Wealth Inequality, Innovative Talent, and Occupational Choices

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Abstract

Does inequality hinder or foster innovation? We study an occupational choice model in which agents differ in observable wealth and unobservable innovative talent. Investors deposit their wealth in banks, whereas entrepreneurs set up risky firms and can privately choose the novelty of the technology used and the effort exerted. Since financial contracts can be made contingent only on wealth, wealth classes form endogenously and, in general equilibrium, the interest rate adjusts to clear the credit market. In a quantitative illustration, we show that increased inequality can lead to a decrease in both the average quality of the innovators and the number of successful innovations, and to an increase in the number of non-innovative entrepreneurs; this effect, however, depends on the original wealth distribution and the aggregate wealth level.

Keywords: inequality, innovative talent, innovation, occupational choice, competitive screening, moral hazard, wealth distribution.

JEL Classification: D53, D82, O31.

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1 Introduction

Since Okun (1975), economists have argued that societies must face a trade-off between equality and efficiency: inequality is considered necessary to provide financial incentives for risky entrepreneurship, fuels of economic growth. But over the last thirty years the gap between rich and poor has widened (Piketty, 2014; OECD, 2015), pushing inequality at the top of the political agenda: for example, former US President Obama (2013) referred to rising inequality as the "defining challenge of our time", and Pope Francis (2015) made inequality, poverty, and climate change the centrepieces of his second encyclical. A rich literature has thus began reinvestigating this trade-off, and found a detrimental effects of inequality on human capital accumulation, consumer spending, and financial stability (OECD, 2015, Chapter 2). Given that technological change induced by firm-level innovations is considered as a driving force of economic growth (Barro and Sala-I-Martin, 1995), it is surprising that only few papers have focused on the effect of inequality on innovation. Does inequality hinder or foster innovation?

We provide an occupational choice model, in which agents differ in their unobservable innovative talent and their observable wealth. They choose between depositing their wealth in a bank for an interest or becoming entrepreneurs. An entrepreneur borrows from financial intermediaries to set up a risky firm, and can privately choose to produce through an old technology with a predictable outcome (and become a non-innovative entrepreneur), or a new technology that involves a large risk of initial failure but the small chance of a breakthrough (thus becoming a potential innovator). Further, talented innovators can increase their probability of success by exerting effort.

We show that the wealth of an agent (and thus the amount of capital a potential entrepreneur needs to borrow) plays a crucial role in the kind of contracts that she is offered. Indeed, since financial contracts can be made contingent only on wealth, endogenous wealth classes arise in equilibrium. Agents in the lower-class are only offered pooling contracts, where the talented innovators are supposed to cross-subsidise the untalented innovators. The resulting contractual terms, however, discourage the talented agents from exerting effort: banks know this and thus are forced to treat all agents in this class as untalented. As a consequence, agents in the lower-class prefer to not apply for credit, and thus become investors. The lower middle-class agents are also offered pooling contracts, but since this time talented individuals provide effort, all agents in this class become innovative entrepreneurs. Talented agents cross-subsidise untalented innovators by paying an interest rate higher than the one consistent with their risk level. Conversely,

in the upper middle-class, banks are able to separate between talented innovators and untalented investors. Finally, upper-class agents accept pooling contracts, but this time talented agents start innovative firms, whereas untalented agents become non-innovative entrepreneurs. Since non-innovative agents are initially more likely to succeed, in this class cross-subsidisation runs from untalented entrepreneurs to talented innovators.

We also show that a change in the wealth distribution has general equilibrium repercussions on the occupational choices of the agents. Indeed, the credit market must clear and thus the risk-free interest rate adjusts to make the demand and supply of loans meet. But movements in the interest rate influence the payoff from investment and entrepreneurship, and thus they shape the size and the composition of the wealth classes. We present a quantitative illustration where we keep both the total (and average) wealth and the number of entrepreneurs constant, but we vary the distribution of wealth, and thus the inequality levels of our general equilibrium economy. In more equal societies, the proportion of agents at the very extremes of the lower- and upper-class decreases. Keeping other things constant, this has two effects. On the one hand, the supply of loans increases as investors get relatively wealthier, pushing the interest rate down; on the other, the demand of loans also increases as new firms are started by relatively poorer (i.e. more reliant on credit) individuals, pushing the interest rate up. We show that which one of these two effects dominates depends on initial conditions, as the original wealth distribution or the aggregate wealth level. Poor and/or very unequal economies experience a decrease in the average talent of the innovators as equality increases. Indeed, in these economies, the former effect dominates at first: a decrease in the interest rate means that pretending to be talented becomes more convenient than investing for a growing proportion of middle-class untalented agents, who thus self-select into the lower middle-class, where the selection problems are greater. However, for richer and more equal economies, further decreases in the inequality level lead to an increase in both the number of successful innovations and the average talent of the innovators, and to a decrease in the number of non-innovative entrepreneurs.

The remainder of this paper is organised as follows. Section 2 quickly reviews previous literature on the relationship between inequality and innovation, both from a theoretical and an empirical perspective. Section 3 presents the model. Section 4 solves for the partial equilibrium and the general equilibrium. Section 5 presents some quantitative illustrations. Finally, Section 6 concludes.

2 Related Literature

The relationship between inequality and innovation is traditionally studied as one-way: the introduction of new technologies can increase income inequality through skill-biased technological change (see Violanti (2008) for an introduction to the topic and a brief survey of this vast literature). The theoretical papers considering the reverse relationship mainly focus on the effect of inequality on the incentives to innovate through demand composition (e.g. Foellmi and Zweimüller, 2006, 2017; Hatipoğlu, 2012). An exception is Acemoglu et al.'s (2017) endogenous growth model where entrepreneurial success is influenced by unobservable effort choices, and thus inequality of outcomes is needed to incentivise entrepreneurs to engage in innovation. Differently from Acemoglu et al. (2017), we focus on the effect of inequality of opportunity on the decision to become innovator. According to Romer (2011), policies that focus on increasing the number of innovators are important but under-researched.

A recent empirical literature has investigated the determinants of an individual's decision to become an innovator, and has usually found that children from richer backgrounds are far more likely to become inventors (Bell et al., 2016; Akcigit et al., 2017; Aghion et al., 2018; Celik, 2018). To explain this finding, Celik (2018) constructs a heterogeneous agents model with production and innovation sectors where the inefficiency arises because inventor training is scarce but wealthy individuals can afford to spend more on (intrinsically useless) credentialing. Conversely, we focus on the differential access to credit between rich and poor.

Our occupational choice framework is based on Grüner (2003) and Inci (2013).[1] Our novelty is that entrepreneurs can privately choose to produce through a conventional technology with a known probability of success or a new technology that involves a large risk of initial failure but the small chance of a breakthrough.[2] Similarly to Weitzman (1979), Manso (2011), and Spiganti (forthcoming) innovation in this context is the discovery of superior actions through experimentation and learning.

[1] There is a rich literature, too vast to be summarised here, that uses occupational choice models to study the relationship between wealth and entrepreneurship. See, among many others, Aghion and Bolton (1997), Meh (2005), Ghatak, Morelli and Sjöström (2007), and Coco and Pignataro (2014). However, none of these papers distinguish between regular entrepreneurs and innovative entrepreneurs.

[2] Jaimovich (2011) and Ghiglino and Tabasso (2016) construct endogenous growth models to study the relationship between financial market imperfections and investments in innovation, but neither analyses the role of wealth inequality.

3 The Model

This section describes the model that we employ. The following sections set the environment, introduces the assumptions that we use, and discuss the agents's preferences and the credit market.

3.1 Environment and Agents

The economy is populated by a continuum of risk neutral agents of mass one, with different observable wealth levels, A. Wealth is distributed according to the cumulative distribution function $G(A)$, whose probability density function is $g(A)$ with support $[0, I]$. Total wealth in the economy, which is equal to average wealth, is $\bar{A} = \int_0^I A dG(A)$. Wealth completely depreciates at the end of the first period if unused. A proportion $\lambda \in (0, 1)$ of agents is talented (or high ability), the remaining proportion $1 - \lambda$ is untalented (or low ability). Talent is time invariant and private information of the agent, but the proportion of talented agents in the population is common knowledge. For simplicity, wealth and talent are assumed independent, thus low ability and high ability agents are equally likely in all wealth classes.

Agents live for two periods. Future payoffs are discounted using the common discount factor, normalised to one. At the beginning of their life, after having observed their own (private) talent and (public) wealth, agents choose to become either investors (i.e. to deposit their wealth in a bank) or entrepreneurs (i.e. to undertake risky investments in the form of starting a firm). An entrepreneur needs to borrow $I - A$ to finance the firm's setup cost I.[3] Having started a firm, an entrepreneur has two options: she can become an exploiter (C, mnemonic for conventional) or an explorer (N, mnemonic for novel). Exploiters (or non-innovative entrepreneurs) set up a conventional firm: with a known probability of success p, the high outcome (i.e. a success, S) is realized, with the remaining probability $1 - p$, a failure (F) occurs. This success probability is independent of both wealth and innovative talent. Explorers (or innovators) experiment with a novel approach whose probability of success q is unknown. The novel approach is of exploratory nature: an explorer is not initially as likely to succeed as an exploiter, $E[q] < p$, but if a success occurs in the first period, the novel approach becomes perceived as better than the conventional one, $E[q|success] > p$; after a failure in the first period, the explorer

[3] We are imposing maximum self-finance. As explained by DeMeza and Webb (1987), Grüner (2003), and Inci (2013), this is without loss of generality if one type of agents wants to self-finance themselves to the maximum because this comes with better terms than any pooling contract offered.

gives up and runs the conventional project in the second period.[4]

Both the unconditional probability, $E[q]$, and the conditional probability, $E[q|success]$, of success of the novel approach depend on the innovative talent of the explorer. For an untalented agent, these are given by q_L and q_L^S, respectively. The talented agent faces a choice between providing effort and shirking. If she shirks, she faces the same probabilities of success as the untalented explorer. Conversely, she can provide effort to increase the probabilities of success to q_H and q_H^S, respectively, but this come with a one-time effort cost of $e > 0$. Effort is prohibitely costly for untalented agents.[5] With this in mind, we will denote with H the talented agents who provide efforts, and with L those agents who are untalented or who are talented but do not provide effort. The following assumption summarises the relationships between the various success probabilities,

Assumption A. *(Probabilities of success)* $0 < q_L < q_H < p < q_L^S < q_H^S < 1.$

Independently of ability, period, and approach used, the outcome in case of success is given by the strictly positive value Y, the outcome in case of failure is normalised to zero.[6]

3.2 Banks and Contracts

In the first period, there are several banks competing à la Bertrand,[7] each owned equally by all agents. For simplicity, banks only live for the first period.[8] Banks can observe the wealth of the agents and the outcomes are verifiable, but they can observe neither the

[4]The choice between being an explorer or an exploiter is equivalent to the choice between exploration and exploitation in a canonical two-arm two-period bandit problem. Exploitation consists of choosing the safe arm in any contingency; exploration consists of pulling the risky arm in the first period, stick with it in case of success, but resort to the safe one in case of failure. Any other combination of actions is dominated by these two.

[5]Imagine all agents are born with low ability. Some of them though have the possibility of taking some costly action to improve their ability in managing an innovative firm, e.g. getting an education, improving their network of contacts, attending seminars, reading biographies of successful innovators, finding a mentor. For others, this is prohibitely costly. Thus, certain agents can become high ability if they choose to do so, others are naturally low ability.

[6]Since outcomes will be contractible, assuming that outcomes are independent of both ability and approach used ensures that neither ability nor approach are inferable from the outcome of the firm.

[7]This assumption is made for simplicity. We leave the monopoly screening setting, and the case in which neither part has all the bargaining power, to future research.

[8]Indeed, having long-lived banks complicates the analysis. With long-lived banks, and if one assumed non-negative repayments, the graphical solution method would require three-dimensional graphs, but the conclusions of the model would not qualitatively change.

abilities (or efforts) nor the choice between exploitation and exploration.[9] Banks take the risk-free interest rate r as given (which will be endogenised later), and can offer a distinct menu of contracts for every wealth level. A contract can be contingent on the announced ability and effort combination (low L versus high H), and outcome realizations (success S versus failure F). A menu of contract is given by $\boldsymbol{\sigma}(A, r) = \{\sigma_L(A, r), \sigma_H(A, r)\}$,[10] where σ_i specifies the repayment by an entrepreneur with ability $i = \{H, L\}$ to the bank in any contingency,

$$\sigma_i(A, r) = \begin{bmatrix} \tau_i^S(A, r) & \tau_i^F(A, r) \end{bmatrix} \qquad \forall i = \{H, L\}. \tag{1}$$

In the above, τ_i^S represents the repayment after a success in period 1, whereas τ_i^F represents the repayment after a failure in period 1. These contracts will incentivise the agents to choose between exploration and exploitation.[11] Agents are protected by limited liability: since the outcome is zero after a failure, the repayment after a failure will be non-positive, i.e. $\tau_i^F \leq 0$; the repayment after a success will be such that $\tau_i^S \leq Y$.

3.3 Timing

There are only two periods, during which timing is as follows. At the beginning of period 1, agents first observe their private ability and public wealth, banks then propose a menu of financial contracts, and agents choose an occupation. Entrepreneurs pay the setup cost, privately choose the project and the effort level, and production takes place. At the end of period 1, outputs are realized; entrepreneurs make contractual payments to banks, and banks return principals and interests to depositors. At the beginning of period 2, production takes place and outputs are realized at the end of period 2.

[9] Unobservable abilities are needed to force some talented agents into becoming investors. Differently from Spiganti (forthcoming), we use the effort-elicitation rather than the cash flow diversion model, because with unobservable outcomes, and under the current settings of the model (i.e. the absence of working capital in the production process and, in particular, in the second period), there is no "carrot" that can incentivise the agent to truthfully reveal the high outcome realizations. Unobservable actions are needed to have some untalented explorers in equilibrium. See Appendix B.3 for the observable actions case.

[10] Note that for completeness, there should be a subscript, say z, to indicate the bank offering the contract. We shall drop it since its absence does not cause any confusion. Moreover, we shall drop the arguments of the contract for the sake of brevity when no confusion arises.

[11] A more formal way of writing the menu of contracts would be to have contracts entailing not only the repayment policy but also effort levels and the choice between exploration and exploitation. The method in the text, however, requires less notation.

3.4 Assumptions

We make the following assumptions. We firstly assume that the innovative activity of untalented agents is inefficient,

Assumption B. *(Untalented exploration is inefficient) Absent the need for financing, the social surplus from untalented exploration,* $\left(q_L + q_L q_L^S + p - q_L p\right) Y$*, is strictly lower than the social surplus from exploitation,* $2pY$*, and the surplus from investing,* rI*.*

We also assume that effortful exploration is socially optimal,

Assumption C. *(Talented exploration is socially optimal) Absent the need for financing, the social surplus from talented exploration,* $\left(q_H + q_H q_H^S + p - q_H p\right) Y - e$*, is strictly greater than the social surplus from exploitation,* $2pY$*, and the surplus from investing,* rI*,*

which implies that the effort cost is not too high, $e < \left(q_H + q_H q_H^S - q_H p - p\right) Y$.

Finally, we take some tie-breaking assumptions. We assume that agents choose to become investors if indifferent between becoming investors or entrepreneurs; if indifferent between exploitation and exploration, they become exploiters (obviously, agents choose with certainty an occupation if associated with a strictly higher expected payoff).[12]

3.5 First Best

Assumptions B and C suggest that, in first best, all talented agents should become effort-exerting explorers, whereas untalented agents should either invest (if the equilibrium risk-free interest rate is relatively high) or exploit (if the interest rate is low).[13] However, due to the informational asymmetry between agents and financiers, untalented agents may find it profitable to pretend to be talented individuals; at the same time, having to pool with untalented entrepreneurs may discourage talented agents from exerting effort, or may force them out of entrepreneurship and into becoming investors.

[12] The parameter values used to generate the figures in the text and appendix are given in Section 5. These satisfy all previous assumptions. Quantitatively, these numbers clearly have an impact; however, qualitatively, there is (little to) no dependence upon the specific parametrization.

[13] Indeed, we have not made any assumption regarding the social value of exploitation versus the social value of investing: investing is more efficient than exploiting if $r > 2pY/I$, and Assumptions B and C guarantee that the right-hand side is between $\underline{r}$ and $\bar{r}$.

4 Equilibrium

In this section, we first solve for the partial equilibrium of the model: taking as given the risk-free interest rate, we find the contracts offered by the banks and the occupational choices that follow. Later, we solve for the general equilibrium by finding the risk-free interest rate that clears the credit market.

4.1 Partial Equilibrium

A bank makes zero profits if the expected repayment from an entrepreneur is equal to the amount the bank needs to raise from depositors (plus interests) to finance the setup cost. The zero-profit conditions for separating contracts are

$$\tau_H^S = \frac{r(I-A)}{q_H} - \frac{1-q_H}{q_H}\tau_H^F \tag{ZPC_H}$$

$$\tau_L^S = \frac{r(I-A)}{q_L} - \frac{1-q_L}{q_L}\tau_L^F \tag{ZPC_L}$$

$$\tau_C^S = \frac{r(I-A)}{p} - \frac{1-p}{p}\tau_C^F \tag{ZPC_C}$$

where the first two lines refer to exploration contracts and the last line to exploitation contracts (since the difference in talent is irrelevant when exploiting, we drop the subscript for ability and replace it with C). Indicating the expected payoffs of the explorers and the exploiters with V_H^N, V_L^N, and V^C, respectively, the corresponding iso-payoffs of the agents are

$$\tau_H^S = Y\left(1 + q_H^S + \frac{1-q_H}{q_H}p\right) - \frac{V_H^N + e}{q_H} - \frac{1-q_H}{q_H}\tau_H^F \tag{IP_H}$$

$$\tau_L^S = Y\left(1 + q_L^S + \frac{1-q_L}{q_L}p\right) - \frac{V_L^N}{q_L} - \frac{1-q_L}{q_L}\tau_L^F \tag{IP_L}$$

$$\tau_C^S = 2Y - \frac{V^C}{p} - \frac{1-p}{p}\tau_C^F. \tag{IP_C}$$

The zero-profit conditions from (the relevant) pooling contracts are

$$\tau_{HL}^S = \frac{r(I-A)}{\bar{q}_{HL}} - \frac{1-\bar{q}_{HL}}{\bar{q}_{HL}}\tau_{HL}^F \tag{ZPC_{HL}}$$

$$\tau_{HC}^S = \frac{r(I-A)}{\bar{q}_{HC}} - \frac{1-\bar{q}_{HC}}{\bar{q}_{HC}}\tau_{HC}^F, \tag{ZPC_{HC}}$$

where the first line refers to pooling exploration contracts, and the second line to talented explorers pooling with (untalented) exploiters; τ_{ij}^S and τ_{ij}^F are repayments of a random entrepreneur after success and failure, respectively; $\bar{q}_{HL} \equiv \lambda q_H + (1-\lambda)q_L$ and $\bar{q}_{HC} \equiv \lambda q_H + (1-\lambda)p$ are the corresponding Bayesian probability of success in the first period. One can easily obtain the corresponding iso-payoffs of the agents by substituting the appropriate repayment schedule in the IPs above.

Imagine drawing all the zero-profit conditions and iso-payoffs in a (τ^F, τ^S)-space. We refer to the payoff from investing, rA, as the outside option to entrepreneurship. There is a wealth level ϕ_{HL} for which an untalented exploring agent's iso-profit line passing through her outside option also passes through the point where ZPC_{HL} intersects the vertical axis. Similarly, there is a wealth level ϕ_I for which an untalented exploring agent's iso-profit passing through her outside option also pass through the vertical intercept of ZPC_H. There is a wealth level ϕ_{HC} for which the exploiter's iso-payoff at the outside option level intersects ZPC_{HC} on the vertical axis. Finally, there is a wealth level ϕ_{HC}^{IC} for which the iso-profit from untalented exploration and the iso-profit from exploitation both pass through the vertical intercept of ZPC_{HC}. The following Proposition uses these wealth levels to summarise the types of contracts offered by the banks. In the rest of the paper, we focus on the most interesting case that arises in our application, with $\phi_{HC}^{IC} > \max\{\phi_I; \phi_{HC}\}$; the other cases, together with the analytical expressions for these levels and the proofs, are relegated to Appendix A.

Proposition 1. *(Contracts offered)*
When talented individuals provide effort, banks offer a cross-subsidising pooling exploration contract to agent with wealth between $[0, \phi_{HL}]$*; a profitable separating contract to agents with wealth between* $[\phi_{HL}, \phi_I]$*; a zero-profit separating contract to agents with wealth* $[\phi_I, \phi_{HC}^{IC}]$*; and a cross-subsidising pooling exploration and exploitation contract to agents with wealth between* $[\phi_{HC}^{IC}, 1]$*. When talented individuals do not provide effort, banks offer a pooling exploration contract.*

For very poor and very wealthy agents, banks can only offer cross-subsidising pooling contracts, since untalented individuals at these wealth levels would always pretend to be talented explorers otherwise. Under these contracts, talented agents are supposed to exert effort while exploring.[14] Untalented agents would like to become explorers if poor and exploiters if wealthy. Indeed, exploration is associated with a higher long-term payoff

[14]This is because talented agents always prefer effortful exploration to exploitation, and pooling with low ability exploiters to investing, given Assumptions C.

but a lower short-term payoff, as compared with exploitation. Relatively poorer agents thus prefer exploration because the likelihood of having to repay the relatively larger loan is lower under exploration than under exploitation (and thus the second period payoff has more weight), given the initial probabilities of success in Assumption A; for relatively richer agents, the amount they need to borrow is lower thus, since they can keep a relatively bigger share of the first period payoff, they prefer exploitation. For individuals in the middle part of the wealth distributions, banks are able to offer separating contracts. When wealth is sufficiently high, untalented individuals earn enough from investing to not be interested in the zero-profit contract offered to talented explorers. However, for slightly lower wealth levels, banks need to increase the interest rate asked to talented explorers in such a way that makes untalented individuals indifferent between investing and exploring.[15]

Each agent is faced with the choice between accepting the contract offered given her wealth level or investing. These choices are summarised in Proposition 2 below.

Proposition 2. *(Occupational decisions)*
When banks offer the cross-subsidising pooling exploration contract, talented agents provide effort only if their wealth is higher than a threshold ϕ^H_{HL}. All agents with wealth between $[0, \phi^H_{HL}]$ become investors, whereas agents with wealth between $[\phi^H_{HL}, \phi_{HL}]$ become explorers. For wealth levels between $[\phi_{HL}, \phi^{IC}_{HC}]$, talented individuals become explorers, whereas untalented individuals become investors. Finally, talented individuals with wealth in $[\phi^{IC}_{HC}, 1]$ become explorers, whereas their untalented counterparts become exploiters.

The agents' choices and the contracts offered together constitute the partial equilibrium of our model, summarised in Figure 1.

We define the agents with wealth lower than ϕ^H_{HL} as the lower-class. Agents in this class are offered a pooling exploration contract. Very poor talented agents do not accept the contract, since investing results in an higher payoff than cross-subsidising the untalented explorers. Conversely, relatively richer talented agents in this class are not willing to exert effort given the contractual terms of the cross-subsidising exploration contract, and by shirking they drive the probability of success of exploring down to q_L. Banks know this and thus demand an interest rate of r/q_L on the loans. This interest rate, coupled with the size of the loan required to finance the setup cost, discourages these agents from applying for credit. All agents in this class thus become investors.

[15] This is a Bertrand-Nash equilibrium where banks make positive profits, since no profitable deviations are available. See Appendix A for more details.

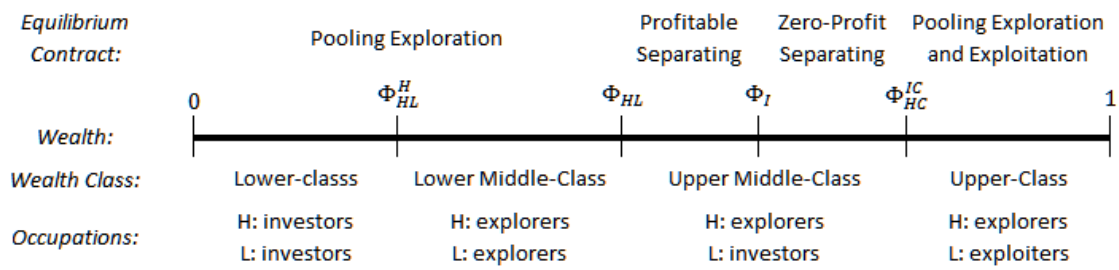


Figure 1: Partial Equilibrium

The lower middle-class agents are those with wealth levels between $\left[\phi_{HL}^{H}, \phi_{HL}\right]$. They are offered a pooling exploration contract, and since talented agents provide effort, all agents in this class become explorers. The probability of success is $\bar{q}_{HL}$ and the interest rate is $r/\bar{q}_{HL}$. Talented agents cross-subsidise untalented explorers by paying an interest rate higher than the one consistent with their risk level.

Agents with wealth levels between $\left[\phi_{HL}, \phi_{HC}^{IC}\right]$ constitute the upper middle-class. Untalented agents stay out of entrepreneurship, while talented agents become effort-exerting explorers. For wealth levels higher than ϕ_I, banks offer zero-profit loans (at the interest rate of r/q_H) to talented agents. For wealth levels lower than ϕ_I, the zero-profit loans would attract untalented agents as well, thus banks raise the interest rate to make untalented agents indifferent with investing.[16]

Finally, the upper-class agents are those with wealth levels between $\left[\phi_{HC}^{IC}, I\right]$. Only the pooling exploration and exploitation contract can be offered: untalented agents become exploiters and talented agents effort-exerting explorers. The interest rate is $r/\bar{q}_{HC}$, thus entailing cross-subsidisation that runs from untalented exploiters to talented explorers.

4.2 General Equilibrium

The number of talented and untalented explorers, and the number of exploiters are, respectively

$$E_H^N(r) = \lambda\left[1 - G\left(\phi_{HL}^{H}(r)\right)\right] \tag{5a}$$

$$E_L^N(r) = (1-\lambda)\left[G\left(\phi_{HL}(r)\right) - G\left(\phi_{HL}^{H}(r)\right)\right] \tag{5b}$$

$$E^C(r) = (1-\lambda)\left[1 - G\left(\phi_{HC}^{IC}(r)\right)\right]. \tag{5c}$$

[16]More information are given in Appendix A.

The total number of entrepreneurs, E, is $E(r) = E_H^N(r) + E_L^N(r) + E^C(r)$, and thus, the total demand of funds is $I \times E$. The total availability of funds is given by aggregate wealth, $\bar{A}$. In general equilibrium, the risk-free interest rate clears the credit market:

$$\bar{A} = I \times E(r^\star). \tag{6}$$

Thus, the number of entrepreneurs in equilibrium is fixed, and equal to the ratio between aggregate wealth and setup cost.[17]

5 Quantitative Illustrations

In this section, we present some quantitative illustrations of our general equilibrium. Parameter values, which respect all the assumptions, are arbitrary chosen as: $p = 0.50$, $q_H = 0.45$, $q_L = 0.42$, $q_H^S = 0.65$, $q_L^S = 0.60$, $\lambda = 0.60$, $I = 1.00$, $Y \approx 1.50$, and $e \approx 0.02$.

In each economy, wealth is distributed according to a Beta distribution, $A \sim \beta(a, b)$.[18] We let the shape parameter a vary between $(0, 10)$, and we set $b = a/\bar{A} - a$, so that in all economies, aggregate wealth (which is equal to average wealth) is approximately the same, and approximately equal to $\bar{A}$. Therefore, given the credit market equilibrium condition in (6), in each economy there is the same number of entrepreneurs (and thus investors). We keep the number of entrepreneurs constant, so that any difference among these economies is due to a composition effect (i.e. who becomes entrepreneur) rather than a quantity effect (i.e. how many agents choose entrepreneurship).

We run these simulations for two levels of aggregate wealth, $\bar{A} = \{0.30, 0.35\}$. The main difference is that for $\bar{A} = 0.35$, the average agent belong to the middle-class, whereas for $\bar{A} = 0.30$, she belongs to the lower-class.[19] We show that this has important repercussion on the relationship between inequality and innovation.

[17] Also, note that the left-hand side of (6) is constant in the risk-free interest rate, whereas it is easy to prove that the right-hand side is strictly decreasing in r: if it exists, there is only one equilibrium for the range of interest rates considered here.

[18] In the main text, we use draws from positively skewed Beta distributions. Indeed, the bounded domain and great flexibility of the Beta distribution make it very convenient for our application. The Beta distribution has been used to fit income and wealth distributions since Thurow (1970) and Podder and Kakwani (1976). In Appendix B.2 we present more simulations with different wealth distributions.

[19] Simulations for other average wealth levels are available on request.

5.1 An Economy with $\bar{A}$ equal to 0.35

Table 1 and Figure 2 present a comparison between the general equilibrium for different economies with different levels of wealth inequality, but the same total wealth, $\bar{A} = 0.35$.[20] A look at Table 1 confirms that the average agent is in the middle-class.

Table 1: A quantitative illustration with $\bar{A} = 0.35$

(a, b)	Gini	ϕ^H_{HL}	ϕ_{HL}	ϕ_I	ϕ^{IC}_{HC}	$r^\star$	E^N_H	E^N_L	E^C	$E^\star = \bar{A}$
(0.1, 0.19)	0.625	0.3342	0.386	0.623	0.7734	1.4844	0.2239	0.0054	0.1136	0.35
(0.5, 0.93)	0.492	0.3333	0.421	0.643	0.7734	1.4822	0.2666	0.0286	0.0550	0.35
(1.0, 1.86)	0.395	0.3333	0.419	0.642	0.7735	1.4823	0.2816	0.0424	0.0250	0.35
(2.0, 3.71)	0.299	0.3339	0.396	0.628	0.7737	1.4838	0.2977	0.0464	0.0064	0.35
(3.0, 5.57)	0.249	0.3344	0.382	0.619	0.7738	1.4847	0.3048	0.0439	0.0017	0.35
(4.0, 7.43)	0.219	0.3347	0.370	0.612	0.7739	1.4854	0.3101	0.0393	0.0005	0.35
(5.0, 9.27)	0.197	0.3349	0.363	0.607	0.7740	1.4859	0.3154	0.0344	0.0001	0.35
(6.0, 11.1)	0.181	0.3351	0.358	0.604	0.7741	1.4862	0.3181	0.0316	0.0000	0.35
(7.0, 13.0)	0.168	0.3352	0.355	0.602	0.7741	1.4864	0.3203	0.0292	0.0000	0.35
(8.0, 14.9)	0.157	0.3353	0.350	0.599	0.7741	1.4867	0.3270	0.0235	0.0000	0.35
(9.0, 16.7)	0.149	0.3353	0.349	0.599	0.7742	1.4867	0.3270	0.0230	0.0000	0.35
(9.9, 18.4)	0.143	0.3354	0.345	0.597	0.7742	1.4869	0.3293	0.0204	0.0000	0.35

The Gini coefficient of the sample decreases (i.e. there is an increase in equality) as the shape parameters of the Beta distribution increase, since mass is moved from the tails of the distribution to the centre. Keeping other things constant, when this happens, there is a decrease in the number of both investors (since most agents in the lower tail do not have access to the credit market) and non-innovative entrepreneurs (since only untalented agents in the upper tail become exploiters). On the one hand, the investors disappearing as the equality level increases are the poorest ones, who will have to be substituted by relatively wealthier individuals: the supply of loans increases, pushing the interest rate down. On the other hand, exploiters are among the richest entrepreneurs: when their number decreases, new firms will have to be opened up by relatively poorer agents, pushing the demand for loans, and thus the interest rate, up. Which one of these two effects prevails depends on initial conditions.

In this illustration, as inequality quickly decreases, the interest rate also initially decreases sharply, but then starts to increase, as one can see in the fifth panel of Figure 2. This is because the former effect (i.e. investors getting relatively richer) dominates only at first here, where wealth is right-skewed. A movement in the interest rate only slightly changes the ϕ^H_{HL} and ϕ^{IC}_{HC} thresholds in the same direction: the number of people in

[20] Sample distributions for the economies shown in Table 1 are given in Figure B.13.

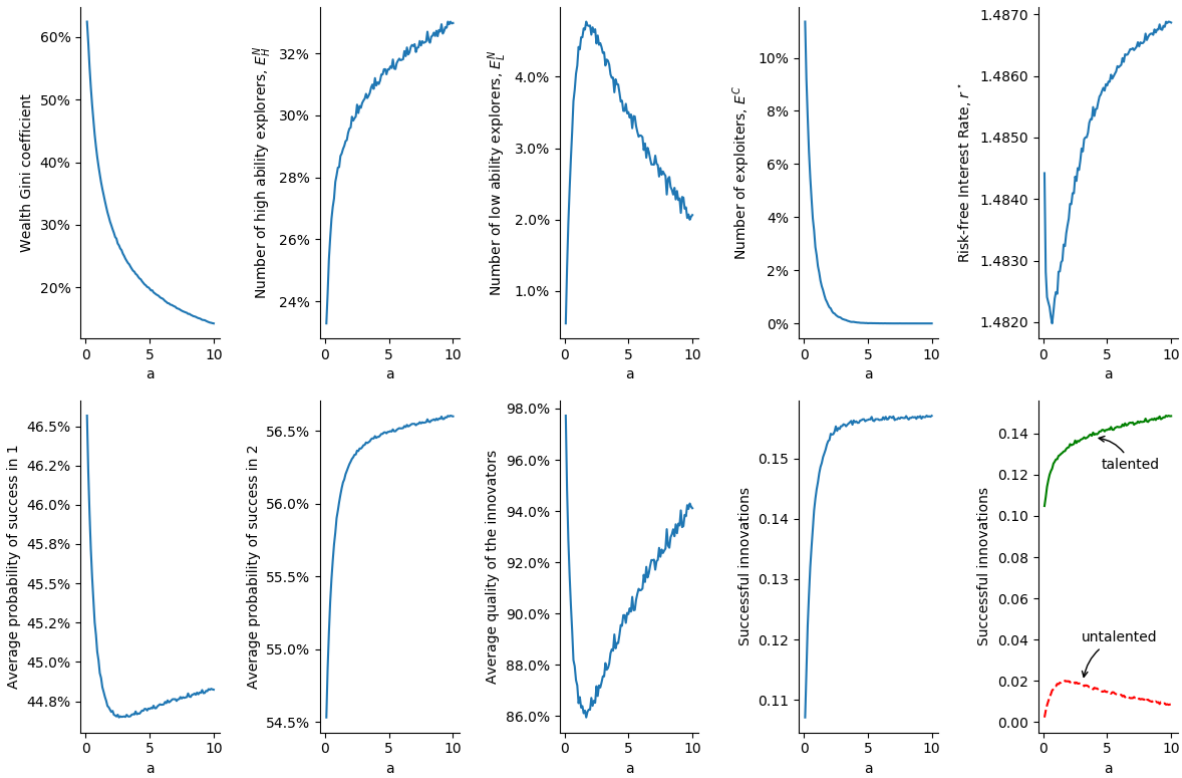


Figure 2: A quantitative illustration with $\bar{A} = 0.35$

Notes. The average quality of the innovators is given by the percentage of effort-exerting explorers out of the total number of explorers. The number of successful innovations is given by the number of explorers times the relative probability of success in the first period.

the lower- and upper-class is mostly influenced by the shape of the wealth distribution, and only marginally by the interest rate that clears the credit market. As inequality decreases, mass is moved from the two extreme classes towards the middle-class, and thus the number of exploiters monotonically decreases (as shown in the fourth panel of Figure 2), whilst the number of talented explorers monotonically increases (see the second panel of Figure 2).

Conversely, changes in the interest rate negatively affect the ϕ_{HL} and ϕ_I thresholds, thus carrying repercussions on the composition of the middle-classes. As one can see in the third panel of Figure 2, the number of untalented explorers sharply increases initially. Indeed, on the one hand, agents are being moved from the lower-class to the lower middle-class (where average wealth lies), and thus untalented agents switch from investing to untalented exploration. On the other hand, keeping other things constant, the initial decrease in the interest rate means that pretending to be talented becomes more

convenient than investing for a growing proportion of middle-class untalented agents, who thus self-select into the lower middle-class. This entails a decrease in the average talent of the innovators (see the eight panel of Figure 2). The increasing number of innovative firms opened up by both talented and untalented explorers exactly balances the decrease in the number of conventional firms, given condition (6). Since conventional firms are initially more likely to succeed, the average probability of success of the economy in the first period plummets, as shown in the sixth panel of Figure 2; at the same time, though, the economy becomes more successful in the long-term, as shown in the seventh panel of Figure 2.

New firms are being started by relatively poorer agents, and the subsequent increased demand of loans eventually entails a rise in the risk-free interest rate that clears the credit market. Shortly after, the number of untalented explorers start decreasing, as low ability agents switch to investing. Since the number of entrepreneurs must remain constant, untalented explorers are replaced by talented innovators, and thus both the economy-wide average probability of success in the first period and the average talent of the innovators start to recover. Finally, the last two panels of Figure 2 show that the number of successful innovations, i.e. the number of innovative firms that were successful in the first period and thus discovered a superior action, is monotonously increasing in the equality level of the economy. This number skyrockets initially, as innovative firms are being started by both talented and untalented agents, and then levels off, as the two components diverge.

5.2 An Economy with $\bar{A}$ equal to 0.30

Here, we reduce total wealth to $\bar{A} = 0.30$. This means that the average agent now is in the lower-class, rather than in the middle-class as before. The general equilibrium for different level of wealth inequality are given in Table 2 and Figure 3.

Initially, the economy behaves like the previous one when inequality is decreased: the interest rate drops before starting to rise again, the number of innovators increases, whereas the number of exploiters decreases. Soon enough, however, things change. Indeed, whereas in the previous illustration the average quality of the innovators started increasing due to a reduction in the number of untalented explorers, here it is the number of talented innovators that decreases.

Table 2: A quantitative illustration with $\bar{A} = 0.30$

(a, b)	Gini	ϕ_{HL}^{H}	ϕ_{HL}	ϕ_{I}	ϕ_{HC}^{IC}	$r^{\star}$	E_{H}^{N}	E_{L}^{N}	E^{C}	$E^{\star} = \bar{A}$
(0.1, 0.23)	0.669	0.3336	0.410	0.636	0.7736	1.4829	0.2019	0.0079	0.0913	0.30
(0.5, 1.17)	0.517	0.3326	0.444	0.657	0.7732	1.4808	0.2281	0.0363	0.0355	0.30
(1.0, 2.33)	0.412	0.3326	0.445	0.658	0.7732	1.4807	0.2328	0.0542	0.0129	0.30
(2.0, 4.67)	0.313	0.3330	0.431	0.649	0.7733	1.4816	0.2316	0.0666	0.0019	0.30
(3.0, 7.00)	0.260	0.3333	0.422	0.644	0.7734	1.4822	0.2257	0.0740	0.0002	0.30
(4.0, 9.33)	0.228	0.3334	0.419	0.642	0.7735	1.4824	0.2199	0.0796	0.0000	0.30
(5.0, 11.7)	0.205	0.3334	0.416	0.640	0.7735	1.4825	0.2156	0.0840	0.0000	0.30
(6.0, 14.0)	0.189	0.3335	0.414	0.639	0.7735	1.4827	0.2125	0.0877	0.0000	0.30
(7.0, 16.3)	0.175	0.3334	0.418	0.641	0.7735	1.4825	0.2070	0.0931	0.0000	0.30
(8.0, 18.7)	0.164	0.3334	0.418	0.641	0.7735	1.4824	0.2027	0.0973	0.0000	0.30
(9.0, 21.0)	0.155	0.3332	0.423	0.644	0.7734	1.4821	0.1982	0.1019	0.0000	0.30
(9.9, 23.1)	0.148	0.3330	0.429	0.648	0.7734	1.4818	0.1941	0.1056	0.0000	0.30

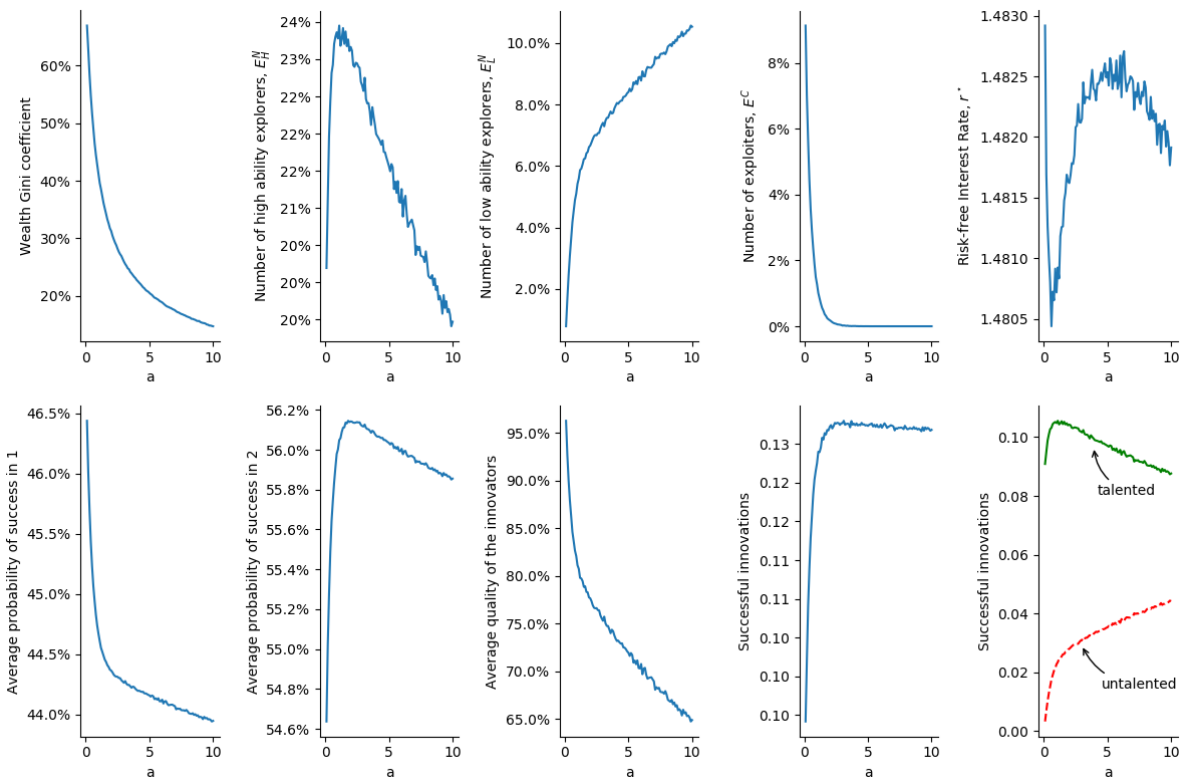


Figure 3: A quantitative illustration with $\bar{A} = 0.30$

Notes. The average quality of the innovators is given by the percentage of effort-exerting explorers out of the total number of explorers. The number of successful innovations is given by the number of explorers times the relative probability of success in the first period.

6 Conclusions

Does inequality hinder or foster innovations? In this paper, we offered a two-period general equilibrium model, where agents differ in observable wealth and unobservable innovative talent. Agents can choose their occupation between non-risky investment and risky entrepreneurship; entrepreneurs can further choose between conventional projects and more innovative ventures. Investors deposit their wealth in banks, which, in turn, provide credit to entrepreneurs to finance the firms' setup costs.

We showed that the wealth of an agent, and thus her funding need, plays a crucial role in the kind of contracts that she is offered. Poor agents are only offered pooling contracts, and talented innovators in the lower wealth classes are supposed to cross-subsidise untalented innovators. As a consequence, the poorer talented innovators do not ask for credit, whereas some untalented agents start innovative firms. Medium-class agents are offered separating contracts: talented agents start innovative firms, whereas untalented agents choose the non-risky activity. Rich agents are also offered pooling contracts, but this time untalented agents choose safer projects and cross-subsidise talented innovators, who experiment with riskier approaches.

In general equilibrium, the credit market must clear and thus the risk-free interest rate adjusts to make the demand and supply of loans meet. Since movements in the interest rate influence the payoff from investment and entrepreneurship, they have general equilibrium repercussions on the size and the composition of the wealth classes. We showed that a decrease in the inequality level of an economy can lead to an increase in both the average talent of the innovators and the number of successful innovations, and to a decrease in the number of non-innovative entrepreneurs. However, the effect of a reduction of inequality on innovation depends on initial conditions: poor and/or very unequal economies experience a decrease in the average talent of the innovators when equality increases.

Of course, our model could be improved in many directions. For simplicity, we have assumed that talent is a vertical characteristic, and that the firm's setup cost is the same among conventional and innovative firms. More realistically, one could assume that talent is a horizontal dimension, with some agents more inclined to conventional projects, and others more inclined to deal with innovative technologies. Similarly, both incremental and disruptive innovations could be modelled. A labour market could also be added to the model, as in Inci (2013): the wage would thus constitute an additional channel through which changes in the wealth distribution would have general equilibrium reper-

cussions. It would be important to include capital in the model: one could, for example, endogenise the scale of the firm, and start considering the difference between subsistence and transformational entrepreneurship. We have seen that the wealth of the economy is important for the relationship between inequality and innovation, but what happens when economic growth is also involved? Finally, since the relationship between inequality and innovation is intrinsically a two-way dynamic problem, an important extension of this paper would be to embed this occupational choice framework into an overlapping generation model. One could then start considering the interplay between inequality of opportunity, innovation, and inequality of outcomes. The non-monotonic relationship between inequality and innovation that we find, depending on the average wealth of the economy or the initial inequality level, suggests that multiple equilibria could arise in such dynamic setting, with some economies stuck in highly unequal and non-innovative traps, and others perhaps converging to steady states with different combinations of equality and innovation levels. We leave these interesting extensions to future research.

References

Acemoglu, D., J. A. Robinson, and T. Verdier. 2017. "Asymmetric growth and institutions in an interdependent world." *Journal of Political Economy*, 125(5): 1245 – 1305.

Aghion, P., U. Akcigit, A. Hyytinen, and O. Toivanen. 2018. "The social origins and IQ of inventors." Mimeo.

Aghion, P., and P. Bolton. 1997. "A theory of trickle-down growth and development." *Review of Economic Studies*, 64(2): 151 – 172.

Aitchinson, J., and J. A. C. Brown. 1957. *The Lognormal Distribution with Special Reference to its Use in Economics*. Cambridge: Cambridge University Press.

Akcigit, U., J. Grigsby, and T. Nicholas. 2017. "The rise of American ingenuity: Innovation and inventors of the golden age." Mimeo.

Barro, R., and X. Sala-I-Martin. 1995. *Economic Growth*. New York: McGraw Hill.

Bell, A., R. Chetty, X. Jaravel, N. Petkova, and J. Van Reenen. 2016. "The lifecycle of inventors." Mimeo.

Celik, M. 2018. "Does the cream always rise to the top? The misallocation of talent in innovation." Mimeo.

Chatterjee, A., S. Yarlagadda, and B. K. Chakrabarti. 2005. *Econophysics of Wealth Distributions*. New York: Springer International Publishing.

Clementi, F., and M. Gallegati. 2016. *The Distribution of Income and Wealth. Parametric Modeling with the κ-Generalized Family*. New York: Springer International Publishing.

Coco, G., and G. Pignataro. 2014. "The poor are twice cursed: Wealth inequality and inefficient credit market." *Journal of Banking & Finance*, 49: 149 – 159.

DeMeza, D., and D. Webb. 1987. "Too much investment: A problem of asymmetric information." *Quaterly Journal of Economics*, 102(2): 281 – 292.

Foellmi, R., and J. Zweimüller. 2006. "Income distribution and demand-induced innovations." *Review of Economic Studies*, 73(4): 941 – 960.

Foellmi, R., and J. Zweimüller. 2017. "Is inequality harmful for innovation and growth? Price versus market size effects." *Journal of Evolutionary Economics*, 27(2): 359 – 378.

Ghatak, M., M. Morelli, and T. Sjöström. 2007. "Entrepreneurial talent, occupational choice, and trickle up policies." *Journal of Economic Theory*, 137(1): 27 – 48.

Ghiglino, C., and N. Tabasso. 2016. "Risk aversion in a model of endogenous growth." *Journal of Mathematical Economics*, 64(C): 30 – 40.

Gibrat, R. 1931. *Les Inégalités Économiques. Applications: Aux Inégalités des Richesses, à la Concentration des Entreprises, aux Population des Villes, aux Statistiques des Familles, etc., d'une Loi Nouvelle: La Loi de l'Effet Proportionnel*. Paris: Librairie du Recueil Sirey.

Gini, C. 1921. "Measurement of inequality of incomes." *Economic Journal*, 31(121): 124 – 126.

Grüner, H. P. 2003. "Redistribution as a selection device." *Journal of Economic Theory*, 108(2): 194 – 216.

Hatipoğlu, O. 2012. "The relationship between inequality and innovative activity: A Schumpeterian theory and evidence from cross-country data." *Scottish Journal of Political Economy*, 59(2): 224 – 248.

Inci, E. 2013. "Occupational choice and the quality of entrepreneurs." *Journal of Economic Behavior & Organization*, 92(C): 1 – 21.

Jaimovich, E. 2011. "Sectoral differentiation, allocation of talent, and financial development." *Journal of Development Economics*, 96(1): 47 – 60.

Kleiber, C., and S. Kotz. 2003. *Statistical Size Distributions in Economics and Actuarial Sciences*. New York: Wiley.

Manso, G. 2011. "Motivating innovation." *The Journal of Finance*, 66(5): 1823 – 1860.

Meh, C. A. 2005. "Entrepreneurship, wealth inequality, and taxation." *Review of Economic Dynamics*, 8(3): 688 – 719.

Obama, B. 2013. "Remarks by the President on Economic Mobility." Transcript available online at `https://obamawhitehouse.archives.gov/the-press-office/2013/12/04/remarks-president-economic-mobility`.

OECD. 2015. *In It Together: Why Less Inequality Benefits All*. Paris: OECD Publishing.

Okun, A. 1975. *Equality and Efficiency: The Big Tradeoff*. Washington D.C.: Brookings Institution Press.

Pareto, V. 1897. *Cours d'Economie Politique*. Lausanne: F. Rouge.

Piketty, T. 2014. *Capital in the Twenty-First Century*. Cambridge: Harvard University Press.

Podder, N., and N. C. Kakwani. 1976. "Distribution of wealth in Australia." *Review of Income and Wealth*, 22(1): 75 – 92.

Pope Francis. 2015. "Encyclical Letter Laudato Si': On Care for Our Common Home." Available online at `https://laudatosi.com/watchl`.

Romer, P. M. 2011. "Should the government subsidize supply or demand in the market for scientists and engineers?" In *Innovation Policy and the Economy, Volume 1*. Eds. by A. B. Jaffe, J. Lerner, and S. Stern: MIT Press, 221 – 252.

Spiganti, A. forthcoming. "Can starving start-ups beat fat labs? A bandit model of innovation with endogenous financing constraint." *Scandinavian Journal of Economics*.

Thurow, L. C. 1970. "Analyzing the American income distribution." *American Economic Review*, 60(2): 261 – 269.

Violanti, G. L. 2008. "Skill-biased technical change." In *The New Palgrave Dictionary of Economics*. Eds. by S. Durlauf, and L. Blume.

Weitzman, M. 1979. "Optimal search for the best alternative." *Econometrica*, 47(3): 641–54.

A Proofs

A.1 Proof of Proposition 1

Assumption B and C imply that the equilibrium risk-free interest rate must be such that

$$r^\star \in \left(\frac{Y\left(q_L + q_L q_L^S + p - q_L p\right)}{I}; \frac{Y\left(q_H + q_H q_H^S + p - q_H p\right) - e}{I} \right).$$

Let $\underline{r}$ and $\bar{r}$ be the shorthand for these lower and upper values of r. Below, we tackle separating, pooling, and other types of contracts in turn.

Separating Contracts. Each iso-payoff in (2) has the same slope as the corresponding zero-profit condition in (3). Moreover, an indifference curve for a low ability or shirking high ability explorer L is steeper than an indifference curve for effort-exerting high ability explorer H, which in turn is steeper than an indifference curve for an exploiter C; the vertical intercept of the zero-profit condition for L is higher than the one for H, which is higher than the one for C. Thus, there is no fully separating menu of contracts for which the zero-profit conditions and incentive compatibility constraints are all satisfied (see Figure A.4).

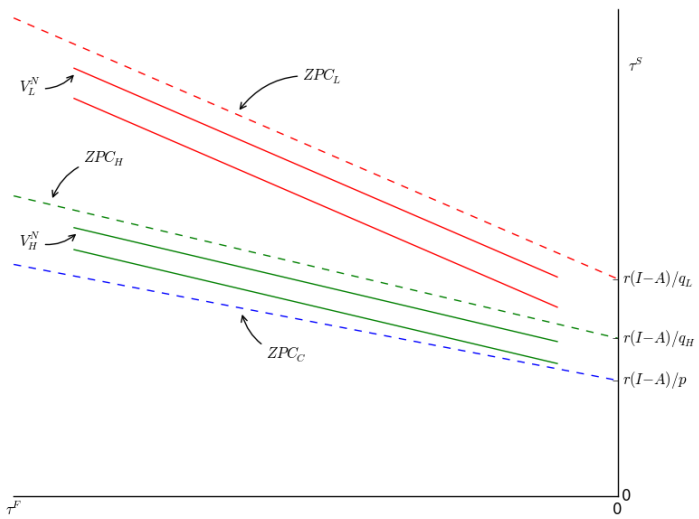


Figure A.4: Non-existence of fully separating contracts

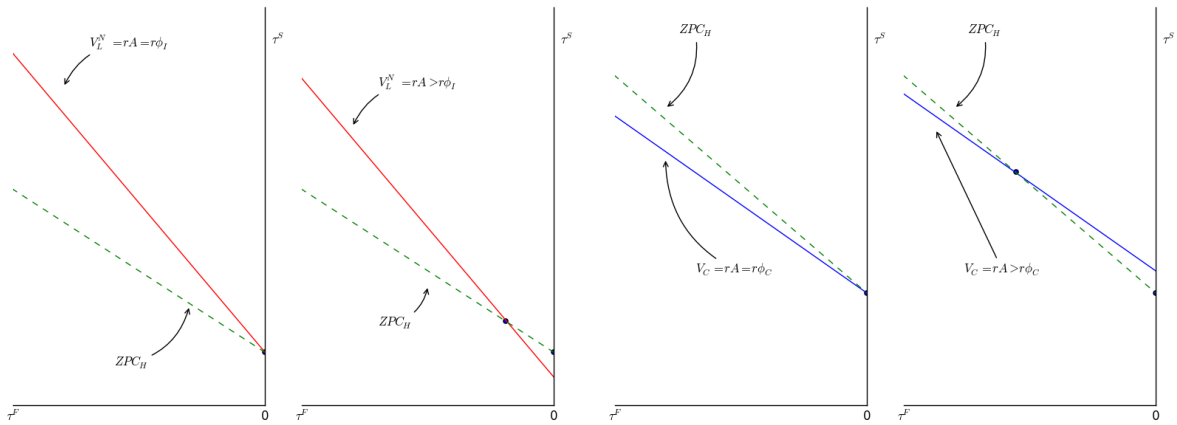
Notes. Solid lines are indifference curves, utility of the agents increases as we move south-west. Dashed lines are zero-profit conditions.

However, for certain wealth levels it is possible to separate high ability from low ability even with a contract designed for high ability alone. This happens if the wealth level of the low ability agents is such that they prefer investing to entrepreneurship using the contract designed for H. Consider the wealth level such that a low ability explorer's

indifference curve at level rA (i.e. the outside opportunity to entrepreneurship) intersects the zero-profit condition for an exploration contract requiring effort on the vertical axis. This wealth level is given by

$$A = -\frac{q_L}{q_H - q_L} I + \frac{\left(q_L + q_L q_L^S + p - q_L p\right) q_H}{r\left(q_H - q_L\right)} Y =: \phi_I(r). \tag{A.7}$$

This is depicted in Panel (a) of Figure A.5. In the first panel, A is exactly equal to ϕ_I and thus L is just indifferent between investing and accepting the contract on the intersection between the zero-profit condition for talented exploration and the vertical axis. In the second panel, $A > \phi_I$ and thus L prefers investing to any contract offered to a high ability explorer between the two points shown (on the zero-profit condition). Note that there is a continuum of contracts between the two dots, each associated with a different repayment schedule. Hereafter, we focus on the contracts on the vertical axis for simplicity, but this is without loss of generality for our purposes, since the participation choices of the agents, and the expected repayment, are the same for all these contracts.



(a) Exploring (b) Exploiting

Figure A.5: Separating exploration contract

Notes. Solid lines are indifference curves for low ability explorers at rA levels (thus L is indifferent between investing and using a contract on these indifference curves), utility of the agents increases as we move south-west. Dashed lines are zero-profit conditions for the bank from an exploration contract requiring effort. Dots are putative contracts. Note that both lines are function of A, and so they both move when A changes.

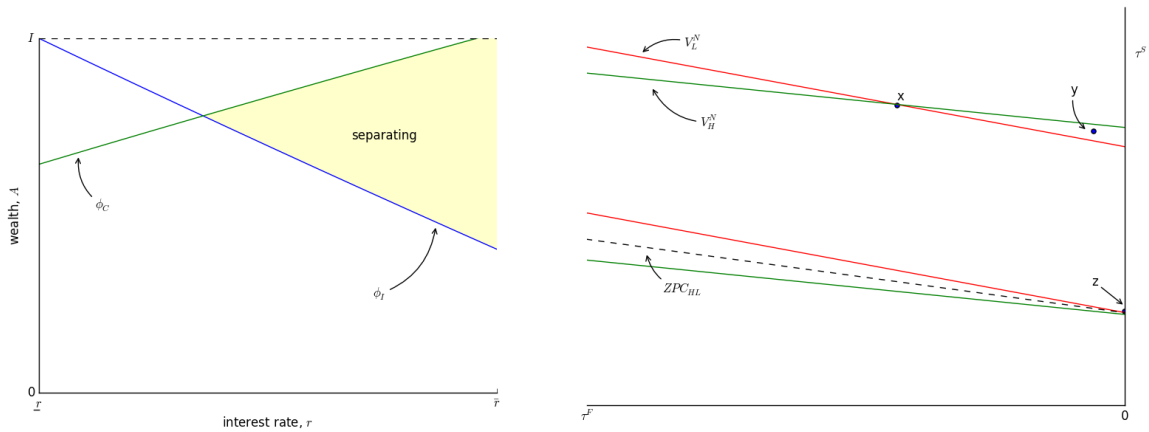
However, the low ability agent has access to another possible deviation: even if she prefers investing to exploration using the contract designed for the high ability agents, she might prefer exploitation using this contract to investing. For a certain wealth level, the untalented agent is indifferent between investing for a payoff equal to rA and use this contract to exploit. Consider a wealth level such that the indifference curve from exploitation at utility level rA intersects the zero-profit condition for an exploration

contract with effort on the vertical axis:

$$A = \frac{p}{p - q_H} I - 2\frac{pq_H}{r(p - q_H)} Y =: \phi_C(r). \tag{A.8}$$

See Panel (b) of Figure A.5. In the first panel, A is exactly equal to ϕ_C and thus an exploiter is just indifferent between investing and accepting the contract designed for a high ability explorer on the vertical axis. In the second panel, $A > \phi_C$ and this time we see that the exploiter strictly prefers exploiting using this contract than investing.[21]

To summarise, suppose a bank is offering the talented agent an exploration contract with effort on the vertical axis, $\sigma_H(A, r) = [r(I - A)/q_H \quad 0]$. An untalented agent will prefer exploration (using this contract) to investing if $A < \phi_I(r)$, and exploitation (using this contract) to investing if $A > \phi_C(r)$. These conditions are summarized in Panel (a) of Figure A.6 in the (r, A) space. In the yellow area (labelled "separating"), wealth levels are between $[\phi_I, \phi_C]$,[22] and investing is weakly preferred by the low ability agents. Thus, it may be possible for the bank to offer a separating exploration contract involving effort to the talented agents. In the other areas, the untalented agent would accept the separating exploration contract with effort even if she is not supposed to, and thus offering such contract cannot be an equilibrium.



(a) Separating

(b) Pooling

Figure A.6: Separating contracts and existence of pooling contracts

Pooling Contracts. When the principal cannot offer a separating contract, she may

[21]The last panel of Figure A.5 also shows that the low ability agent prefers exploiting using any contract between the two dots to investing, but a separating contract may be possible on the left of the intersection between the zero-profit condition and the indifference curve. However, it is straightforward to show that this cannot be an equilibrium since low ability agents would use that contract to explore.

[22]Note that $\phi_I'(r) < 0$ and $\phi_C'(r) > 0$; $\phi_I(\underline{r}) = I$ and $\phi_C(\underline{r}) < I$. Since $\phi_C(2pY/I) = I$, $\phi_I(r)$ and $\phi_C(r)$ cross for an $r \in (\underline{r}, 2pY/I)$; thus such area exists under our assumptions.

be able to offer a pooling contract. For the time being, take effort, participation, and project selection decisions as given.

Consider, for example, a particular wealth class for which high ability agents choose effortful exploration and low ability agents choose exploration. This is depicted in Panel (b) of Figure A.6, which can be used to show that in a pooling contract, the repayment in case of failure is zero. Consider a putative equilibrium contract x: a bank can deviate and offer any contract between the two indifference curves, e.g. y, which is strictly preferred by high ability agents only. This profitable deviation survives until we are on the vertical axis. Such a contract can be undercut until banks make zero profits, e.g. point z.

The analysis above can be repeated for any pair of agents and actions. Therefore the zero-profit condition of a bank offering a pooling contract requires $\tau^F = 0$ and $\tau^S = r(I - A)/\bar{q}$, where $\bar{q} \in [q_L, p]$ is the weighted average of the success probability in period 1 for a particular wealth level, and depends on the equilibrium choice of the agents with that wealth.[23]

A pooling contract cannot be offered if agents have an outside option that is strictly preferred to any pooling contract on the relevant zero-profit condition. There is a wealth level such that a low ability explorer's indifference curve at level rA intersects the zero-profit condition with both high and low ability explorers on the vertical axis. This wealth level is given by

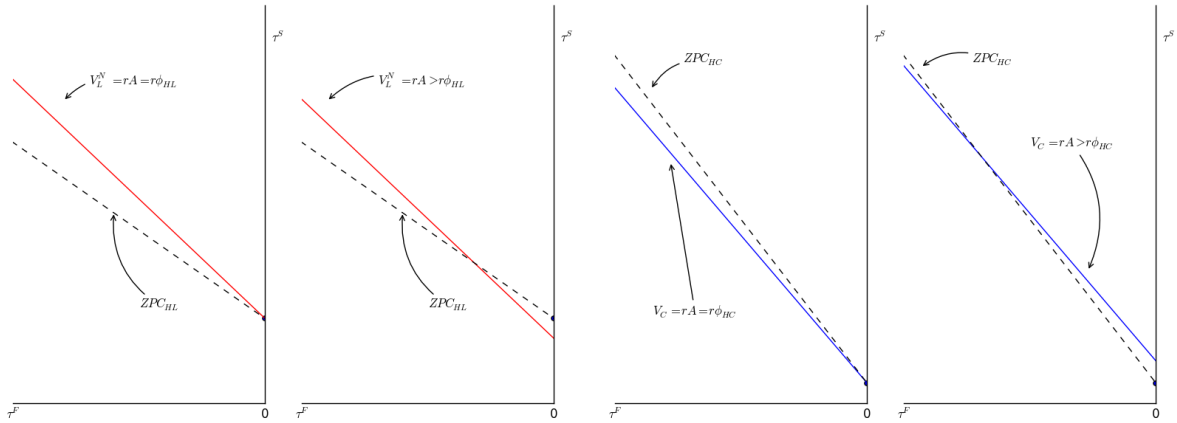
$$A = -\frac{q_L}{\bar{q}_{HL} - q_L} I + \frac{\left(q_L + q_L q_L^S + p - q_L p\right) \bar{q}_{HL}}{r(\bar{q}_{HL} - q_L)} Y =: \phi_{HL}(r), \tag{A.9}$$

where $\bar{q}_{HL} = \lambda q_H + (1 - \lambda) q_L$. See Panel (a) of Figure A.7. In the first panel, A is exactly equal to ϕ_{HL} and thus a low ability explorer is just indifferent between investing and accepting the pooling exploration contract. In the second panel, $A > \phi_{HL}$ and she strictly prefers investing than accepting the contract on the vertical axis. Thus, only for wealth levels between $(0, \phi_{HL})$, the bank may be able to offer a pooling exploration contract on the vertical axis. However, L would like to use this contract to explore and not to exploit (i.e. the contract is incentive compatible with respect to exploitation) only if

$$A < I - \frac{\left(p + q_L p - q_L - q_L q_L^S\right) \bar{q}_{HL}}{r(p - q_L)} Y =: \phi_{HL}^{IC}(r). \tag{A.10}$$

Likewise, there is a wealth level such that an exploiter's indifference curve at level rA intersects the zero-profit condition with both high ability explorers and low ability

[23] We have not yet considered a situation in which adverse selection is not a problem, i.e. when high ability agents do not provide effort (and thus they are no different from low ability agents), or when both high ability agents and low ability agents choose exploitation. In such cases, the analysis is similar to the one above: banks would offer a pooling contract with $\tau^F = 0$, and τ^S such that the relevant zero-profit condition is satisfied (i.e. consistent with the risk level in the first period of those accepting the contract).



(a) Exploration

(b) Exploration and Exploitation

Figure A.7: Pooling contracts

Notes. Solid lines are indifference curves. The dashed line is the zero-profit condition for the bank from a pooling contract.

exploiter on the vertical axis. This wealth level is given by

$$A = \frac{p}{p - \bar{q}_{HC}} I - \frac{2p\bar{q}_{HC}}{r(p - \bar{q}_{HC})} Y =: \phi_{HC}(r), \tag{A.11}$$

where $\bar{q}_{HC} = \lambda q_H + (1-\lambda)p$. See Panel (b) of Figure A.7. In the third panel, an exploiter is indifferent between investing and accepting the pooling (effortful exploration and exploitation) contract on the vertical axis. In the last panel, $A > \phi_{HC}$ and the exploiter strictly prefers accepting the contract than investing. Thus for wealth levels between $(\phi_{HC}, I]$, the bank may be able to offer a contract pooling effort-exerting explorers with exploiters. However, L would like to use this contract to exploit and not to explore (i.e. the contract is incentive compatible with respect to exploration) only if

$$A > I - \frac{\left(p + q_L p - q_L - q_L q_L^S\right) \bar{q}_{HC}}{r(p - q_L)} Y =: \phi_{HC}^{IC}(r). \tag{A.12}$$

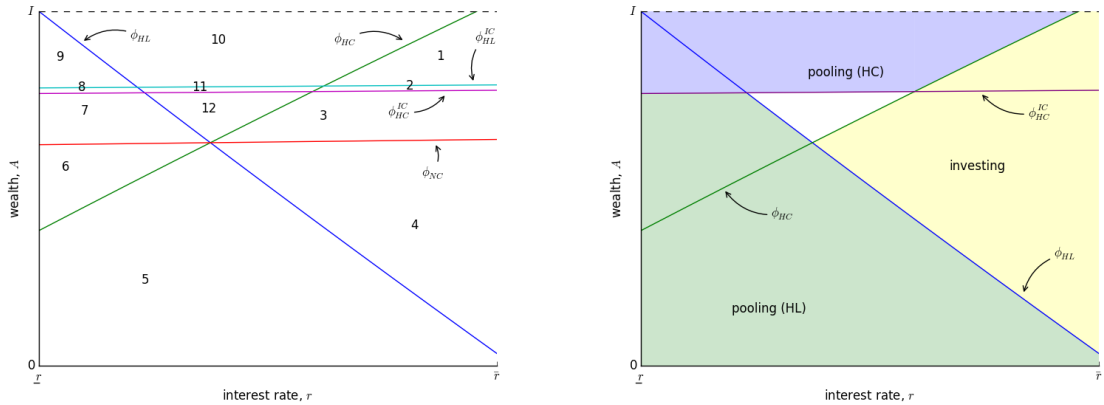
Imagine the bank offering both the exploration pooling contract on the vertical axis, and the effortful exploration and exploitation pooling contract on the vertical axis. A low ability agent will prefer the former to the latter if

$$A < I - \frac{\left(p - q_L - q_L q_L^S + q_L p\right) \bar{q}_{HL} \bar{q}_{HC}}{\lambda r q_H (p - q_L)} Y =: \phi_{NC}(r).$$

The wealth levels ϕ_{HL}, ϕ_{HC}, ϕ_{NC}, ϕ_{HC}^{IC}, and ϕ_{HL}^{IC} naturally divide the (r, A) space into twelve areas, as shown in Panel (a) of Figure A.8.

In the areas (1)-(4), the low ability agent prefers investing to both pooling contracts, and thus a pooling contract is not offered in equilibrium. In the areas (5) and (6), the low ability agent prefers the pooling exploration contract to both investing and the pooling exploitation and effortful exploration contract, and the pooling exploration contract is incentive compatible. Thus, the pooling exploration contract can be offered. In area (7), L would like to be offered the pooling exploitation and effortful exploration contract but this is not incentive compatible; however, the pooling exploration contract is both incentive compatible and preferred to investing, and thus it can be offered. In areas (8)-(11), L prefers the pooling exploitation and effortful exploration contract to both the pooling exploration contract and investing, and the contract is incentive compatible. Finally, in area (12), L prefers the pooling exploitation and effortful exploration contract, which is not incentive compatible; however, the pooling exploration contract cannot be offered because L would prefer to become an investor (the equilibrium contract is derived below).

The relevant conditions are summarized in Panel (b) of Figure A.8. In the yellow area (labelled "investing"), low ability agents prefer investing to accepting a pooling contract. In the blue area (labelled "pooling (HC)"), the pooling contract that can be offered by banks is the one pooling effort-exerting explorers with exploiters; in the green area (labelled "pooling (HL)"), the equilibrium pooling contract is the exploration one. In the remaining white area, a pooling contract cannot be offered, because the one designed for both exploiters and effort-exerting explorers is not incentive compatible, whereas the pooling exploration one does not satisfy the participation constraint.



(a) All Conditions

(b) Relevant Conditions

Figure A.8: Contracts Offered

Other Contracts. In Panel (a) of Figure A.9 we add ϕ_I and ϕ_C to Figure A.8 above.

The (r, A) space is now divided into 22 areas, but the analysis mostly carries over.[24]

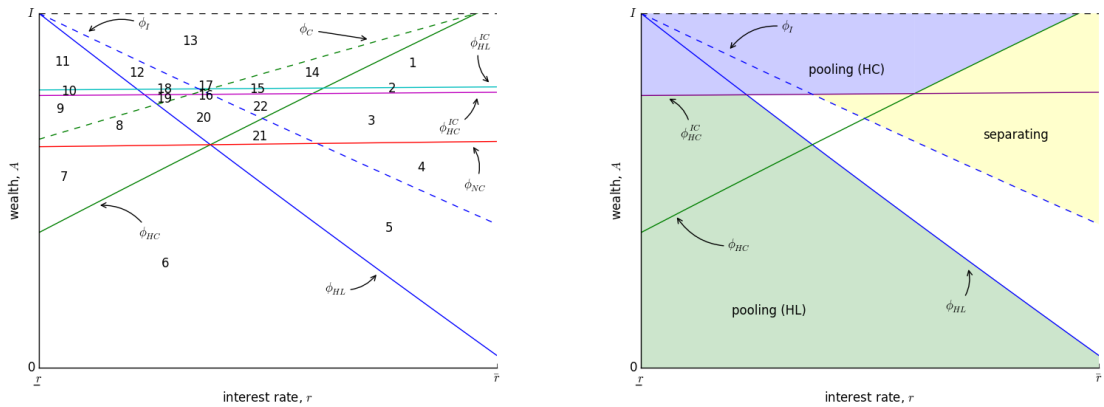
In the areas (1)-(4), the low ability agent prefers investing to improperly accepting the separating effortful exploration contract (or a pooling contract), thus this contract can be offered to the high ability agents. In the areas (6)-(9), the pooling exploration contract is the only contract both incentive compatible and preferred to the outside option of investing, thus it can be offered. In areas (10)-(18), the pooling exploitation and effortful exploration contract is incentive compatible and satisfies the participation constraint: thus, it can be offered.[25] In the areas (5) and (21), a pooling contract is not accepted by the low ability agents (since they prefer investing), but the separating effortful exploration contract cannot be offered to high ability agents because low ability agents would accept it too and use it to explore (the equilibrium contract is derived below). In area (22), a pooling contract cannot be offered (since the pooling exploitation and exploration contract is not incentive compatible, and investing is preferred to the pooling exploration contract), but the separating efficient exploration contract is incentive compatible, and thus can be offered to the high ability agents. In the areas (19) and (20), the separating contract is not incentive compatible, neither is the exploitation and exploration pooling contract, whereas the exploration pooling contract is not accepted by low ability agents (the equilibrium contract is derived below). Therefore, we still need to determine the equilibrium contract for areas (5), (19), (20), and (21).

The relevant conditions are summarised in Panel (b) of Figure A.9. So far, we have shown that for certain wealth and risk-free interest rate combinations, a separating exploration contract with effort is incentive compatible, as shown in the yellow area (labelled "separating"). We have also shown that there is an area where the only contract that can be offered is a pooling contract. In the blue area (labelled "pooling (HC)"), the equilibrium pooling contract is the one pooling effort-exerting explorers with exploiters; in the green area (labelled "pooling (HL)"), the equilibrium pooling contract is the exploration one.

We still need to determine which contract is offered in the area between ϕ_{HL}, ϕ_I, and ϕ_{HC}^{IC}. The separating exploration contract requiring effort is not incentive compatible, as it is also accepted by low ability agents, but a pooling contract cannot be offered. This is represented in Panel (a) of Figure A.10, where r and A have been chosen so that in the first panel we are in the white area on the left of ϕ_{HC}, while on the second panel we are

[24]Note that by Assumption B, $\phi_I > \phi_{HL}$. Also, ϕ_C is greater than ϕ_{HC} if $r > 2pY/I$, i.e. if investing is more efficient than exploiting.

[25]In the areas (14) and (15), we are below ϕ_C and above ϕ_I, thus a separating contract is in principle incentive compatible, as low ability prefers investing to improperly accept it. However, above ϕ_{HC}, the pooling exploitation and exploration contract is preferred to investing. Thus, in these areas, the separating exploration contract cannot be an equilibrium because banks can undercut each other by attracting both high ability explorers and low ability exploiters, until the pooling exploitation and exploration contract is offered. In area (10), also the pooling exploration contract is incentive compatible and satisfies the participation constraint but no agent would accept it if the other pooling contract is also offered.



(a) All Conditions

(b) Relevant Conditions

Figure A.9: Separating and Pooling Contracts

in the white area on the right of ϕ_{HC} from Panel (b) of Figure A.9.[26] The pooling contract cannot be offered either because low ability agent prefers investing to both pooling contracts (second panel), or because the pooling exploration contract does not satisfy the participation constraint while the exploitation and exploration pooling contract is not incentive compatible (first panel).[27] In both cases, however, the banks can offer a separating pair of contracts, like $\{y_L, y_H\}$. Effort-exerting high ability agents strictly prefer y_H,[28] while low ability agents are indifferent among y_L, y_H, and investing: thus, they choose to become investors by assumption. This is a Bertrand-Nash equilibrium where banks make positive profits, since no profitable deviations are available.[29]

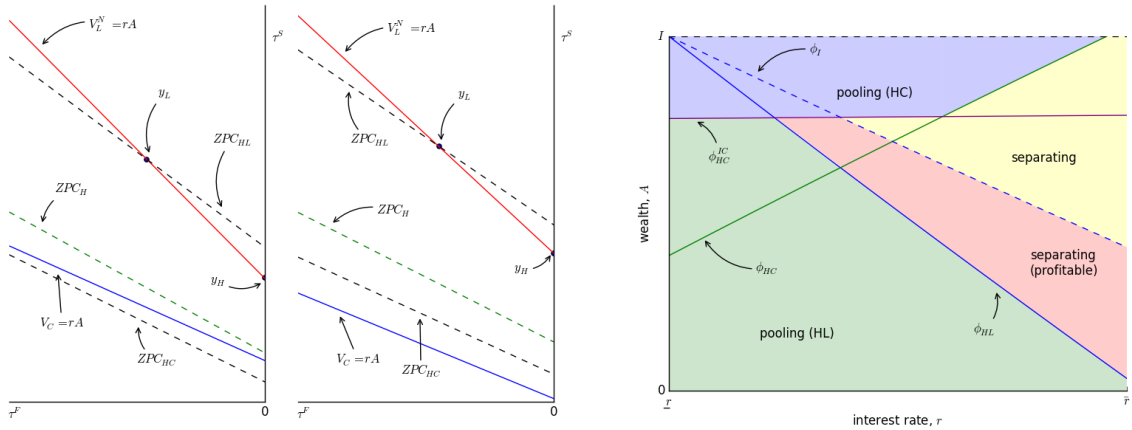
What are the terms of the profitable separating menu of contract? From Panel (a) of Figure A.10, the contract offered to the low ability agent (when neither the zero-profit separating contract nor a pooling contract can be offered) is given by the intersection of $V_L^N = rA$ and the zero-profit condition from a pooling exploration contract. Solving the

[26] Qualitatively, the only difference between the two panels is the relative position of the iso-payoff of the exploiter at the outside opportunity level rA and the zero-profit condition from an exploitation and exploration pooling contract.

[27] That the exploitation and exploration pooling contract is not incentive compatible in the left panel is not immediate from the graph, but it means that, given a contract on ZPC_{HC}, the indifference curve V_L^N passing through this contract is associated with a higher utility than the indifference curve V_C passing trough the same contract. This can be shown analytically.

[28] Moreover, Assumption C ensures that the participation constraint is satisfied.

[29] Alternatively, one could follow Inci (2013) by enlarging the set of feasible contracts that the bank can offer and imposing a Bertrand-Wilson equilibrium concept. Banks would be willing to offer contracts to low ability depositors on which they make a loss, and this would exactly compensate the positive profits they make with high ability entrepreneurs: profits would be driven to zero.



(a) Profitable Separating

(b) Contracts Offered

Figure A.10: Contracts offered

corresponding system of equations,

$$\begin{cases} Y\left(q_L + q_L q_L^S + p - q_L p\right) - q_L \tau^S - \left(1 - q_L\right)\tau^F = rA \\ \tau^S = \frac{r(I-A)}{\bar{q}_{HL}} - \frac{1-\bar{q}_{HL}}{\bar{q}_{HL}}\tau^F, \end{cases}$$

reveals that the contract offered to the low ability agent, y_L, is

$$y_L(A,r) = \begin{bmatrix} \frac{r(1-q_L)}{\bar{q}_{HL}-q_L} I - \frac{\left(q_L+q_L q_L^S+p-q_L p\right)(1-q_L)}{\bar{q}_{HL}-q_L} Y - rA \\ -\frac{rq_L}{\bar{q}_{HL}-q_L} I + \frac{\left(q_L+q_L q_L^S+p-q_L p\right)\bar{q}_{HL}}{\bar{q}_{HL}-q_L} Y - rA \end{bmatrix}^T.$$

The terms of the contract offered to the high ability agents, y_H, are derived by the intersection of $V_L^N = rA$ with the vertical axis, $\tau^F = 0$, i.e.

$$y_H(A,r) = \begin{bmatrix} \dfrac{Y\left(q_L + q_L q_L^S + p - q_L p\right) - rA}{q_L} & 0 \end{bmatrix}.$$

The high ability agent's expected utility associated with this contract is

$$Y\left(q_H + q_H q_H^S + p - q_H p\right) - \frac{q_H}{q_L}\left[Y\left(q_L + q_L q_L^S + p - q_L p\right) - rA\right]. \tag{A.13}$$

Assumption C ensures that high ability agents prefer this contract to investing. Setting Equation A.13 equal to $Y\left(q_H + q_H q_H^S + p - q_H p\right) - \hat{r} q_H \left(I - A\right)$ and solving for $\hat{r}$ reveals

that the interest rate on this contract is

$$\hat{r} = \frac{Y\left(q_H + q_H q_H^S + p - q_H p\right) - rA}{q_L\left(I - A\right)}.$$

This completes the set of contracts offered by the banks, as summarised in Panel (b) of Figure A.10. We now turn our attention to the agents' decisions.

A.2 Proof of Proposition 2

We now consider the agent's decision given that banks offer one of the pooling contracts above. An untalented individual with wealth A has three options: she can become an investor, she can become an exploiter, or she can become an explorer. Panel (b) of Figure A.8 above gave us the preferred option for each r and A combination.

Likewise, a talented individual with wealth A has four options: (a) she can become an investor, (b) she can become an exploiter, (c) she can become a shirking explorer, or (d) she can become an explorer who exerts effort. By Assumption C, effortful exploration is always preferred to exploitation, and pooling with low ability exploiters is always preferred to investing.[30] A shirking high ability agent is no different from a low ability agent, and thus the analysis is the same as above. In addition to those conditions, effortful exploration is preferred to shirking if

$$A \geq I - \frac{\bar{q}_{HL}}{r(q_H - q_L)}\left\{\left[q_H q_H^S - q_L q_L^S + (1-p)(q_H - q_L)\right]Y - e\right\} =: \phi_{HL}^H(r) \tag{A.14a}$$

$$A \geq I - \frac{\bar{q}_{HC}}{r(q_H - q_L)}\left\{\left[q_H q_H^S - q_L q_L^S + (1-p)(q_H - q_L)\right]Y - e\right\} =: \phi_{HC}^H(r) \tag{A.14b}$$

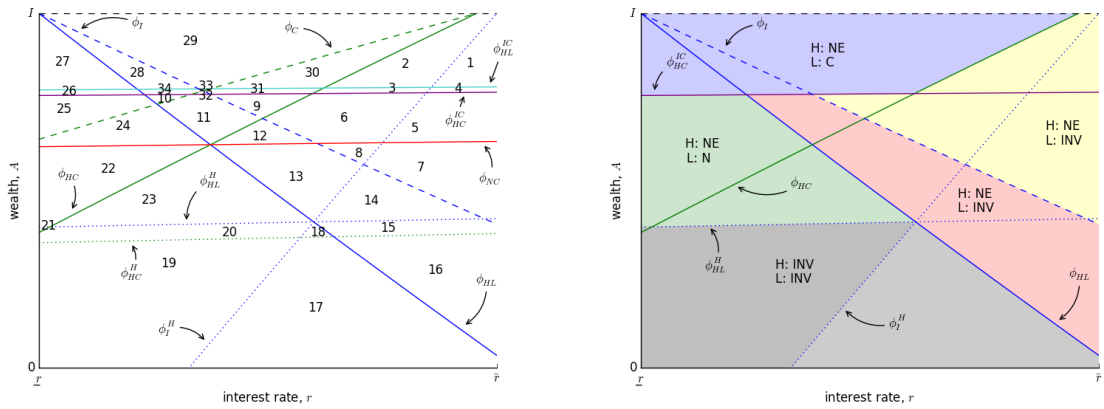
and to investing if

$$A > \frac{q_H}{q_H - \bar{q}_{HL}} I - \frac{\bar{q}_{HL}}{r(q_H - \bar{q}_{HL})}\left[\left(q_H + q_H q_H^S + p - q_H p\right)Y - e\right] =: \phi_I^H(r). \tag{A.15}$$

Panel (a) of Figure A.11 summarises all participation and incentive compatibility constraints in the (r, A) space. This allows us to complement the analysis regarding the banks' problem by adding the decisions of the agents.

In the areas (1)-(9), banks offer the zero-profit separating exploration contract to high ability agents, high ability agents accept it and exert effort, whereas low ability agents prefer investing. In the areas (10)-(16), the profitable separating exploration contract is offered, high ability agents accept it and exert effort, whereas low ability agents become investors. In the areas (17)-(18), only the pooling exploration contract can be offered,

[30] Indeed, effortful exploration is preferred to exploitation if the wealth level is lower than $I + \bar{q}\left[\left(q_H + q_H q_H^S - q_H p - p\right)Y - e\right]\left[r(p - q_H)\right]^{-1}$, for $\bar{q} = \{q_{HL}, q_{HC}\}$. Effort-exerting high ability explorers prefer to pool with low ability exploiters to investing if A is lower than $\left[r(\bar{q}_{HC} - q_H)\right]^{-1}\left\{-q_H r I + \bar{q}_{HC}\left[\left(q_H + q_H q_H^S + p - q_H p\right)Y - e\right]\right\}$. Both conditions are always satisfied given Assumption C.



(a) All Conditions

(b) Relevant Conditions

Figure A.11: Occupational choices

Notes. INV stands for investing, C for setting up a conventional firm, N for untalented exploration, and NE for effortful exploration.

but this does not satisfy the participation constraint of the high ability agents, who thus decide to become investors. Low ability agents do not explore because they would be identified as low ability, and thus they prefer to invest. In the areas (19)-(21), the pooling exploration contract is offered, but high ability agents do not exert effort. Therefore, they are no different from low ability agents and bank, to break even, must ask for the interest rate consistent with the low ability applicants. Thus, all agents prefer to invest. In the areas (22)-(25), the pooling exploration contract is offered, high ability agents exert effort and low ability agents become explorers. In the areas (26)-(34), the exploitation and exploration pooling contract is offered, high ability agents exert effort and low ability agents become exploiters.

These insights are summarised in Panel (b) of Figure A.11. In the yellow area, the zero-profit separating exploration contract is offered by the banks, high ability agents accept it and exert effort, whereas low ability agents become investors. Similarly, in the red area, low ability agents become investors, and high ability agents become effort-exerting explorers, but banks make positive profits. In the grey area, only the pooling exploration contract can be offered, but high ability agents do not become explorers either because they do not want to (light-grey area), or because they are unwilling to provide effort (dark-grey area): everyone would be treated as a low ability agent by the banks, and thus all agents prefer to become investors given Assumption B. In the green area, the pooling exploration contract is offered, high ability agents provide effort and low ability agents become explorers. Finally, in the blue area, low ability agents become exploiters and high ability agents become effort-exerting explorers, thanks to the pooling exploration and exploitation contract.

While in the main text we focused on the relevant situation for our application, here

we quickly go through all possible equilibrium scenarios. See Figure A.12.

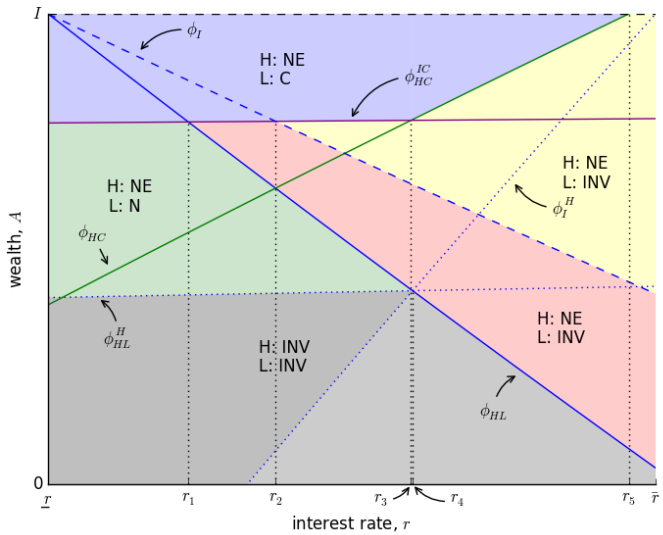


Figure A.12: Occupational choices and wealth classes

Up to the risk-free interest rate r_1 (defined by $\phi_{HL} = \phi_{HC}^{IC}$), there are only three wealth classes: a lower-class where everyone become an investor, a (lower) middle-class where high ability agents exert effort and cross-subsidise low ability explorers, and an upper-class where low ability agents become exploiters who cross-subsidise the high ability effort-exerting explorers. Since ϕ_{HL}^H is strictly increasing in r, the number of entrepreneurs decreases as we increase the risk-free interest rate in $[r, r_1]$.

Between r_1 and r_2 (defined by $\phi_I = \phi_{HC}^{IC}$), we have four wealth classes, since (part of) the upper middle-class shows up, where low ability agents become investors and banks make positive profits on the effortful exploration contract accepted by the high ability agents. The number of entrepreneurs is strictly decreasing in the interest rate both because ϕ_{HL}^H is strictly increasing in r and because the richest low ability agents (that were previously lower middle-class and are now middle middle-class) switch from entrepreneurship to investing.

The case analysed in the text is the one where the interest rate is between r_2 and r_3 (defined by $\phi_{HC} = \phi_{HC}^{IC}$). The number of entrepreneurs is still strictly decreasing in r since ϕ_{HL}^H is strictly increasing in r (and thus agents move from the lower middle-class to the lower-class where they become investors), ϕ_{HL} is strictly decreasing in r (more and more agents move from the lower middle-class to the middle middle-class where low ability agents become investors), and ϕ_{HC}^{IC} is strictly increasing in r (the upper-class shrinks in favour of the newly formed upper middle-class, and thus the poorest low ability agents of the upper-class move from non-innovative entrepreneurship to investing). For interest rates between r_3 and r_4 (defined by $\phi_{HL} = \phi_{HL}^H$), the case is similar to the previous one,

with the difference that ϕ_{HC} is steeper than ϕ_{HC}^{IC} and thus the number of entrepreneurs decreases even faster as r increases.

For interest rates between r_4 and r_5 (defined by $\phi_{HC} = I$), the lower middle-class disappears. Since ϕ_{HL} is strictly decreasing in r, the richest members of the lower-class start entering the (upper) middle-class, and thus the number of entrepreneurs increases. However, since ϕ_{HC} is strictly increasing in r, the poorest members of the upper-class enter the upper middle-class, pushing the number of entrepreneurs down. Which of these two effects dominates depends on the wealth distribution.

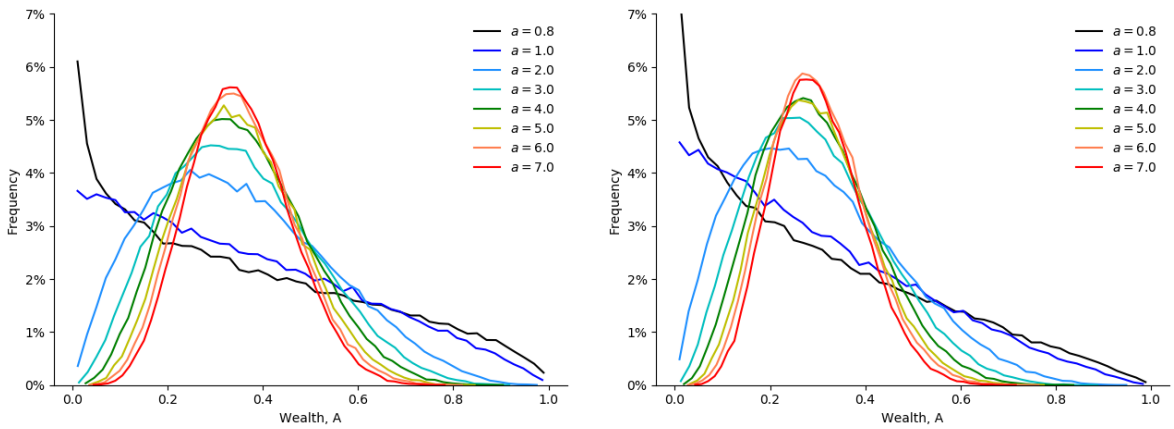
Finally, for interest rates above r_5, the upper-class disappears. The number of entrepreneurs is strictly increasing in r as the lower-class shrinks.

To summarise, the number of entrepreneurs is strictly decreasing in r up to r_4, it is potentially non-monotonic between r_4 and r_5, and strictly increasing above r_5. Thus, depending on the wealth distribution (and parameters), we could have multiple equilibria. If we restrict our attention to interest rates below r_4, the equilibrium, if it exists, is unique.

B Additional Quantitative Illustrations

This section presents supporting figures to our illustrations and additional quantitative illustrations using different wealth distributions.

B.1 Sample distributions



(a) $\bar{A} = 0.35$ (b) $\bar{A} = 0.30$

Figure B.13: Some sample distributions

Notes. Each line represents the empirical distribution function of a sample. Each sample comes from a Beta distribution with different shape parameters a and $b = a/\bar{A} - a$.

B.2 Other Distributions

Pareto (1897) started the quest for a functional form approximating the observed distributions of wealth and income, and suggested a power law. Whereas the so-called Pareto law is still considered as the parametric model of the rich (Clementi and Gallegati, 2016), the lognormal distribution is often used to described the bulk of income and wealth distribution (e.g Gini, 1921; Gibrat, 1931; Aitchinson and Brown, 1957; Chatterjee et al., 2005). For a review of the literature estimating wealth and income distributions, see Kleiber and Kotz (2003) and Clementi and Gallegati (2016, Chapter 2).

In Table 3, we present equilibrium results under different functional form and parametrisation; sample distributions are shown in Figure B.14, where dashed lines are threshold levels for the different wealth classes.

Table 3: Additional illustrations

cdf par	U	MPC	MPS1	MPS2	β 0.735	β 0.525	LN (0, 4)	LN (0, 8)	LN (1.75, 8)	LN (0, 12)
$\bar{A}$	0.500	0.500	0.500	0.500	0.500	0.500	0.433	0.329	0.433	0.286
Gini	0.333	0.316	0.366	0.399	0.366	0.399	0.355	0.466	0.371	0.521
ϕ_{HL}^{H}	0.335	0.335	0.331	0.332	0.335	0.335	0.334	0.332	0.334	0.331
ϕ_{HL}	0.361	0.342	0.507	0.462	0.363	0.369	0.393	0.459	0.401	0.492
ϕ_{I}	0.606	0.594	0.696	0.668	0.607	0.611	0.626	0.666	0.631	0.687
ϕ_{HC}^{IC}	0.774	0.774	0.773	0.773	0.774	0.774	0.774	0.773	0.774	0.773
$r^{\star}$	1.486	1.487	1.477	1.480	1.486	1.486	1.484	1.480	1.483	1.478
E_{H}^{N}	0.401	0.417	0.350	0.331	0.383	0.366	0.344	0.244	0.342	0.206
E_{L}^{N}	0.010	0.002	0.036	0.016	0.010	0.009	0.030	0.045	0.029	0.045
E^{C}	0.089	0.081	0.114	0.153	0.107	0.125	0.059	0.040	0.062	0.035
$E^{\star}$	0.500	0.500	0.500	0.500	0.500	0.500	0.433	0.329	0.433	0.286

Notes. U represents a uniform distribution. MPC is a mean-preserving contraction of the uniform: 28% of the population has wealth uniformly distributed between $[I/2.5, 1.5I/2.5]$, while the remaining 72% is uniformly distributed in the tails. MPS1 and MPS2 are mean-preserving spreads of the uniform: in MPS1, 16% of the population has wealth uniformly distributed between $[I/3, I2/3]$, and in MPS2, 16% of the population has wealth between $[I/4, I3/4]$; the remaining 84% is uniformly distributed in the tails. Beta distributions are symmetric, with both shape parameters equal to the number in the second line. LN stands for truncated lognormal distribution with (μ, s) given in the second line.

B.3 Observable Actions

In this section, we assume that banks can observe the choice between exploration and exploitation, in addition to the wealth of the agent and the outcome realizations (i.e. innovative talent is the only source of informational asymmetry).

We start with the banks' problem, by taking the risk-free interest rate, the effort decision, and the occupational choices of the agent as given. One can use the same logic as above to show that, if both types of agents choose exploration, there is no fully separating menu of exploration contracts for which the zero-profit conditions and the incentive compatibility constraints are all satisfied, as untalented agents would always prefer the contract designed for talented innovators. However, a zero-profit separating exploration contract can be offered to talented innovators if untalented agents prefer to invest (and this happens for $A \geq \phi_I$) or to explore, and this happens if[31]

$$A \geq I + \frac{\left(q_L + q_L q_L^S - p - q_L p\right) q_H}{r\left(q_H - q_L\right)} Y =: \phi_{CN}^{sep}(r).$$

Therefore, for $A \geq \min\left(\phi_I, \phi_{CN}^{sep}\right)$ the effortful exploration contract on the zero-profit

[31] We are considering an exploitation contract on the zero-profit condition that pays zero in case of failure (i.e. on the vertical axis). This is without loss of generality because any contract on the zero-profit condition is associated with the same expected payoff.

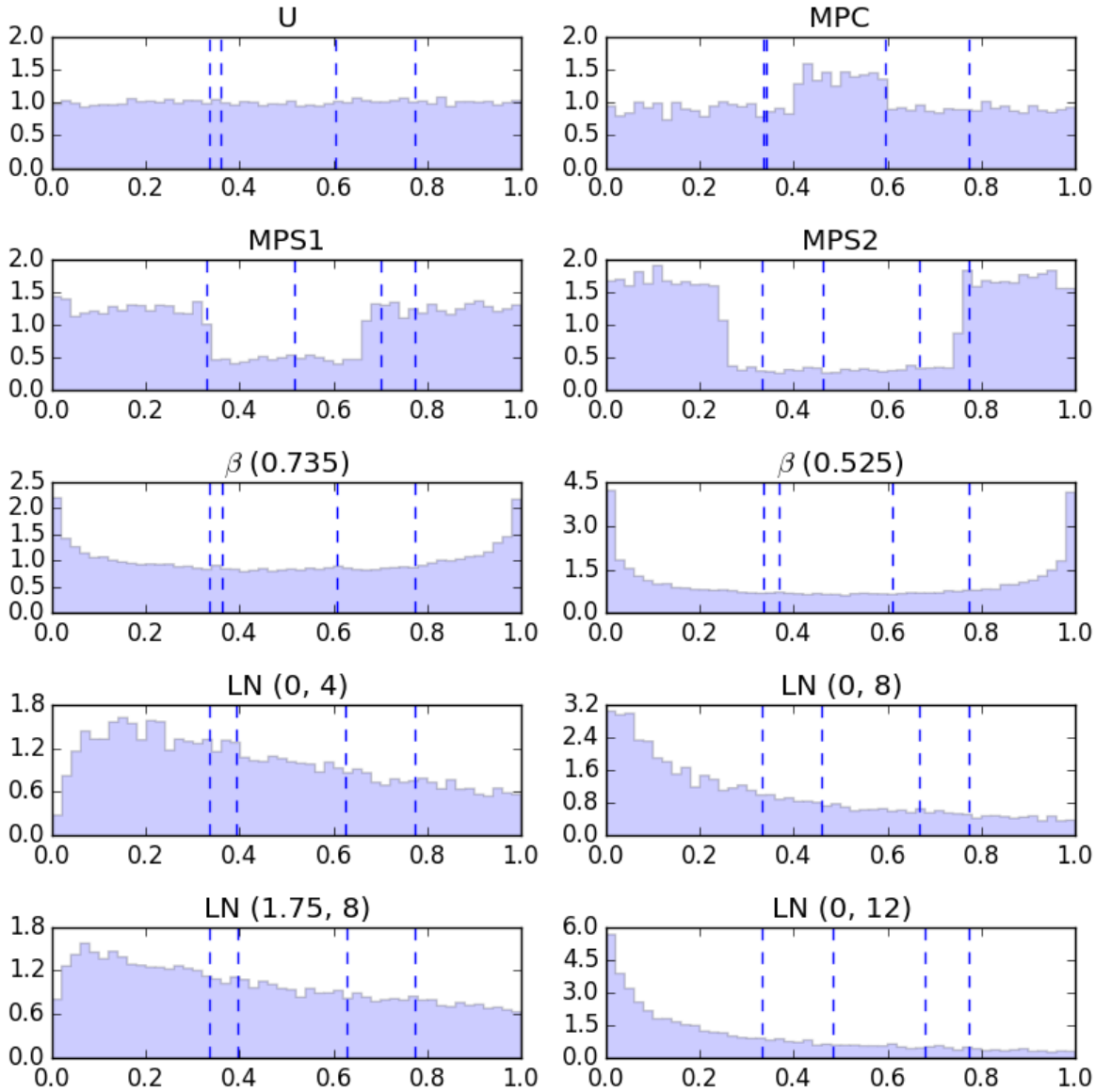


Figure B.14: Draws for different parametrisations

condition is incentive compatible. With regards to a pooling exploration contract, one can once again use the logic in the main text to show that a pooling exploration contract must be on the intersection of the zero-profit condition with both types and the vertical axis. The pooling exploration contract is not accepted by the untalented agent if $A \geq \phi_{HL}$ (as such agent prefers to invest) or if

$$A \geq I + \frac{\left(q_L + q_L q_L^S - p - q_L p\right) \bar{q}_{HL}}{r\left(\bar{q}_{HL} - q_L\right)} Y =: \phi_{CN}^{pool}(r)$$

(as such agent prefers to exploit). For certain wealth and risk-free interest rate combinations, neither the zero-profit separating exploration contract nor the pooling contract can be offered. Banks will thus offer a profitable separating contract to the talented agents (as in the main text); the terms of the contract are such that the untalented agent is indifferent between pretending to be talented and taking her preferred outside option (exploitation or investing). If the preferred outside option is exploitation, the exploration contract offered to the talented agent is

$$\left[\frac{r(I-A)}{q_L} - \frac{Y\left(-q_L - q_L q_L^S + p + q_L p\right)}{q_L} \qquad 0\right];$$

conversely, it is $y_H(A, r)$, as in Appendix A.[32] See Figure B.15.

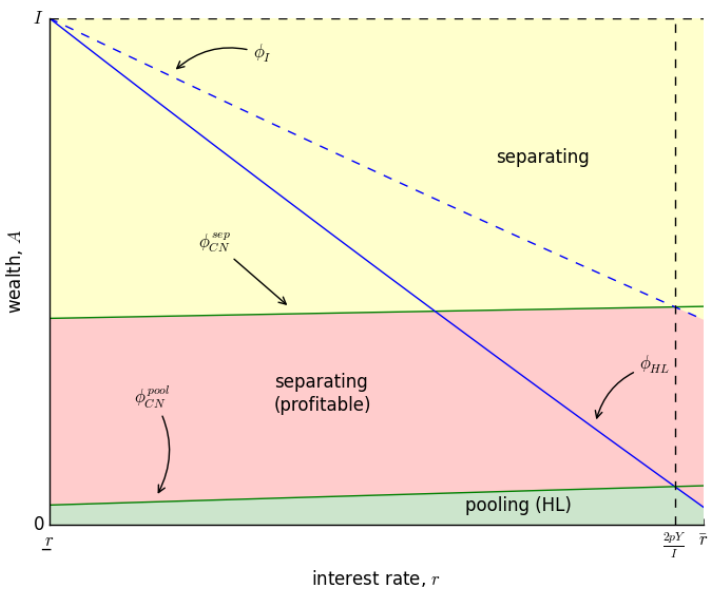


Figure B.15: Contracts offered with observable actions

We can now tackle the agent's problem. An untalented agent accepts the pooling exploration contract in the area where it is offered (if the talented agent exerts effort), whereas in the areas where a separating exploration contract is offered to the talented agent, the untalented agent exploits if $r < 2pY/I$ and invests otherwise. Conditional on a pooling exploration contract being offered, a talented agent prefers effortful exploration

[32] Whereas y_H respect the participation and incentive compatibility constraints of the talented agent, the same might not happen for the other profitable separating contract. If the talented agent does not accept the separating contract, one is left with non-existence. We assume that she does in this appendix.

to shirking if $A \geq \phi_{HL}^{H}$, to investing if $A > \phi_{I}^{H}$, and to exploiting if

$$A \geq I - \frac{\bar{q}_{HL}}{r\left(q_H - \bar{q}_{HL}\right)} \left\{ \left[q_H + q_H q_H^S - p - q_H p\right] Y - e \right\} =: \phi_{CH}(r).$$

Figure B.16 presents the partial equilibrium under observable actions: adverse selection into exploration is not a problem, and the only inefficiency arises from the poor class not being offered credit.

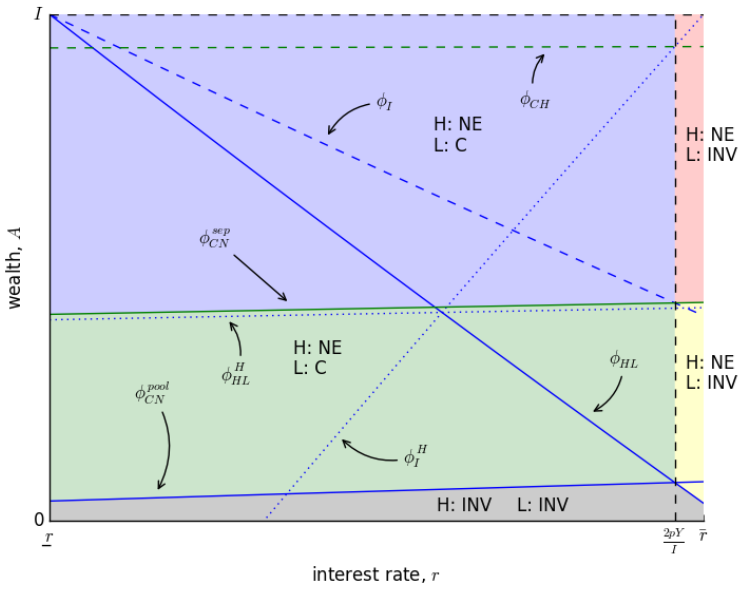


Figure B.16: Occupational choices and wealth classes with observable actions