Total factor productivity by imitative behavior[1]

Abstract: We study the determinants of total factor productivity (TFP) growth and economic development, where worker's decisions and firms' decisions are driven by the imitative behavior of economic agents in their decisions about to update or not of their human capital and/or the technology. An "imitation" function is postulated whereby the social prevalence of a behavior (skill and/or technological upgrading) increases the probability that such a behavior is copied and spreads further in the population. We show the evolutionary dynamics of TFP growth, and that economic growth is self-promoting, but poverty traps can arise.

Keywords: Developing countries; Imitative behavior; Productivity factors; Welfare and Growth.

JEL classification: D03; D24; D60; J24; O12; O49.

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1. Introduction

Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production. As such, its level is determined by how efficiently and intensely inputs are utilized in production. TFP growth is usually measured by the Solow residual.[1] TFP plays a critical role on economic fluctuations, economic growth and cross-country per capita income differences. The goal of this paper is to show that the characteristics from an imitation process followed by workers and/or firms when they need to choose their future behavior, plays an important role in the creation of the wealth/welfare of a country. Thus, a precise understanding of this process may shed light on the tasks to solve the growth divergences among countries.

A number of studies have documented the importance of TFP in explaining the difference in economic growth between countries (examples of these papers include King and Levine (1994), Prescott (1998), Hall and Jones (1999), Easterly and Levine (2001) and Islam (2003)).[2] In this vein, Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999) have confirmed that a majority of the gaps in income per capita between rich and poor countries are associated to large cross-country differences in TFP. Cross-country differences in TFP can be due to differences in physical technology used by countries or in the efficiency with which technologies are used. We take this idea and we show that TFP may be the responsible for the occurrence of poverty trap. It is worth noting that given the importance of TFP in shaping countries growth experiences, modeling TFP and finding the factors that affect their trends have very significant policy implications.

By linking the TFP growth rate to innovation, endogenous growth models shed light on the determinants of TFP growth. Both R&D subsidies and abundance of skilled labor can reduce the marginal cost of conducting R&D and increase the rate of innovation development, and therefore the TFP growth rate. Increasing the size of markets increases the innovators' revenues, leading to more innovation and higher TFP growth. In this work, our aim is to explain economic growth by TFP, assuming TFP is linked with the evolution of technology and human capital formation, where firms and workers follow an imitative behavior of the more successful agent given the current state of the economy.

To use the language of the traditional empirical growth literature, our model attempts to explain that long-run level of TFP is determined by an imitative behavior which characterizes the level of human capital and the number of firms using high-tech in the economy. This agents' imitative behavior can drive the economy to a high growth path, raising the level of TFP and therefore the level of welfare, or conversely, drive the economy to a low growth path and a poverty trap. What and who to imitate is an individual decision that is governed by the laws of the market, however this decision can be influenced by a central authority (see Accinelli and Carrera (2011)).

Note that by imitation, in this work, we mean a social behavior where economic agents choose to perform a spectrum of tasks "as others do". Each one makes decisions by analyzing, the results obtained by their peers. To explain why economic agents imitate we should think of it as a kind of rational behavior (see Accinelli et al., 2010).

Unlike the authors Accinelli-Carrera (2011) and Accinelli et al. (2010) where they get the evolutionary dynamics of the strategic complementarities between innovative firms and skilled workers to overcome a poverty trap, and the way in which such economic agents imitate the most successful one. In this short paper, we study the imitative behavior of economics agents who need to decide by human capital and/or technology, and the preferences are modeled by a Cobb-Douglas function and its relation with the Total Factor Productivity. Then, we explain the evolution of the TFP due to an imitation process followed by economic agents. Agents can chose to follow a behavior of low-profile (workers prefer not to invest in their own education and firms

[1] The Solow residual is a number describing empirical productivity growth in an economy from period to period. The residual is that part of growth not explicable by measurable changes in the amount of physical capital and the number of workers. Recall that Solow (1956) demonstrated that cross-country differences in technology may generate important cross-country differences in per capita income.

[2] Hall and Jones (1999) suggested that differences in TFP might account for more than 60% of the differences in output per worker. Not surprisingly, this has led to an increasing focus on explaining differences in TFP, often taken to mean technology or efficiency, rather than factor accumulation.

prefer not to invest in R&D activities) or a behavior of high-profile (workers invest in education and firms prefer to be innovators investing in R&D activities).

We assume that occasionally each individual firm and worker in their finite population gets an impulse to revise her (pure) strategy choice (innovative/non-innovative and skilled/unskilled). We assume that the information available to the agents about the payoffs and the other agents' strategies at the time they are asked to make a decision upon whom and/or what to imitate, is not necessarily complete. There are two basic common elements to these models. The first is a specification of the time rate at which individuals in the population review their current strategy choice. This rate may depend on the current performance of the agents' pure strategy and on other aspects of the current population state. The second element is a specification of the choice probabilities of the reviewing individual. The probability that the strategists will switch to some pure different strategy may depend on the current performance of this strategy and other aspects of the current population state. If these impulses arrive according to i.i.d. Poisson processes, then the probability of simultaneous impulses is zero, and the aggregate process is also a Poison process. Moreover, the intensity of the aggregate process is just the sum of the intensities of the individual processes. If the population is large, then one may approximate the aggregate process by deterministic flows given by the expected payoffs (see Weibull, 1995).

Hence, our central contribution is to explain how the main characteristics of an imitative process followed by individual agents characterize twofold, and explains the TFP and the evolution of the whole economy, and defines the role of the central planer. Both workers and firms, when choosing their strategies, solve their own optimization problem. This individual process of imitation creates externalities on the society as a whole. Agents are not aware of the social effects of their decisions. In these cases the participation of a central planner can be justified when the result from the decentralized action of agents is a Pareto dominated outcome. Hence the role of the central planner will be to design an incentive policy such that the individually optimal choice made by economic and individual agents match with the socially optimal choice, which is to bring the economy in a high-level growth path. Such a policy must increase the likelihood that agents imitate those behaviors considered socially optimal, i.e. high-profile economic agents.

The remainder of this paper is organized as follows. Section 2 presents a process of TFP that is part of a growth model with imitative agents and characterizes the economic performance of an economy. Section 3 studies the imitation process of workers for human capital formation. Section 4 spells out how firms become high technological given certain cost of innovation. Section 4 concludes the paper.

2. The model

In line with the endogenous growth models, let us consider human capital instead of just labor. Moreover, crucial remarks for the sequel model are:

Remark 1: *Economic welfare can be considered as the level of prosperity and quality of living standards in an economy that can be measured through a variety of factors such as GDP and other indicators which reflect welfare of the population. We claim that the level of economic welfare equals the level of output or GDP. Irrespective of any important consideration of wealth distribution.*

Remark 2: *The benchmark is an economy composed by innovative/non-innovative firms and skilled/unskilled workers.*[3]

[3] Our benchmark is close to Acemoglu (1996) who develops an endogenous growth model, where firms and workers choose the amount of their investments. Then, they are matched randomly, production takes place, and income distribution is determined by a bargaining process.

Remark 3: *We will show that if the level of output is a measure of the economic welfare, then there exists a relationship between economic welfare and the behavior of the economic agents driven by an imitation process.*

Assume that the feasible technology is able to transform, K_t units of physical capital and H_t units of human capital into Y_t units of output at any point in time *t.* Y_t denotes the aggregate total output of the economy. Assume moreover Y_t is a Cobb-Douglas production function:

$$Y_t = A_t K_t^{\alpha} H_t^{\beta} \tag{1}$$

where by A_t we symbolize the total-factor productivity (TFP) at time t and α and β are the output elasticities of physical capital and human capital, respectively.

Notice that, for fixed K and/or H, output can grow over time, due to technological efficiency or due to innovation processes embodied on A, which will be defined later. We will assume that physical capital is constant in the short-run, but human capital and efficiency can change even in the short run. Composed, the *In* function (1) with the aggregate total outputs and derived it respect to *t*, equation (1) leads to the following growth equation --which is in line with Solow-- given by:

$$\frac{\dot{Y}_t}{Y_t} = \frac{\dot{A}_t}{A_t} + \alpha \frac{\dot{K}_t}{K_t} + \beta \frac{\dot{H}_t}{H_t}. \tag{2}$$

This equation establishes the linkage between output and total factor productivity.

Consider that the human capital sector is based on the idea that a key role of education is not only to produce human capital but also to screen individuals by innate ability (see Hoff and Stiglitz (2001)). Education credentials (e.g. skilled/unskilled) sort people into distinct groups in the labor market. So there are only two kinds of workers: skilled and unskilled. Skilled workers may have a high level of capital H_s and the level of human capital for the unskilled workers is $H_{ns} < H_s$. Consider that H is the mean value of human capital in the economy, then:

$$H_t = H_s s_t + H_{ns}(1 - s_t) \tag{3}$$

Where S_t is the fraction of skilled workers in the population, at time t So, how the average skill level varies is:

$$\dot{H} = (H_s - H_{ns})\dot{s}_t \tag{4}$$

Suppose that the behavior of the population of workers follows an imitative model, where each individual chooses in every period to be s - type or nor ns- type according with the expected value of each strategy.[4] Hence,

$$\dot{s}_t = [E(s_t) - E(ns_t)]s_t \tag{5}$$

[4] More details on this payoff differences are in Accinelli-Carrera (2011). The authors show that positive payoff differences provide a dynamic strategy to copy the higher payoffs.

Total factor productivity (TFP) can be taken as a measure of an economy's long-term technological change or technological performance. Let us consider that A represents the mean efficiency value, where a high-tech firm has a high-efficiency value given by A_h and a low-tech firm has associated a low-value of efficiency: $A_{nh} < A_h$. Let h_t be the share of high-tech firms and $nh = (1\text{-}h_t)$ is the share of low-tech firms, at time t Then,

$$A = A_h h_t + A_{nh}(1-h_t) \tag{6}$$

represents the mean efficiency value of the economy. Therefore:

$$\dot{A} = (A_h - A_{nh})\dot{h}_t. \tag{7}$$

Consider also that the population of firms evolves according to an imitative model, so:

$$\dot{h} = [E(h_t) - E(nh_t)]h_t \tag{8}$$

Notice that the equations (4) and (7) are describing the evolution of the average level of human capital and the average efficiency of firms over time, which are among the most essential equations for the paper, is based solely on the change of the proportions of skilled workers and high-tech firms. Tacitly we consider that the absolute levels of human capital depend exclusively on the amount of skilled workers existing in each time. Certainly, technology increases over time, however its successful use requires for the economy the existence of a minimum of skilled human capital. If this threshold is not achieved the impact of technology on growth will be null.

Since, our aim in this paper is merely to emphasize the importance of imitation process in the development of the richness of the countries. Let us assume technology free access for every country that requires it. But the absolute level of human capital in each country depends on the share of skilled workers existing over the total population of workers, which is assumed to be constant. This last assumption is made with the objective to avoid the discussion about the characteristics of the rate of growth of the human populations. This topic will be a matter of future research.

In line with the endogenous growth model, we put emphasis in human capital and in improvement of the efficiency of the economy. We assume that the total capital is constant over time, i.e. $\dot{K}_t = 0.$ Hence, we can state that:

Proposition 1: *TFP comes from the strategic foundation of workers and firms driven by imitation of the most successful to raise human capital formation and R&D activities. That is, the Solow residual is giving the effect of productivity improvements on the economy and depends on the share of workers and firms and their differences in expected payoffs.*

Proof. Substituting into equation (2), the equations (3 to 8), it follows that with some algebraic manipulations,

$$\frac{\dot{Y}_t}{Y_t} = \frac{(A_h - A_{nh})}{A_h h_t + A_{nh}(1-h_t)}\dot{h}_t + \frac{(H_s - H_{ns})}{H_s s_t + H_{ns}(1-s_t)}\dot{s}_t. \tag{9}$$

and therefore considering (5) and (8) and substituting in the above equation (9), we get the Solow residual:

$$\frac{\dot{Y}_t}{Y_t} = \frac{(A_h - A_{nh})}{A}[E(h) - E(nh)]h_t + \frac{(H_s - H_{ns})}{H}[E(s) - E(ns)]s_t \tag{10}$$

From this equation (10) it follows that if: $E(s) > E(nh)$ and $E(h) > E(nh)$, then the growth rate of the TFP increases. This result is crucial for the design of a economic policy. From equation (10) it follows that negative growth rates of human capital will lead to a deceleration in output's growth. This negative process is motivated by an economic situation where the expected payoffs for being skilled and not investing in technology (R&D activities) is lower than the expected payoffs for being skilled and innovative firm. If the central authority is not successful in designing a good policy, then the economy will fall in a poverty trap, where the best individual choice raises a Pareto dominant outcome from a social viewpoint. Conversely, a good policy, focused to incentive investments in technology and human capital, can give place to a process of economic growth. Increasing the percentage of skilled workers raises the innovators' revenues, leading to more innovation and higher TFP growth. That is, economies with the same amount of physical capital can have different levels of economic welfare according to the characteristics of their human capital.

Cross-country differences in TFP can be due to differences in the technology used by countries or in efficiency with which technologies are used. We argue that these differences (and hence differences in economic growth) rely on the characteristics of the imitation processes followed by the populations of firms and workers on those countries.

Understanding the determinants of technology adoption is crucial to explain cross-country variations in TFP and so to understand why and who people copy. While TFP differences explain most of the static variation in GDP across countries, human capital accumulation is a crucial determinant of the dynamic path of TFP, and the decision to accumulate human capital is personal. We suggest that the key for understanding productivity growth in most countries is through an imitative process followed by firms and workers. Thus, cross-country variation in TFP is, to a large extent, determined by the cross-country differences in the imitation process.

3. The dynamic system of the imitation process

Consider a full employment such that at the end of every period, workers need to decide whether to be skilled or not. That is the idea of a depreciation of human capital (lost of skills) arises when training is not permanently, it is easy to understand and is strongly associated with the level of technology development. As more developed and sophisticated is the technology, then harder is to keep up it without permanent training. The rapid development of modern technology requires a permanent process of skills of human capital to be able to use it. Hence, a worker will be skilled at each period of time, if and only if consciously chooses being training, but when taking this decision has a cost, which is the education (or training) cost.

The imitative behavior works in the following way[5]:

- Workers may be in a reviewer condition, i.e. each period they need to choose their strategies for the next period about to be skilled or not, following an imitative behavior. A reviewer worker at time t, is a worker that reviews her current strategy, sometimes changing it. That is, under the probabilities $r_h \in [0,1]$ and $r_{nh} \in [0,1]$ each individual, respectively, skilled and unskilled worker raises the question about she must change or not her current strategy, h or nh. Where the subscripts h/nh denote human capital (skilled) or not human capital (unskilled). It is natural to take into consideration that these probabilities depend on the performance of the agents' pure strategy and other aspects of the current economic condition. For instance, the reviewing rate of a skilled worker, $r_h(t)$, is for all times t a decreasing function on the expected payoff of the skilled worker, $E(s_{t-1})$, and the reviewing rate of a unskilled worker, $r_{nh}(t)$, is a decreasing function on the expected payoff of the unskilled worker, $E(ns_{t-1})$. So a reviewer skilled worker decides to be unskilled if

[5] See details in Accinelli, Brida and Carrera 2010; Weibull,1995).

and only if $E(ns_{t-1}) > E(s_{t-1})$ otherwise she remains on her current strategy. The problem is analogous for a reviewer unskilled worker.

According to the above considerations, the evolution of the share of skilled workers is defined by the system:

$$\dot{s}_t = \begin{cases} s_{nh} r_{nh} \big(h_I(t)\big) \chi_{[E(s_{t-1}) - E(ns_{t-1})]} \\ \\ - s_h r_h \big(h_I(t)\big) \chi_{[E(ns_{t-1}) - E(s_{t-1})]} \end{cases} \tag{11}$$

where by $h_I(t)$ we denote the given profile distribution of innovative firms at time t, and by $x[.]$ we denote the characteristic function:

$$\chi_{[A(t)]} = \begin{cases} 1 & \forall\, t \ : \ A(t) > 0 \\ \\ 0 & \forall\, t \ : \ A(t) \le 0 \end{cases}$$

Following Accinelli-Carrera (2011), workers have incomplete information at the time when they must choose their strategy for the next period, because they do not know initially the type of firm they will be hired from. This fact will be revealed only at the end of actual period, when innovative (or high-tech) firms pay prizes to skilled workers (only innovative firms pay these prizes). But to become, or to remain in the next period, a skilled worker, people need to do an investment in education. It is worth paying the opportunity cost of education if and only if the probability to be enrolled by a high-tech firm is high enough, because only high-tech firms pay skill prize.

So, if workers have incomplete information about the expected value of their available strategies, then they make their decisions according to some signal. A typical signal could be the payoff obtained by their peers. This behavior gives place to an imitation process where workers look the behavior of their friends or neighbors. Assume for instance that according to the rule of "the majority do the best", a worker decides to imitate the behavior of the first he meets. This behavior is consistent with the rule of the majority, because the probability of meeting a person with the majority behavior is greater than the probability of meeting a person of minority behavior.

Consider also that the share of skilled-unskilled workers depends on the "true" value of the expected value of the strategies. So the probability that a reviewer worker imitates a skilled worker is an increasing function of the true value of the difference $E(s) - E(ns)$ that is to say:

$$P(\text{a reviewer worker imitates a skilled worker}) = \begin{cases} f(u), & u > 0 \\ \\ 0, & \text{otherwise} \end{cases}$$

where $u = E(s) - E(ns)$ and $0 \le f(u) \le 1$, such that $f'(u) > 0$ and $f''(u) < 0$. So for the population of workers with incomplete information, the dynamic system (11) becomes:

$$\begin{cases} \dot{s}_h(t) = s_{nh}(t) r_{nh} f(u) - s_h(t) r_h (1 - f(u)) \\ \\ s_h(t_0) = s_{h0}. \end{cases} \tag{12}$$

or equivalently,

$$\begin{cases} \dot{s}_h(t) = s_h(t)[(r_h - r_{nh})f(u) - r_h] + r_{nh}f(u) \\ \\ s_h(t_0) = s_{h0}. \end{cases} \tag{13}$$

The next proposition is straightforward.

Proposition 2: *By imitation among the population of workers:*

1. *The percentage of skilled workers increases if and only if E(s) > E(ns).*
2. *The intensity of the process of transformation of an unskilled worker into a skilled worker is reinforced by the probability that an unskilled worker becomes a reviewer. To observe this fact, consider* $\dot{s}_h(t)$ *as a function of* r_{nh} *according to the equality (equation:dynsis1) and takes the derivative with respect to this variable:*

$$\frac{d}{dr_{nh}}\dot{s}_h(t) = s_{nh}(t) \geq 0.$$

Proof: The assertion (1) is consequence of the workers' rationality driven by imitation. Assertion (2) is a consequence of the differential equation given in (12) or (13), so the proposition holds.

Analogously, firms at the end of every period need to choose between to become or not a high-tech firm. This decision depends on the supply of skilled workers, because high-tech firms can obtain economic advantages by exploiting technological competencies if and only if the supply of skilled workers in the labor market is relatively high. Following this claim, it is possible to affirm that a central planner can improve the functioning of markets by implementing a set of public policies with the goal of increasing the rate r_{nh}, which means the probability that an unskilled worker becomes a reviewer.

It is in this vein that one can claim that human capital is the engine of the economy. This is very close to the Nelson-Phelps (1966) hypothesis that human capital is crucial in enabling the imitation of technologies developed at the frontier. An increase in human capital intensity today has an impact on TFP in all subsequent periods, not just in the current one. However there is a necessary dependence between the decision of the firms and the decision of workers taken at the same time.

4. The imitation process defines the growth path

TFP plays an important role in explaining the output growth, and therefore the evolution of the welfare in an economy. On the basis of the evolutive dynamics of the TFP, we consider an imitative process, when defines the welfare of the economy.

We assume that technology of a high-tech firm is:

$$Y_h = A_h K^{\alpha_h} H_s^{\beta_h}$$

and technology of a low-tech firm is:

$$Y_{nh} = A_{nh} K^{\alpha_{nh}} H_{ns}^{\beta_{nh}}.$$

skilled labor productivity is higher than the productivity of unskilled labor. However getting high-technology is costly, and to obtain non-negative profits using a high-technology function requires the existence of an abundant supply of skilled workers.

In order to maximize the expected profit, the firm must invest when the net present value of the investment becomes greater than the opportunity cost of investing. Since high-technology and human capital are complementary inputs, in order to obtain positive expected profits, high-tech firms need a relative high probability to find skilled workers in the labor market.

A firm decides to be innovative, at time t_0, if and only if the expected payoff for this decision is large enough, i.e. if $E_{t0}(h) > E_{t0}(nh)$. Certainly, this inequality holds if and only if the cost to produce using advanced technology is lower than the cost to produce without advanced technology. Note that, if the supply for skilled workers is less than the optimal demand for skilled workers by the technologically advanced firms, then the costs to produce in the innovative way may be so high such that it is preferable to produce without using this advanced technology. On the other hand, the decision to use advanced technology could have an associated sunk costs. And this fact, could make for a firm to take the decision for the use of advanced technology while waiting for a higher supply of skilled labor, but just if the variable costs are low enough that this decision makes sense.

Therefore, there is a threshold value $\hat{s}_h$, such that only if the proportion of skilled workers is higher, then the decision of a firm to become innovative makes sense:

$$\hat{s}_h < s_h(t) \,. \tag{15}$$

where $s_h(t)$ is the share of high-skilled workers at time *t*. This threshold value decrease if the sunk costs associated with technologically advanced production decreases. In fact, it is the decision of the workers to become skilled the real engine of this technological growth process. In this sense, the participation of a benevolent central planner (policy maker) can have good results if she is able to encourage workers to become skilled, or to take measures with the object of decreasing the sunk costs associated with the technological investments. So the growth path can be characterized by:

1. The dependence between the expected payoffs and the share of skilled workers comes naturally if we assume that high-tech and high human capital are complements. The relative abundance of skilled workers in the labor market leads to a reduction of the costs in the short and long run of high-tech firms. Low-tech firms cannot take advantage of this abundance, because they use indistinguishably unskilled and skilled workers. In the long-run, if the supply of skilled workers increases continuously, most of the non-innovative firms should exit from the market, or shall become high-tech. If the supply of skilled workers is increasing, innovators can obtain larger benefits for cover the innovation costs despite being perfectly competitive, because they can reduce the marginal cost of technology by increasing the use of the complementary input. Then the virtuous circle restarts. The virtuosity of this cycle explains the increase in the total factor productivity and then in the economic welfare, and the economy is evolving in a high-performance path.
2. Reciprocally, if the supply of skilled workers decreases or it is not enough large to cover the high-tech firms' aggregate demand, then this kind of firms cannot increase their output without losses, or cover the investment cost in technology. Thus is production costs using high-technology are higher than the optimal. Recall that:

$$c_h(y,s_h) > c_h(y,s_h(y)) \quad \forall\, s_h \neq s_h(y)$$

where $c_h(y,s_h)$ denotes the costs faced by the high-tech firms producing y units of output when the supply of skilled workers is s_h and $s_h(y)$ is the high-tech firms optimal demand of skilled workers. So in this case, the total factor productivity decreases over time and the economy is immersed in a poverty trap.

The behavioral rule that firms should use in order to decide to be innovative or not should consider both: i) cost of investment, denoted by CI and, ii) the number of high-skilled workers that makes such an investment profitable in the long-run. The investment in innovation is profitable when the net present value of the expected profits is greater than the investment cost on innovation, i.e.

$$E(h_{t_0}) = \int_0^{\infty} \pi_{ht} e^{-rt} dt - CI > 0 \tag{16}$$

where π_{ht} denotes the high-tech firm's expected profit at time t, and r is the discount rate.

The next proposition is a straightforward consequence of the above considerations, and it summarizes the main result of this section.

Proposition 3: *Consider the cost for being an innovative firm, $CI > 0$. Two necessary conditions to adopt high-technology are that the supply of skilled labor is higher than the threshold value given by $\hat{s}_h$, and that inequality (16) is verified.*

Proof: Firms evolution is given by the equation (8), so the share of innovative firms increases if and only if the inequality (16) is verified and the threshold value (15) of the supply of skilled workers is exceeded.

Note that a positive evolution of the economy depends on the supply of skilled workers and on the value of CI. So within our framework, the main goal of an economic policy is to reduce the cost of the high-technology, and the opportunity cost of investment in human capital formation.

5. Conclusion

Productivity growth is influenced by a range of factors, and most studies suggest that there is no simple way to boost it. Apart from some specific options, such as investment in education, or infrastructure, policies to boost productivity often focus on the framework conditions for productivity growth, including public aid to decrease the opportunity cost to become skilled or to become innovative.

Understanding the strategic foundations and determinants of technology adoption is the key to explain cross-country variation in TFP. As we show, under appropriate initial conditions, the imitation drives technological evolution of the economy. The central authority, in turn, can guide this process by different measures of political economics, with the aim to increase the likelihood that low-tech firms and unskilled workers become reviewers. Obviously these measures will have positive impact on a social welfare, if and only if, at the same time the economy overtakes the threshold values. Hence the main goal of the central planner is to implement measures with the aim of increasing the share of skilled workers and innovative firms existing in the economy. Specific measures with this objective are, for instance, simply subsidize investments in technology and/or in education.

This study suggests that economic welfare (TFP) is driven by imitative behavior of economic agents, namely firms and workers. The economic welfare is positively related to the proportions of skilled workers and of high-tech firms changing over time, where these proportions increase when expected returns from skilled work and high-tech technology are relatively higher than those from unskilled work and from low-tech technology.

Finally, our findings on TFP studied as an endogenous single decision process undertaken by agents of the economy according with the market mechanism that certainly can be influenced by elements of public policy. This possibility opens the doors to a selective public policy. Individual agents are unaware about the social implications of the imitation process in which they are immersed. But the central planner knows the social value of the investment decision in human capital or in technology. For this reason, he is willing to pursue a policy of incentives for increasing the probability that imitation will be aimed at increasing investment in technology and in human capital formation.

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