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FAMILY BACKGROUND, SELF-CONFIDENCE AND ECONOMIC OUTCOMES

by Antonio Filippin* and Marco Paccagnella†

Abstract

In this paper we analyze the role played by self-confidence (modeled as beliefs about one's ability) in shaping task choices. We propose a model in which fully rational agents exploit all the available information to update their beliefs using Bayes' rule, eventually learning their true type. We show that when the learning process does not converge quickly towards the true level of ability, small differences in initial confidence can result in otherwise identical individuals showing diverging patterns of human capital accumulation. If differences in self-confidence are correlated with socio-economic background, self-confidence can be a channel through which education and earning inequalities are perpetuated down the generations (as a large body of empirical literature suggests). Our theory suggests that cognitive tests should be done as early as possible, in order to avoid systematic differences in self-confidence among equally talented people leading to the emergence of gaps in the accumulation of human capital.

JEL Classification: I24, D83, J24, J62.
Keywords: human capital, self-confidence, socio-economic status.

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1 Introduction and motivation*

Gaps in economic outcomes (like educational attainments and earnings) tend to persist across generations, and it is well-known that the socio-economic status of the parents is usually a very good predictor of the outcomes of their offspring.

Bowles, Gintis, and Osborne (2001) stress that "the advantages of the children of successful parents go considerably beyond the benefits of superior education, the inheritance of wealth, or the genetic inheritance of cognitive ability." They propose additional variables comparable to what now goes under the label of "non-cognitive skills" as factors that can supplement the ohterwise low explanatory power of the traditional variables used to fit the variance of earnings.[1] Moreover, they claim that also the contribution of parental socio-economic status to earnings is also partly determined by such non-cognitive skills, genetically transmitted or learned from parents that act as role models.

Since then many other authors have emphasized the role played by non-cognitive skills in explaining economic success and gaps in attainments. The current literature on the economic relevance of non-cognitive skills tends to treat these measures as inputs that enter the "black-box" of the skill production function. Cunha and Heckman (2007) propose a particular formulation of the technology of skill formation featuring self-productivity and dynamic complementarities among a multidimensional vector of cognitive and non-cognitive skills. They argue that insufficient investment in some of these skills early in life has long-lasting consequences that are very difficult or costly to revert. Heckman, Stixrud, and Urzua (2006), Cunha and Heckman (2007, 2008) and Cunha, Heckman, and Schennach (2010) have shown that gaps between children from different backgrounds open up very early in life, as soon as in pre-school age, and then

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[1] Brunello and Schlotter (2011) define non-cognitive skills as "personality traits that are weakly correlated with measures of intelligence." While in some papers the orthogonality between the two types of skills derives from statistical conditions that ensure identification in classical factor analysis, Deke and Haimson (2006) do find that key personality traits are rather poorly associated both with cognitive skills and among themselves, while the correlation among measures of cognitive skills is much stronger.

tend to persist and stay roughly constant over the lifetime; this finding clearly locates the rising of the problem in a period in which the role of the parents is the most important.

In this paper we want to analyze the role possibly played by a single non-cognitive skill, namely self-confidence, defined as the beliefs over one's unknown level of cognitive ability. Hence, our model entails the simplest possible multidimensional vector of skills, containing only two elements: a cognitive skill (innate ability) and a non-cognitive one (self-confidence). The use of such a framework is neither meant to deny the importance of other skills, nor the well-established fact that cognitive and non-cognitive abilities are multidimensional in nature, nor to downplay the significance of the interaction among them. It simply reflects our goal to isolate and highlight a very specific mechanism, i.e. the role that self-confidence plays by distorting task choices. In other words, our purpose is to go into the "black-box" of the skill production function, identifying a precise and specific channel through which inherited differences in self-confidence can endogenously (i.e., through individual choices) explain the emergence and persistence of gaps in the accumulation of human capital. An advantage of our approach is that the single non-cognitive skill we study has a clear and simple economic interpretation, and that we make transparent the channel through which it affects the accumulation of human capital (and thus, indirectly, earnings).

The working idea of our model is that, by acting as role-models, parents transmit to their children beliefs about their (unknown) ability. Such beliefs affect educational and task choices and, through this channel, contribute to widen the gap in the accumulation of human capital while the learning process (of actual ability) takes place. The consequences of initially "wrong" beliefs can thus have long lasting effects, even if agents eventually learn their true level of ability.

There is an extensive literature, both theoretical and empirical, that motivates and provide support to our approach.

The strong inter-generational persistence of self-confidence has been recently documented by Cesarini, Johannesson, Lichtenstein, and Wallace (2009): using Swedish data on a sample of twins and defining overconfidence as the difference between the perceived and actual rank in cognitive ability, they argue that genetic differences explain 16-34% of the variation in overconfidence, and that common environmental differences explain an additional 5-11%. Furthermore, a series of studies on different longitudinal

UK datasets (collected in Goodman and Gregg, 2010) find a strong inter-generational correlation not only in cognitive skills, but also in a variety of attitudes that can be considered proxies of confidence. In particular, Gregg and Washbrook (2011) find that, even controlling for family background and prior attainment, children are more likely to perform well in tests at age 11 if they have strong beliefs in their own ability and a more internal locus of control, and that children from poorer families are less likely to possess these attributes. Chowdry, Crawford, and Goodman (2011) find that richer parents have higher expectations of their children's educational attainments and that young people from poorer families have lower ability beliefs, a more external locus of control and lower educational aspirations and expectations. After controlling for attainment at age 11, 15% of the socio-economic gap in attainment at age 16 is accounted for by child attitudes, and an additional 12% by parents' attitudes.[2]. Additional evidence about the link between socio-economic background and self-confidence can be provided using data from the OECD-PISA study. In particular, using data from the 2006 wave of the survey, we find a robust correlation between self-efficacy[3] and students' economic, social and cultural background. The correlation survives the inclusion of a good proxy for "true" (and unobserved) ability, namely the PISA score itself. Furthermore, these empirical results are confirmed using data on a quite different population, i.e. second-year students at Bocconi University. We refer the interested reader to the Appendix for a more detailed presentation of the empirical analysis.

For self-confidence to have important effects we do not need to assume that agents

[2]Starting from Lazear (1977), some authors have considered education as a normal consumption good. As long as ability is also positively correlated with the family background, this would constitute an alternative mechanism capable of explaining the positive correlation between family background, confidence, and the persistence of gaps in educational outcomes. However, the fact that the results of Chowdry, Crawford, and Goodman (2011) are observed during compulsory education constitutes supporting evidence of a direct inter-generational transmission of confidence rather than an indirect effect mediated by tastes for schooling, which are more likely to matter for tertiary education enrollment.

[3]An index built from student's answers to questions about the ease with which they believe they could perform eight science-related tasks; this variable is a good proxy for beliefs about academic ability because it is meant to go "beyond how good students think they are in subjects such as science; it is more concerned with the kind of confidence that is needed for them to successfully master specific learning tasks, and is therefore not simply a reflection of a student's abilities and performance" (OECD, 2009). See Ferla, Valcke, and Cai (2009) for a discussion on the differences between Self-Efficacy and Self-Concept. Since Self-Efficacy solicits goal-referenced evaluation and does not ask students to compare their ability to that of others, we believe it is a better proxy for the notion of confidence that we use in the model of Section 2

enjoy holding a good image of themselves (i.e., that self-confidence enters directly the utility function), something that would imply that some degree of overconfidence is optimal. Such an assumption is quite common in the behavioral economics literature (e.g. in Köszegi, 2006 and Weinberg, 2009). While such models rationalize many interesting features of human behaviour (along with the result that moderate levels of overconfidence turn out to be optimal), we decide to stick to a simpler theoretical framework in which this does not happen. The main reason is that once agents are supposed to enjoy holding a good self-image, they should also be capable of tailoring the information acquisition during their learning process in such a way to preserve it, for instance by means of beliefs that are "pragmatic" (Hvide, 2002) or, more generally, self-serving, as well as with selective memory (Bénabou and Tirole, 2002). Manipulating the information acquisition can only be effective *in the short run*, unless agents end up stuck in a self-confirming equilibrium in which their learning process reaches a fixed point: in such case, wrong beliefs would not be disconfirmed by the evidence, either because further experimenation is not available, or because agents continue to indefinitely self-deceive themselves. Although such an outcome cannot be exclueded, we find more interesting to analyze the effect of holding a wrong self-image when the true type is eventually learned. Including beliefs in the utility function would only provide incentives to implement some form of self-deception that, even allowing the manipulation of information acquisition, would only have the transitory effect of slowing down the learning process. Therefore, we prefer to avoid such a complication. In our theoretical framework fully rational agents extract all the available information from the signals received in order to update their beliefs, and this implies that they eventually learn their true type. Similarly, we exclude any other form of self-deception. The Bayesian learning mechanism is based on observing success or failure in the endeavour undertaken, given that the probability of success depends on the true level of ability as well as on the difficulty of the task, which is chosen endogenously in accordance with (updated) beliefs about one's ability.

We also choose to set aside any issue related to risk-aversion, by assuming risk-neutrality and by focussing on a definition of self-confidence based on the *level*, rather than on the *precision* of beliefs.[4] The former implies that an overconfident holds too

[4]Both definitions are used in the literature. The first by Hvide (2002), Bénabou and Tirole (2002), and

high an estimate of his ability. The latter refers to an evaluation that is too precise, and better fits a situation in which an investor underestimates the variance of future returns. As long as the true level of ability is a point estimate, as in our case, it would be meaningless to talk about over- or underconfidence in these terms.

The two concepts, however, are not correlated, and their interaction can also determine counterintuitive results. For instance, it may happen that an agent that is quite confident along both dimensions thinks to have a lower probability of success than another who is totally agnostic about his ability. To avoid such a possibility we assume that the probability of success is linear in ability, and we adopt a notion of confidence that refers to the level (rather than to the precision) of beliefs. Such a focus is one of the main difference between our model and the one proposed by Sjögren and Sällström (2004), who also describe the endogenous evolution of self-confidence for rational agents that choose tasks and update their beliefs in a Bayesian fashion after observing the outcomes of their choices. A second major difference is that, in our framework, agents eventually discover their true type, while in Sjögren and Sällström (2004) agents can remain "trapped" with wrong beliefs due to insufficient experimentation and learning.[5]

We finally simulate the model with a bootstrapping procedure, showing that choices distorted by under-confidence (while all the other sources of heterogeneity are neutralized) lead to a significant gap in the accumulation of human capital during the learning process of the true level of ability. As long as it correlates with the family background, self-confidence constitutes therefore a channel through which gaps in educational attainments and earnings perpetuate across generations.

This finding also helps to explain why the early gaps based on the socio-economic background do not narrow when the role of the family becomes less important relative to other factors (like school and teacher quality, or peers' characteristics). This also suggests that policies aimed at providing early and accurate feedbacks on the cognitive skills of disadvantaged children can be important in promoting inter-generational income mobility.

The outline of the paper is as follows. In section 2 we present a simple and parsimo-

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Weinberg (2009), among others; the second by Sjögren and Sällström (2004). Köszegi (2006) and Belzil (2007) use both.

[5]To achieve this result, they have to assume the existence of non-informative tasks, in which the probability of succes is equal to one.

nious theoretical model that highlights how self-confidence can affect the accumulation of human capital via task choice. In section 3 we run a simulation of our model in order to better assess its implications in terms of the emergenge of gaps in educational attainments between people from different backgrounds. Section 4 comments upon the results and draws some conclusions.

2 The Model

In this section we present in more details a multi-period model in which agents choose a task on the basis of their beliefs, which are then updated in a Bayesian manner after observing the outcome of every choice. Our purpose is to highlight the role played by confidence in determining educational attainments via task choice.

Ability is randomly distributed in the population and is represented by the random variable A, with $A \in [0, 1]$. We assume that agents do not know their own realization of A, but hold some beliefs represented by the density function:

$$\mu(a) = Pr(A = a)$$

Confidence is defined as agent's perceived ability:

$$E(A) = \hat{\mu}(a) = \int a\mu(a)da$$

and is *not* randomly distributed in the population. In particular, we assume a positive correlation between confidence and the socio-economic status of parents.

We define underconfident an agent that underestimates her ability:

$$\hat{\mu}(a) < a$$

while overconfident agents overestimate it:

$$\hat{\mu}(a) > a$$

Students make educational choices by choosing "tracks", denoted by ψ, with $\psi \in$

$(0, 1]$. We think of tracks as a rather general concept, encompassing either "real" school tracks (e.g. academic vs. vocational high schools) or any goal that the student sets herself. In the latter sense, for instance, a student choosing a more difficult "track" could be a student choosing to study for many exams at the same time (with the "risk" of failing or doing poorly in all of them), or choosing to delve into a subject by devoting a lot of time to it (with the "risk" of not getting that much out of it. A failure could be interpreted either as a true failure in a "real" track (e.g. the student drops out or must repeat a grade) or as the chance that, in trying to deeply understand some difficult material, the student wastes energy and time, ending up learning less than she would have done had she been less ambitious.in the end).

Letting the realization of the random variable S denote success $(S = 1)$ or failure $(S = 0)$, the probability of success is described by:[6]

$$Pr(S = 1) = f(a, \psi) = \psi a + (1 - \psi) \tag{1}$$

The probability of success is assumed to be increasing in ability:

$$\frac{\partial f}{\partial a} > 0$$

and decreasing in the difficulty of the track:

$$\frac{\partial f}{\partial \psi} < 0$$

Such specification implies that the importance of ability is proportional to the difficulty of the track (see Figure 1)

The restrictions on the supports of A and ψ described above ensures that the proba-

[6]This specification of the probability of success is a major difference between our model and the one proposed by Sjögren and Sällström (2004). They assume that the probability of succesfully acquiring skills of type c_1 is $Pr\,(S = 1) = a^{c_1}$, where $a \in [0, 1]$ is the agent's unknown ability, while $c_1 > 1$ measures the ability elasticity of success. In such a framework the precision of the signal is crucial, because uncertainty about ability makes riskier options more or less attractive depending on whether the probability of success is convex or concave in ability. For instance, what could happen with a convex probability of success is that a totally uncertain agent could think to have more chances of succeeding than an agent characterized by quite a precise belief of being above the average. We chose to remove such discontinuities by assuming linearity in ability in equation (1) and to focus on the effect of the level of confidence.

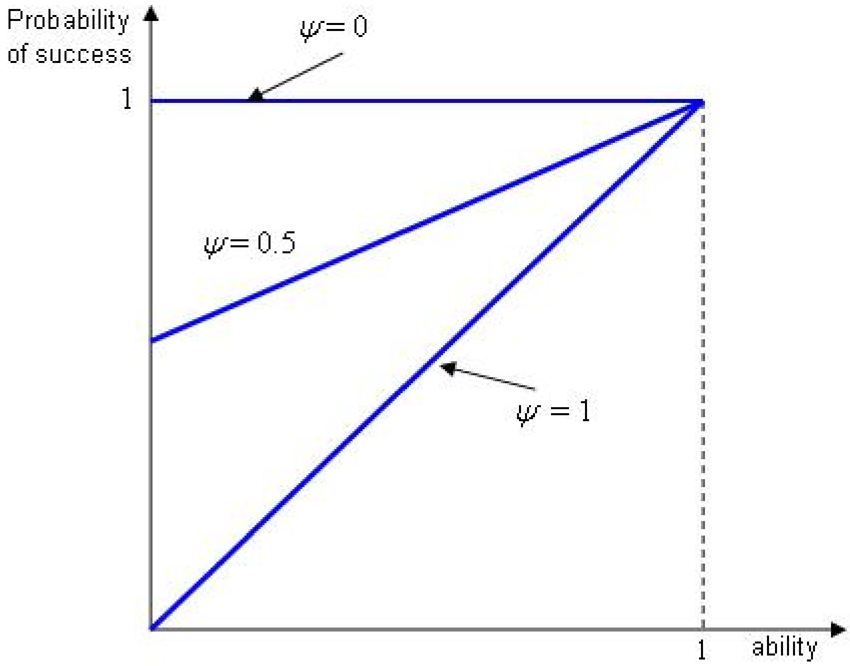

Figure 1: Different tracks in terms of importance of ability

bility of success is properly defined over the interval $[0, 1]$. If the track chosen is totally uninformative ($Pr(S = 1) = 1$) the student does not gather evidence that contradicts her (possibly wrong) beliefs. This may happen, for instance, if we assumed the existence of a discrete set of tracks, with the least able students self-selecting into the easiest track characterized by no probability of failure. This is admittedly a limit situation, which is why we chose to restrict the support of ψ by excluding the limiting case of $\psi = 0$ (which would have implied $Pr(S = 1) = 1$, given the specification of equation 1).

More difficult tracks are more costly in terms of effort, but they also yield higher payoffs in case of success.

In particular, for given beliefs about ability, students choose tracks in order to maximize the following utility function:

$$U = \begin{cases} k(\psi|S=1) - \psi^2 & \text{if } S = 1 \\ -\psi^2 & \text{if } S = 0 \end{cases}$$

where $k(\psi|S = 1)$ denote the human capital acquired when succesfully completing track ψ, with $\frac{\partial k}{\partial \psi} > 0$.

Expected utility is therefore given by:

$$E(U) = Pr(S = 1)k(\psi|S = 1) - \psi^2 \tag{2}$$

After observing the outcome of their choice, students have the possibility to update their beliefs using Bayes' rule. Given a generic density of prior beliefs $\mu(a)$, posterior beliefs are equal to:[7]

$$\mu(a|S) = \frac{Pr(S)\mu(a)}{\int Pr(S)\mu(a)da} \tag{3}$$

As far as human capital is concerned, we assume the following specification of the production function:

$$k(\psi|S = 1) = \frac{\psi}{1 + g(m)}, \tag{4}$$

where $m \equiv a - a^*(\psi)$ represents the mismatch between the actual level of ability of the student (a) and the optimal level of ability for track ψ. More precisely, $a^*(\psi)$ is the ability level possessed by a perfectly informed student choosing track ψ.

We assume that $g(0) = 0$, i.e. that human capital concides with the difficulty of the track when ability perfectly fits; otherwise, the amount of human capital actually acquired is discounted, with the shape of $g(m)$ crucially affecting the results when $m \neq$

[7]Note that if the agent received a perfectly informative signal (like the exact amount of human capital acquired when successful) she could invert $k(\psi|S)$ deriving with certainty her true ability level. However, the empirical evidence suggests that uncertainty about ability survives many signals (see Section 1 and the Appendix), meaning either that signals are not perfectly informative, or that agents cannot fully exploit them. In what follows we assume that agents only observe the event success vs. failure. In other words, agents only know the *potential* amount of human capital ψ, but not the *actual* amount (which is also corrected for the ability mismatch $1 + g(m)$ - see Equation 4). An intermediate situation in which additional information can be extracted from a noisy signal of the level of human capital actually acquired (in other words when different degrees of success are observable) could be formalized at the price of a significant increase in the complication of the model, but without appreciable additional insights. Hence, we prefer to stick to the simplest version of the information structure.

0. In particular, we assume that

$$\frac{\partial g}{\partial |m|} \geq 0$$

meaning that neither under- nor overconfidence can increase human capital beyond ψ. This assumption might appear counterintuitive at first glance, but it has the great advantage of preventing self-deception. Consider the case in which in the same track the human capital is lower for the overconfident successful student, because her ability is lower than what optimal for such a track, while the opposite happens for the underconfident successful student. The possibility of supplementing the human capital provided by the chosen track with an ability higher than a^* would imply that there is room for self-deception, i.e. that systematically underestimating one's ability might become an optimal solution, with a consequent bias in the choice of the track. The effect of the mistake in evaluating ability does not need to be symmetric. In the simulation below we will assume that underconfidence has no effect ($g(m) = 0$ when $m < 0$), while overconfidence has a negative impact ($\frac{\partial g}{\partial |m|} > 0$ when $m > 0$). To complete the picture, we assume that a failure leaves the stock of human capital unchanged:[8]

$$k\left(\psi|S=0\right) = 0$$

Students are free to self-select into different tracks given the best estimate of their ability, trading off a lower human capital in case of success with a higher probability of acquiring it. If ability was known, the first-order conditions would imply:[9]

[8]This assumption is made without loss of generality as compared to the case in which the human capital accumulated in case of failure is positive but strictly lower: $k(\psi|S=1) > k(\psi|S=0)$.

[9]To analyze the role played by self-confidence in shaping the gap in educational attainments when agents are eventually learning their true level of ability we need to iterate this choice for several periods. In principle, we should compute the optimal track choice by maximizing a lifetime utility function. Since additional information about one's ability is valuable per se as long as it helps making better choices in the future, agents could be willing to pay a price to receive a more informative signal, by choosing a track slightly different than what would be optimal in a static framework. However, such an effect is of a second order magnitude in our framework and it does not determine appreciable changes in the results (see footnote 14 below), thereby not justifying the corresponding increase in the complication of the model. Hence, we assume that agents are myopic and that they maximize their expected utility period by period. Alternative theoretical approaches in which the information value of the educational or working choice is instead crucial have been proposed by Jovanovic (1979), Miller (1984), and more recently by Trachter (2011).

$$\psi^* = \frac{1}{2}\frac{1}{2 - a^*} \tag{5}$$

Given that the presence of $g(m)$ in equation 4 implies that it is always optimal to truthfully report one's unknown ability (i.e., to set the mismatch $m = 0$), the optimal choice of track becomes an increasing function of confidence. However, even removing any bias in the self-evaluation of ability, a^* and $\hat{\mu}(a)$ may still differ due to insufficient information. Equation 5 therefore implies that both under- and over-confidence determine a suboptimal track choice and a loss of utility, due to the fact that $\hat{\mu}(a) \neq a^*$.

The effect of under- and over-confidence can differ as far as the accumulation of human capital is concerned. Rewriting confidence as the composition of optimal ability and the evaluation mistake $\hat{\mu}(a) = a^* + m$, expected human capital is given by:

$$E(k) = -\frac{1}{4}\frac{a^* + 2m - 3}{(a^* + m - 2)^2(1 + g(m))}. \tag{6}$$

The relationship between confidence and human capital can be summarized by means of the derivative of $E(k)$ with respect to the mistake m:

$$\frac{\delta E(k)}{\delta m} = \frac{1}{2}\frac{m - 1}{(a^* + m - 2)^3(1 + g(m))} + \frac{1}{4}\frac{(a^* + 2m - 3)\frac{\partial g}{\partial m}}{(a^* + m - 2)^2(1 + g(m))^2} \tag{7}$$

As long as small ability mismatches have a negligible impact (i.e. as long as $g'(0)$ is sufficiently small), the derivative is positive around $m = 0$ for every value of $a \in [0, 1]$. This means that a small degree of overconfidence $(m > 0)$ increases the amount of expected human capital, although at a price of lower utility because the increase of human capital would be acquired overestimating the expected return on the additional effort.[10] As overconfidence increases, the sign of $\delta E(k)/\delta m$ depends on the magnitude of the effect of the mismatch. In the limit case in which there is no effect, e.g. when $g(m) = 0$ in Equation 4, or in any case when such an effect is negligible, the human capital acquired would monotonically increase with overconfidence, since the positive effect of a higher human capital acquired in the case of success dominates the negative effect of a

[10]The reason is that the probability of success depends on the true level of ability, and overconfidence would grant a higher level of human capital when successful, but a positive outcome is less likely to happen than what an overconfident agent expects.

lower chance that this event happens. In contrast, if the effect of overevaluating one's ability increases substantially with the size of the mistake (e.g. if $g(m) = m^2$), the relationship between expected human capital and overconfidence becomes bow-shaped. As far as underconfidence is concerned, the condition that ensures that there is no incentive to self-deception is also sufficient to grant that human capital decreases monotonically as underconfidence increases.

3 Simulation

In order to characterize the learning process and to investigate the effect of self-confidence on educational attainments, we need to specify how beliefs about ability are shaped. The Beta distribution perfectly fits our assumption of a finite support of the ability distribution, necessary to ensure that the probability of success is linear in ability. At the same time, the Beta distribution is sufficiently general to allow prior beliefs to represent different levels of confidence while keeping the whole domain of ability in their support, something necessary because with a Bayesian learning process agents can never assign a positive probability to events excluded by the prior.

The density function of the $Beta\,[\alpha, \beta]$ distribution is:

$$\mu(a) = \frac{a^{\alpha-1}(1-a)^{\beta-1}}{\int_0^1 a^{\alpha-1}(1-a)^{\beta-1}da}, \tag{8}$$

while the mean is given by:

$$\hat{\mu}(a) = \int_0^1 a\mu(a)da = \frac{\alpha}{\alpha+\beta}. \tag{9}$$

When $\alpha = \beta > 1$ the distribution is symmetric and bell-shaped. The distribution is skewed to the left when $\alpha > \beta > 1$, and to the right when $\beta > \alpha > 1$.[11] The higher α and β, the lower the variance and therefore the more precise the beliefs. We assume that ability is distributed in the population following a $Beta\,[2.5, 2.5]$, and that the same distribution also characterizes the beliefs of the median student. This is equivalent to assume that the median student ($a = 0.5$) holds correct beliefs about her ability, because

[11] The Uniform is a special case of the Beta distribution when both parameters are equal to 1.

when $\mu(a) \sim Beta[2.5, 2.5]$ confidence is $\hat{\mu}(a) = 0.5$.

Before analyzing the effect of over- and underconfidence let us focus on the median student in order to describe in some details the learning process. After observing the outcome, the agent updates her beliefs using Bayes rule. In particular, her posterior beliefs after observing a success are:

$$\mu(a|S=1) = \frac{(\psi a + 1 - \psi)\mu(a)}{\int_0^1 (\psi a + 1 - \psi)\mu(a)da} \tag{10}$$

By contrast, if a failure was observed:

$$\mu(a|S=0) = \frac{(\psi - \psi a)\mu(a)}{\int_0^1 (\psi - \psi a)\mu(a)da} \tag{11}$$

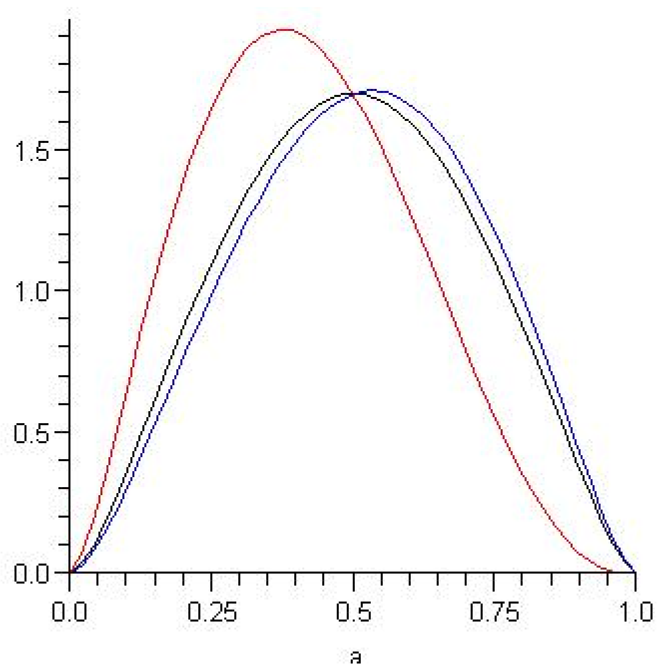

Figure 2: Beliefs updating of the median student after the first signal

The mass of probability is reallocated according to the realization of the signal, towards the upper bound if successful (see Figure 2, right curve) and toward the lower bound if not (see Figure 2, left curve), keeping constant the support of the density.

Notice that the bad event has a stronger effect when updating beliefs.[12]

The agent will then choose again the optimal track given posterior beliefs, that will be further revised after observing the outcome in the second period, and so on and so forth. The bottom line is that, within the support of initial beliefs, the distribution of beliefs changes according to the history of signals observed. Subsequent updates bring beliefs closer and closer to the true ability level as long as the agent receives informative signals.

In order to study the effect of self-confidence, we compare the choices made and the human capital accumulated by an agent whose ability is $a = 0.5$ when she holds correct prior beliefs on average ($\mu(a) \sim Beta[2.5, 2.5]$) against the counterfactuals in which she is underconfident and overconfident, respectively. In other words, we simulate the model picking up the median student and looking at the effect on her educational attainments of a wrong confidence in both directions. In fact, the higher human capital accumulated when the student is not too overconfident (i.e. when the mismatch effect does not prevail) and successful can be compensated by a probability of achieving it that is lower for two reasons. First, because the track is more difficult and therefore the same person is more likely to fail. Second, because true ability is lower than confidence. In the utility maximization only the former is correctly internalized, and the student will therefore be successful less often than she expects. This is the engine that eventually drives her confidence towards the true level of ability.

We represent underconfidence with a distribution of prior beliefs

$$\mu(a) \sim Beta[1.5, 3] \tag{12}$$

skewed to the right. This implies a level of confidence $\hat{\mu}(a) = 1/3$, corresponding to the 24th percentile in the true distribution.

Similarly, overconfidence is summarized by a distribution of prior beliefs

$$\mu(a) \sim Beta[3, 1.5] \tag{13}$$

[12] The reason is that a failure is far less likely given the specification of the model. In fact, the student with correct prior beliefs will revise her confidence upward a fraction $1 - 0.5\psi$ of the times, while she will revise her confidence downward in the other 0.5ψ times. While her expected posterior confidence is always unchanged at 0.5, the upward and downward revisions would be symmetric only when $\psi = 1$, i.e. when the two events are equally likely.

skewed to the left, which implies a level of confidence $\hat{\mu}(a) = 2/3$, corresponding to the 77th percentile in the true distribution. These parameters also imply that the three distributions have roughly the same variance, and therefore that over- and underconfidence are perfectly symmetric.[13] Prior beliefs of the three different types of student are summarized in Figure 3. As far as the ability mismatch described in Equation 4 is concerned, we choose no correction in case of underconfidence ($g(m) = 0$ if $m < 0$) and a quadratic term $g(m) = 3m^2$ if $m > 0$, implying a discount of about 7.5% in the human capital acquired in the first period by a succesful overconfident student.

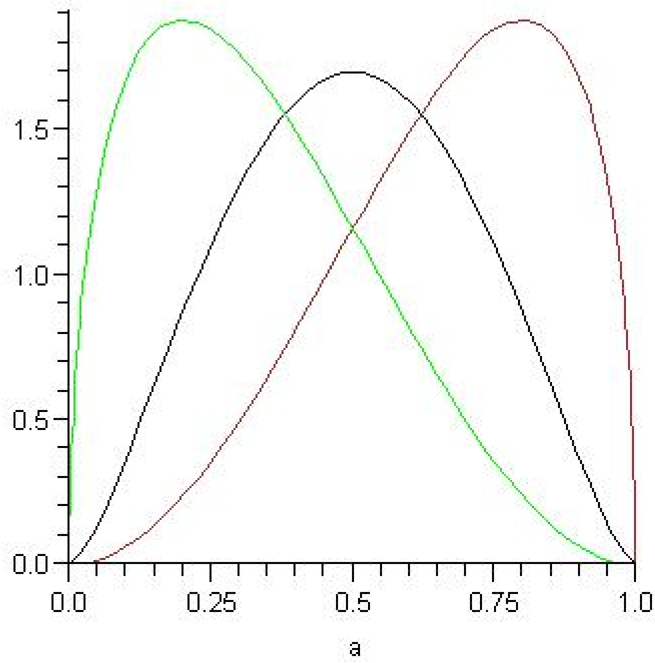

Figure 3: Prior beliefs given the different levels of confidence

We analize what happens to the human capital accumulated by the three types of agents while the learning process takes place, iterating the updating of beliefs 45 times. Since the single realization of human capital relies upon a random component, we replicate the procedure 200 times.

[13]Although the probability of success does not depend on the variance of beliefs, the latter could still affect the updating process, since the more precise the beliefs, the lower the change of confidence induced by the same signal received. We do not want the learning pattern to be affected by a different precision of beliefs, and therefore we assume the same variance in the prior distributions.

Results show that the value of confidence slowly converges towards the true ability level for those starting with a wrong prior, but also that the learning process is far from being completed. In fact, at the end of the 45^{th} iteration confidence is about $.425$ for the underconfident and $.558$ for the overconfident, in both cases significantly different than $.5$ ($|p| < 0.001$).[14]

Figure 4 displays the average gap, period by period, across repetitions, in the accumulation of human capital of the types who start with wrong priors as compared to the student starting with correct beliefs. The human capital accumulated by the underconfident is significantly lower than the human capital acquired by the student holding correct beliefs ($|p| < 0.001$), while the opposite happens for the overconfident type ($|p| < 0.001$), although the magnitude is different in absolute terms because of the cost of the mismatch $g(m)$. Notice that at the beginning, when overconfidence is larger (and therefore also the cost of mismatching), the human capital accumulated is not much higher, while it increases as compared to the student with correct beliefs as long as confidence converges towards the true type and the cost of mismatch decreases. Given the chosen specification of the model, the gap between the overconfident and the underconfident turns out to be about 6%.

To summarize, self-confidence can determine significant differences in the outcomes observed. When the learning process reaches the fixed point implied by discovering the true level of ability, the three types in the simulation will start making the same choices and from that moment onwards they will be observationally equivalent. However, the level of human capital acquired is and will remain significantly different. Wrong beliefs about one's ability do not need to be self-confirming to explain unequal outcomes

[14]The speed of convergence of the two types differs a little bit. In fact, the mistake in confidence becomes significantly smaller for the overconfident ($|p| = 0.038$). The reason is that the higher the track chosen, the more balanced the probability of success given the *true* level of ability $a = 0.5$, the more informative the signal. At first glance this seems to imply that the choice of track and the educational outcomes could have been different had we internalized the different informativeness of the signals by means of dynamic optimiziation. In fact, there seems to be an additional incentive to choose a higher track thereby reducing the effect of underconfidence while increasing that of overconfidence. This is not the case, however, because such an argument holds only when the probability of success is computed knowing the true value of ability. When choosing ψ, in contrast, agents use the best estimate of their ability $\mu(a)$. Notice that the perceived probability of success is increasing in $\mu(a)$. Hence, internalizing the different informativeness of the signal would imply a lower revision of the optimal choice at low levels of ability. In any case, maximizing utility period by period implies choices that marginally differ in terms of magnitude, and therefore a negligible mistake, particularly at low levels of ability.

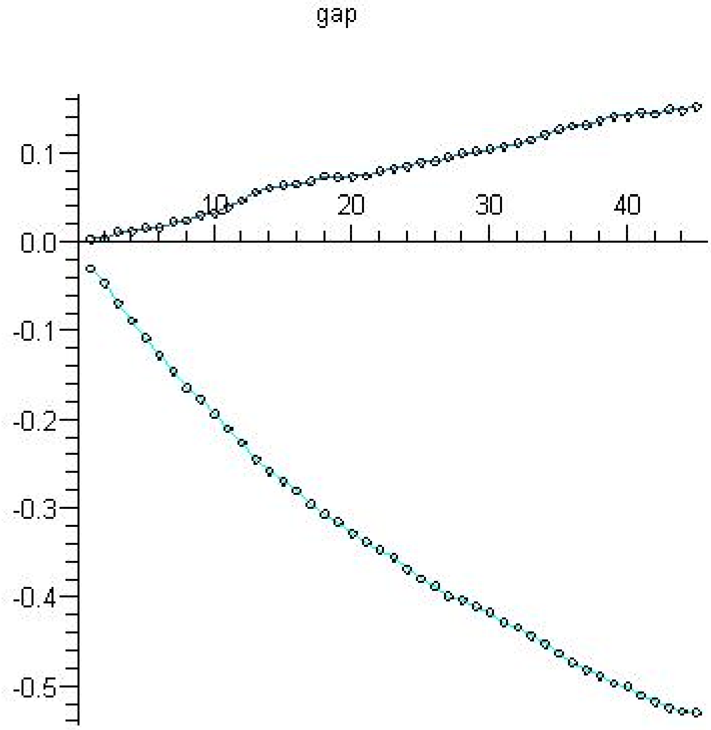

Figure 4: Gap in the accumulation of human capital

if they lead to significantly different choices during the learning process. As long as family background shapes children's beliefs about their ability, confidence can be a transmission mechanism that increases the intergenerational persistence of outcomes.

Notice that in the model the probability of success increases with innate ability only, while the human capital accumulated plays no role. This simplifying assumption downplays the role of nurture, since achievements are also determined by the whole history of intermediate outcomes, in turn also driven by self-confidence, as well as by the environment in which the children grow. Therefore, what found by the model is once more a lower bound of the role of self-confidence, since the cumulative effect of the gap in the human capital accumulated during the learning process of one's ability is not taken into account. The role of nurture therefore implies that tests meant to measure students' ability are instead capturing also the gap in human capital accumulated up to that point because of a different family background. For instance, a centralized test administered at age 15 in order to select students into different tracks would probably classify as different two students characterized by the same innate ability but with a different background, thereby helping to perpetuate intergenerational inequalities. A policy implication arising from the model is therefore that cognitive tests should take place as early as possible in order to endow parents with measures of the innate level of ability of the children that are not confounded with the role that the family background can play through self-confidence.

4 Conclusions

In line with some recent contributions, we claim that the socio-economic background affects not only the actual stock of cognitive skills possessed by a child (innate ability) but also the beliefs about such (unobserved) cognitive skills. There is indeed a vast literature supporting the hypothesis that people have imperfect knowledge of their ability and that many personality traits related to the concept of self-confidence are influenced by the family background in which a child grows up.

We propose a model in which fully rational agents, who maximize the expected acquisition of human capital, choose tasks according to their perceived ability. True ability and the difficulty of the chosen track affect the probability of success. After observing whether they succeed or not, students update their beliefs, fully exploiting the available information, following Bayes' rule. We simulate the model with a bootstrapping procedure and we show that choices distorted by over- and under-confidence lead to a significant gap in the accumulation of human capital during the process in which agents eventually learn their true level of ability.

In our model agents do not derive additional utility by holding a good self-image; the consequence of this assumption is that if a perfectly informed and benevolent planner could force individuals to choose the "right" task, the effect of wrong confidence would disappear. Nevertheless, even in a setting in which agents are fully rational and have standard preferences, a moderate degree of over-confidence can be beneficial in terms of the accumulation of human capital over the life course, although at a price of a lower utility (since overconfident and underconfident agents do not make, by construction, utility-maximizing choices). Underconfidence, on the other hand, is suboptimal in terms of both utility maximization and human capital accumulation.

In the model we assume that only self-confidence is correlated with family background (either genetically or through role-model effects), while cognitive ability is randomly distributed in the population. Nevertheless, the intergenerational transmission of beliefs constitutes a channel through which socio-economic differences perpetuate from one generation to the next because, even if two individuals had the same innate cognitive ability, differences in beliefs would lead them to make different choices in terms of investment in education. The results of our analysis suggest that policy interventions aimed at providing early and precise feedback about the cognitve skills of children from disadvantaged backgrounds can be beneficial in helping to narrow the gaps in educational attainments, by avoiding that equally talented people make different choices only because they have inherited different beliefs about their potential.

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Appendix

In this section we provide additional evidence about the link between socio-economic background and self-confidence using data from the OECD-PISA study. This dataset contains what we believe to be a good proxy for self-confidence, namely "Science Self-Efficacy," an index built from student's answers to questions about the ease with which they believe they could perform eight science-related tasks. This variable is a good proxy for beliefs about academic ability because it is meant to go "beyond how good students think they are in subjects such as science. It is more concerned with the kind of confidence that is needed for them to successfully master specific learning tasks, and is therefore not simply a reflection of a student's abilities and performance" (OECD, 2009).[15]

We thus regress our measure of confidence on family background, adding controls at the individual, school and family level; results are presented in Table A-1.

The relationship between self-efficacy and family background is statistically significant and positive, as expected, displaying a convex correlation. In the second column we also control for the score obtained by the student in the Science section of the test. This is a proxy for "true" ability, comparable across students in different countries and unobserved by the student at the time of filling in the questionnaire. The inclusion of PISA score captures some variance of self-efficacy, but the positive relationship with family background remains strong. Notice that controlling for the PISA score is likely to bias downward the role played by self-confidence, because if our model is correct the PISA score already encompasses the gap in the human capital accumulated up to that point and that is partly due to differences in self-confidence itself. In other words, two students with the same innate ability but characterized by a different initial self-confidence should also display a different PISA score.

Adding further controls at the student level (column 3) and at the parent and school level (column 4) does not change significantly the results, which we interpret as suggestive evidence that family background has a direct impact on self-confidence, over and above the one operating through the transmission of cognitive skills.

[15]See Ferla, Valcke, and Cai (2009) for a discussion on the differences between Self-Efficacy and Self-Concept. Since Self-Efficacy solicits goal-referenced evaluation and does not ask students to compare their ability to that of others, we believe it is a better proxy for the notion of confidence that we use in the model of Section 2.

Table A-1: Results: Science Self-Efficacy

	(1) Baseline	(2) Pisa score	(3) Effort	(4) Parents
Index of socio-ec. status	0.318***	0.145***	0.111***	0.119***
	[0.014]	[0.014]	[0.015]	[0.026]
Index of socio-ec. status^2	0.033***	0.022*	0.030**	0.026
	[0.009]	[0.009]	[0.009]	[0.014]
Female	-0.157***	-0.141***	-0.157***	-0.031
	[0.012]	[0.011]	[0.011]	[0.017]
PISA score in Science		0.004***	0.004***	0.003***
		[0.000]	[0.000]	[0.000]
Out of school - Science			0.112***	
			[0.009]	
Self study - Science			0.114***	
			[0.006]	
Interest in learning science				0.226***
				[0.012]
Personal value of science				0.222***
				[0.013]
Parents' value of science				0.001
				[0.013]
Science career motivation				-0.029**
				[0.009]
Science activities at age 10				0.062***
				[0.008]
School-level characteristics	NO	NO	NO	YES
R^2	0.119	0.230	0.255	0.355
Observations	225,098	225,098	216,304	29,970

BRR standard errors in brackets. $^{*}p < 0.1$,$^{**}p < 0.05$,$^{***}p < 0.01$.
All regressions include country dummies and control for immigrant status, tracking and the interaction between tracking and the socio-economic status. In column 4 we also control for school-level variables like school size, student-teacher ratio, ability sorting and a dummy for public schools.

The PISA dataset has the advantage of being a large-scale, international, representative sample, but it includes extremely heterogeneous students at an early stage of their education career. Therefore, we replicate a similar analysis using another dataset with opposite characteristics, coming from a survey of a much more homogeneous population at a later stage of their academic career. This dataset has been collected in 2001 by circulating a questionnaire to all students enrolled in their second year at Bocconi University (in Milan, Italy), subsequently merged with administrative data. It contains information about students' expectations on occupation and wages 1 and 10 years after graduation, about their family background, as well as detailed information on their academic career.[16] We use expected wage as a proxy for self-confidence,[17] while family-background is proxied by parents' educational levels and the students' tuition category (a function of family income). Wage expectations 10 year after graduation are probably a better measure of self-confidence, since after such a spell of time wages should be expected to reflect productivity more precisely.[18] Notice that also in this case the proxies for ability are likely to bias downward the role played by self-confidence, since they also control for the gap in the human capital accumulated up to that point. Table A-2 reports results from regressing the log of expected wage ten years after graduation on family background variables and individual controls. While parental education does not seem to have a significant impact on expected wages, the effect of family income (proxied by tuition category) is significant and J-shaped, with a minimum in the third category.[19] Results are almost unchanged when both measures of family background are included.

Bocconi University is commonly recognized as an elite institution in Italy, known to

[16]The same data are used in Filippin and Ichino (2005), to which we refer for further details on the characteristics of the dataset.

[17]Admittedly, this is far from being an ideal measure of confidence, since it could also reflect informational differences about labor market conditions and returns to education that are possibly correlated with family background.

[18]Results using short-term expectations are not significantly different, and are available upon request.

[19]At that time, there were 6 brackets, and more than 60% of the students in our sample were in the top three categories (with 35% of students in the top bracket). Our results imply that students in the lowest income category are more confident than those from the middle class (third income bracket). A possible explanation is that Bocconi is a very expensive university where rich families are over-represented. Students from poor families are instead under-represented because they could not afford the tuition fees without financial help, which is awarded only if strict requirements in terms of academic performance are fulfilled. Therefore, the subsample of students in lower income brackets is likely to suffer a stronger self-selection problem because only particularly good and strongly motivated students are able to enroll.

Table A-2: Expected Wage 10 Years After Graduation

	(1) Parental Ed.	(2) Income	(3) Income squared	(4) Full
Parent graduate	0.056			0.030
	[0.030]			[0.031]
Parent primary ed.	0.001			-0.006
	[0.057]			[0.057]
Income bracket		0.030***	-0.138**	-0.142***
		[0.009]	[0.042]	[0.043]
Income bracket^2			0.022***	0.023***
			[0.005]	[0.005]
Female	-0.085**	-0.094**	-0.094***	-0.091**
	[0.029]	[0.029]	[0.028]	[0.028]
Family firm	0.212***	0.174**	0.164**	0.165**
	[0.057]	[0.058]	[0.057]	[0.057]
Average grade	0.022**	0.021**	0.019*	0.019*
	[0.008]	[0.008]	[0.008]	[0.008]
High School grade	-0.395*	-0.342	-0.316	-0.319
	[0.199]	[0.198]	[0.197]	[0.197]
R^2	0.117	0.127	0.146	0.147
Observations	764	764	764	764

Standard errors in brackets. $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
All regressions include dummies for degree program, type of high school, region of residence and expected sector of employment.

attract very good students and well recognized in the labour market. Hence, one should expect that the signal provided by graduating at Bocconi is strong enough to more than counterbalance the effect of any other difference in students' former endowments. In contrast, we find that different socio-economic backgrounds still shape wage expectations. Hence, the same observed (and observable) signals have a different impact on different people. Our interpretation is that inherited beliefs about one's own ability survive a string of commonly-believed-to-be very good signals. Unfortunately, we cannot attribute a causal interpretation to this result, because such a correlation could be a spurious spillover of different networking abilities or different preferences correlated to the family background. However, the same correlation appears in the wage realizations of a similar but richer survey of Bocconi graduates in which a larger set of controls is available.[20] Moreover, our results are similar to what has been recently found by Delaney, Harmon, and Redmond (2011), who use a dataset collected from seven Irish universities (and thus certainly more representative of the population of Irish undergraduate students), and that also include many different measures of non-cognitive skills such as risk attitudes, time preferences and personality traits.

[20] In particular, we are able to control for the channels through which the inviduals found job, and thus we are able to rule out network effects. Results are not displayed to save space but they are available upon request.

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