then the optimal strategy for the policy makers is to maintain the real option alive. So, the FDI is not accepted and the ODA remains the main source of income for the poor country. Obviously, this is not the best choice for the inhabitants of the recipient country, but it is the best choice for the government of it.

This is a novelty in the literature on the poverty trap. Indeed, an important feature of our setup is that the opportunity to accept or refuse a FDI is also assigned to the policy makers of the recipient country.

Some aspects remain unexplored in this paper. For example, one possible scenario is that waiting for a while may no longer be feasible when FDI is available to any of several poor countries. There can be strategic situations with more developing countries, where moving first may be profitable. In practice, these considerations may call for early FDIs at the same time that uncertainty suggests waiting. The optimal choice would then have to balance the two.

We believe that the real option value of FDIs has important implications for effective policies in developing countries. Strategic behavior between foreign firms and poor countries, small nominal and real frictions of prices and costs, the presence of uncertainty about technology and political climate can generate large rigidity affecting strategic choices in poor countries. Further, irreversibility can affect the decisions of the local government to take or to postpone new investment projects. Therefore, the mix between irreversibility and uncertainty can cause the hysteresis which magnifies the impact of the poverty trap quite dramatically.

As said, the present analysis is not intended to be comprehensive. But, it clarifies some thinking about the inter-linkages between uncertainty, option value and timing of FDI at the country level. Further, it allows to get some statements for policies. For example, uncertainty about returns magnifies the opportunity cost of FDI. Political uncertainty can play the same role. Or, hysteresis directly depends on the real option value.

Finally, the model is stylized and may not capture all of the details of reality. Therefore, our aim for future research, is to extend the present setup to include competition between poor countries and foreign firms, institutional measures and strategic elements to reduce irreversibility and uncertainty. The analysis of these issues, and their empirical implications, are left for our future research.

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