Entrepreneurship turnover and endogenous returns to ability *

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August 30, 2007

Abstract

This paper proposes a model of entrepreneurial turnover highlighting a non-monotone relationship between technological change and ability-biased sorting into entrepreneurial types. Entrepreneurial decisions are examined in a two-stage model under uncertainty in which entrepreneurs decide to abandon a project and start a new venture depending on technological change and on ability. We show that technological change affects the quality distribution of entrepreneurship by increasing the ex-ante number of entrepreneurs undertaking the most efficient projects and decreasing the post-entry number of entrepreneurs of low-quality firms who choose to continue their initial business. A higher rate of technological change is therefore likely to induce a cleansing effect on entrepreneurial activity and to alter the market perception of business creation.

JEL Classification: O33. M13
Keywords: Entrepreneur entry and exit, Technological change, Selection, Stigma

*We thank the editor Stephen George Hall and an anonymous referee for their helpful suggestions on an earlier version of this paper. We also wish to thank Franklin Allen, Robert Solow, Christian At, Denis Gromb, David Musto, Laurent Vilanova and participants at the 2007 EARIE conference and the 2006 Public Economic Theory conference for their comments. Hind Sami gratefully acknowledges financial suppport from the Centre Cournot for Economic Studies through a Robert Solow Fellowship.

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1 Introduction

The creation of new businesses and the decline or market exit of less productive firms are often regarded key to business dynamism and economic growth in OECD countries. New firms play an important role as job creators and firm turnover allows reallocating resources from low to higher productivity units. In fact, the entry and exit of firms in fact accounts for approximately 30 % of total productivity growth in OECD countries (OECD, 2003). Yet, survival rates of new firms are strikingly low in many sectors. As documented by Scarpetta et al. (2002), only 30% to 40% of entering firms survive beyond the first two years of life. Explaining the start-up of new firms, their extremely diverse chances of survival and their different post-entry performance is therefore an important challenge for the understanding of entrepreneurship and growth.

Empirical evidence on business dynamics in Europe and in the US remains controversial but several stylized facts have reached a consensus in the recent past. First, at the *aggregate level* the rate of entrepreneurial activity is very different across OECD countries. In 2001 this rate varied from 7.2% in Europe (4.5% in Belgium, 7% in France, 7.5% in the UK, 12% in Ireland) to 12.2% in the US. Similarly, between 1995 and 2000, the annual average rate of new enterprise formation ranged from 6.5% in Denmark to 11.7% in France and 15.7% in Germany (European Commission, 2002). Second, at the *industry level* there are large differences across sectors. In particular, entry rates are very high in information and communication technology (ICT)-related industries (20% on average in computer-related service activities, which is two times higher than the entry rate in business services activities - see Brandt, 2004). In addition, entry and exit rates are highly correlated across industries suggesting that firm turnover is characterized by search and experimentation (Bartelsman et al., 2005; Santarelli and Vivarelli, 2006). Indeed, were firm turnover determined only by profit expectations (as a response to sub- or supra-normal profits), creation and destruction rates should be negatively correlated. In opposition, the observed correlation between entry and exit rates, together with high early failure rates, suggest that firm turnover is characterized by market churning and entry mistakes as hidden costs of exploring of entrepreneurial opportunities. Finally, at the *firm level* there exists a relationship between firms ex-ante characteristics and post-entry performance. In particular, the likelihood of new firms survival and post-entry performance tends to decrease with firm size and credit constraints and to increase with the technological environment and entrepreneur's education and human capital (Bates, 1990; Gimeno et al., 1997). Also, heterogeneity across entrepreneurial types is significant. Entrepreneurial ventures appear as a rather heterogeneous aggregate where innovative entrepreneurs meet passive followers, over-optimist gamblers and escapees from unemployment (Santarelli and Vivarelli, 2006).

In this paper we focus on two characteristics of business dynamics which seem to reach a consensus in the literature:

- Firm entry and exit exhibit strong heterogeneity and significant differences across countries, industries and entrepreneurs.
- New firm creation rests on a process of search and experimentation, with early failures, market churning and turbulence.

Many arguments have been developed in the literature to explain differences in entrepreneurship across countries: individual characteristics, institutional constraints (credit market frictions, administrative costs and barriers to entry), social environment (market's perception of failure), competition, technology and growth, business cycles, information asymmetry, corporate governance (for a recent comprehensive survey see Santarelli and Vivarelli, 2006). For Lazear (2002), the determinants of entrepreneurship lie in education as entrepreneurs are "jacks-of-all-trades who may not excel in any one skill, but are competent at many". Hence, individuals with experience of many different roles are more likely to become entrepreneurs (a positive effect between human capital and entrepreneurship is often observed in empirical studies, see e.g. Wagner, 2005). A less specialist and more versatile education should therefore help to spur the level of entrepreneurial activity. Yet, one may argue that the level of education alone does not provide a sufficient explanation of cross-country differences in entrepreneurial dynamism. Indeed, many more technology-intensive businesses are undertaken in the US compared to Europe[1], even though these economies have comparable levels of skills and human capital[2]. The determinants of cross-country differences in business dynamics are therefore more complex.

[1]According to Sapir et al. (2004), 50% of new pharmaceutical products are introduced by firms that are less than 10 years old in the United States, versus only 10% in Europe. Similarly, 12% of the largest US firms by market capitalisation at the end of the 1990s had been founded less than twenty years before, against only 4% in Europe, and the difference between US and European turnover rates is much bigger if one considers the top 500 firms.

[2]The labor force participation rates of individuals aged 25-64 with a tertiary level of education in 1998 was 86.3% in OECD countries, 87.7% in the US and 87.3% in European economies (OECD, 1999). Similarly, the average annual employment growth of high-skilled workers over the 1995-2001 period equals 2.79% both in the US and in Europe (OECD, 2004).

For Scarpetta et al. (2002), greater financing possibilities combined with low administrative and financial costs in the US are likely to stimulate entrepreneurs with innovative projects and capacities to start on a small scale and then expand rapidly if successful. In Europe on the contrary, high entry and adjustment costs may rather stimulate a pre-market selection of business plans with less market experimentation. This literature essentially explains firm turnover (ex-ante selection *versus* post-entry experimentation) by external barriers to entry. In turn, differences in business dynamism may stem from differences in credit and labor market conditions[3], institutional constraints such as administrative costs, protection of creditors rights or levels of law enforcement (see e.g. Rajan and Zingales, 1998; Bhattacharya and Chakraborty, 2004; Giannetti, 2003). Social interactions also matter in the decision to become an entrepreneur because they create social norms and affect reputation and tolerance toward failure (Landier, 2006; Gromb and Scharfstein, 2001). For example, career concerns can induce inefficient continuation of investments as entrepreneurs may be reluctant to abandon their initial project when this is perceived as recognizing an error was made thereby generating an adverse signal for ability (Boot, 1992; Holmstrom, 1999). Similarly, entrepreneur's failure may be highly stigmatized (implying a high cost of capital after failure) or considered as part of the learning process, leading to different types of entrepreneurial regimes and possibly too much or too little entrepreneurship in equilibrium (Landier, 2006; Gromb and Scharfstein, 2001).

Barriers to entry and institutional and social norms undeniably represent essential determinants of business dynamics in OECD countries[4]. However, the high variability of entry and exit rates across sectors and the within-industry correlation between entry and exit rates suggest that additional factors do matter for business creation and destruction. From this perspective, the literature on firm churning stresses the contribution of producer-level turnover to aggregate productivity growth. This approach proposes models of selection where industries are depicted as collections of heterogeneous-productivity producers and where productivity levels are linked to performance and survival in the industry (see Jovanovic, 1982; Ericson and Pakes, 1995; Melitz, 2003). In these models, low productivity firms are less likely

[3]In a different perspective, a growing literature considers the financing of new ventures through venture capital and focuses on the mechanisms behind financing arrangements such as the allocation of control rights and the staging of investments over time (Berglof (1994), Gompers (1995), Hellman (1998)). Here, our model abstracts from the details of venture capital financing and uses a simpler contracting model.

[4]According to Djankov et al. (2002), the start-up process may take up to 66 days and 16 different legal and administrative steps in France while requiring 7 days and 4 steps in the United States, and such differences are definitely likely to inhibit business creation (see Fonseca et al., 2001).

to survive than their more efficient counterparts creating productivity-survival link as a crucial driver of productivity growth. This literature provides a comprehensive analysis of firm within-industry reallocation and of the contribution of entry to aggregate productivity growth (see Foster, Haltiwanger, and Syverson, 2005). The present model explores a different but complementary mechanism to explain the links between entrepreneurs' selection or churning and productivity growth. We indeed assume that productivity gains of new firms are not equally higher (which is supported by empirical evidence on entry failures), and that such gains depend on the returns to entrepreneurial talent which depend themselves on technical change and credit conditions. In other words, the choice of creating a firm and the quality of the project developed depend on the level of entrepreneurial difficulty, which is driven by the rate of technological change and credit market conditions.

The idea that technical change complements ability in the returns to entrepreneurial activity is borrowed from the literature on skill-biased technical change (See Hornstein, Krusell and Violante, 2005 or Acemoglu, 2002 for excellent surveys[5]). Intuitively, when the technological environment is more turbulent, individual ability becomes more important in the returns to entrepreneurial creation compared to social capital. As in the literature on norms, institutions and entrepreneurship mentioned above, the firm' environment plays an important role in the likelihood of success. But here we focus on the firm's technological environment rather than institutional or social environment. In addition, we know from empirical evidence that new firms are not always the most productive and entry failures are numerous. We therefore allow for both heterogeneity in nascent businesses creation and new business projects implementation. Individual heterogeneity in business creation then leads to an endogenous sorting of individual to entrepreneurial types, depending on the level of technological change. In turn, we also let the rate of technical change depend on the quality of new projects, thereby creating a feedback mechanism between firm creation and destruction, credit market condition and endogenous growth.

More precisely, we propose a model in which entrepreneurs differ in their ability

[5]In this literature, the allocation of individuals over social positions (becoming an entrepreneur or a worker) would depend on the level of entrepreneurial difficulty which is driven by the rate of technological growth (see Hassler and Rodriguez-Mora, 2000). We extend this argument by considering that the attractiveness of entrepreneurial projects to talent depends on the return to ability-biased technical change, and more precisely on the complementarity between ability, technical change and credit conditions. Hence, we depart from this literature and analyze the determinants of the refinancing decision and the existence of an entrepreneurial selection mechanism. By focusing on the sorting of individuals to different ("nascent") entrepreneurial types, we highlight that the endogenous sorting of individuals to entrepreneurial types depends not only on the complementarity between ability and growth but also on credit market conditions captured through banks' interest rates.

to implement business enterprises and the rate of technological progress complements ability in the returns to entrepreneurial decisions. Two types of uncertain entrepreneurial projects may be chosen by individuals: a "high adaptative"(higher quality) project, suited for entrepreneurs able to take correct decisions in rapidly changing environments, and a "low adaptative"(lower quality) project, suited for lower levels of ability to run efficiently projects in changing environments. Projects last for two stages, a research (experimentation) stage and a development stage. The success of the research venture is determined both by the entrepreneur's ability and by the technological environment. We show that the experimentation phase whereby firms may decide to either continue or liquidate and start a new project, leads to a cleansing effect on business creation. Our model therefore implies both pre-entry selection in the choice of the project and post-entry experimentation during the refinancing decision. In addition, both types of decisions depend on the complementarity between individual ability, the technical environment and the cost of capital. This leads to heterogeneity in start-up financing of small and innovative firms and different levels of entrepreneurial activity across countries. The remainder of the paper is organized as follows. Section **??** presents the basic set up. Section **??** describes the research and development stages. Section **??** and **??** examine the equilibrium and main results of the model. Section **??** concludes.

2 Basic set up

2.1 Overview

The model has three dates, t=0,1,2. All agents are risk neutral and the risk-free interest rate is normalized to zero. There is no discounting. The economy is composed of a continuum of entrepreneurs and investors. Projects last for two periods: the first period is a research stage in which entrepreneurs implement their business idea, the second period is a development stage in which production takes place.
At date 0, entrepreneurs are endowed with one research project each and lack any source of finance. Bankers are endowed with plenty of funds but are short of research ideas.
At date 1, after observing privately the business's probability of success, entrepreneurs decide to either continue the existing business or liquidate it and ask for a refinancing to start a new one. Banks decide whether to grant a new loan to second timers entrepreneurs and set interest rates. At the end of the second period, cash flows and repayments are realized.

The sequence of events may be summarized as follows:

- $t = 0$:

  Entrepreneurs ask for loans
  Entrepreneurs choose between two types (qualities) of business creation
  Banks set interest rates
  Business's probability of success is private information to entrepreneurs

- $t = 1$:

  Entrepreneurs choose whether to continue their initial business or liquidate it and start a new one
  Banks decide to refinance the entrepreneur or not

- $t = 2$: Cash flows and repayments are realized

2.2 Contractual variables

In the research stage, the decision to become an entrepreneur implies to choose among two types of firms or projects: a "high-adaptative" (high quality - type H) or a "low-adaptative" (low quality - type L) firm. In the type H firm, entrepreneurs can spread their ability advantage in the sense that adaptativity to technological environment (and therefore the firm's returns) increases with individual ability. In type L firms, entrepreneurs have to spend time learning and adapting to complexity. This learning process increases the firm's returns, but reduces available time for running it and therefore decreases the probability of success of the business which is discovered at the end of the research stage.
In the development stage, a final good is produced using two different types of intermediate goods: goods produced by continued firms (labelled $j = c$) and goods produced by refinanced firms (labelled $j = r$). Hence, we denote the inputs in the production of intermediate goods as "refinanced firms' goods" and "continued firms' goods".

The financing contract between the entrepreneur and the investor, which is signed at date 0, specifies an initial investment for the research venture of \$1, generates a cash flow V_j and final repayment R_j at date 2 ($j = c, r$)[6].

[6] The financing contract can be interpreted as debt or equity. Under risk neutrality, a null transfer in case of termination is not restrictive. Since the abandoned project has a zero reservation value, whether the investor can seize it or not is irrelevant.

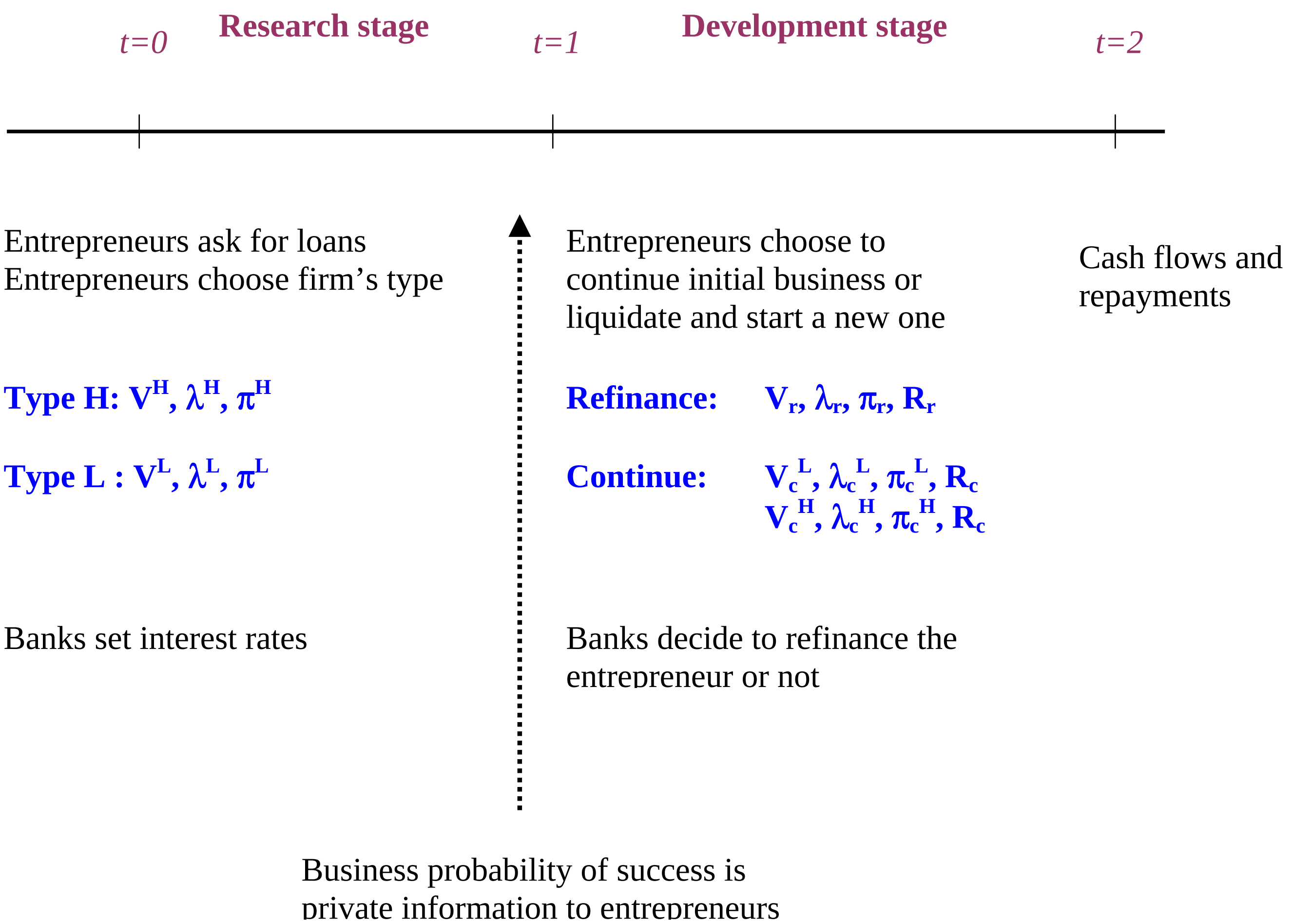
Each entrepreneur can run only one business at a time. At date 1, after observing privately the business's probability of success, entrepreneurs choose whether to continue the initial business ($j = c$) or liquidate it and ask for a refinancing to start a new business ($j = r$)[7]. In this case, the initial business is terminated and its liquidation value is normalized to zero. The new business again requires an initial investment of \$1 and yields a cash flow of V_j at date 2. Hence, the new business becomes a one-period project. Banks decide whether to grant a new loan to second timers entrepreneurs at an interest rate of R_r.

If the business is abandoned or generates no cash flow at date 2, the repayment to the bank is 0. We thus assume that the entrepreneur is liable for payments to the lender only to the extent of current revenues. Therefore, the firm is restricted to a nonnegative cash flow. Hence, we only need to characterize the repayment for the first-timers (those who carry on the initial project until date 2) and second-timers (entrepreneurs who abandon the first business and start again at date 1), R_c and R_r. We assume that at date 0, the average project has a positive net present value[8].

The following figure reproduces the timing and the variables of the model. In the research stage, if we denote by θ the firm's type, $\theta = H, L$, the expected value of a firm, entrepreneurial payoffs and probabilities of success are denoted respectively as V^θ, λ^θ and π^θ, $\theta = H, L$. In the development stage, entrepreneurs choose to continue the initial business or abandon it and ask for a refinancing to start a new one. The firm's expected values, entrepreneurial payoffs and probabilities of success are denoted as V_c^θ, λ_c^θ and π_c^θ, $\theta = H, L$, for continued businesses and as V_r, λ_r and π_r for refinanced businesses.

[7] At date 1, banks can distinguish between new entrants and failed entrepreneurs who are willing to start a new business. We thus omit news entrepreneurs applying for a loan at the beginning of the second period.

[8] Formally, see assumption 3 below .



t=0
Research stage
t=1
Development stage
t=2
Entrepreneurs ask for loans
Entrepreneurs choose firm's type
Type H: V^H, λ^H, π^H
Type L : V^L, λ^L, π^L
Banks set interest rates
Entrepreneurs choose to continue initial business or liquidate and start a new one
Refinance: $V_r, \lambda_r, \pi_r, R_r$
Continue: $V_c^L, \lambda_c^L, \pi_c^L, R_c$
$V_c^H, \lambda_c^H, \pi_c^H, R_c$
Banks decide to refinance the entrepreneur or not
Cash flows and repayments
Business probability of success is private information to entrepreneurs

3 The research and development stages

3.1 The research stage

At date 0, there is a continuum of mass one of wealthless entrepreneurs who may create "high-adaptative" (type H) or "low-adaptative" (type L) firms. The complementarity between ability and technology in the individuals' decision to become entrepreneurs of type H or type L firms relies on the idea that basic skills become rapidly obsolete in a rapidly changing environment. The most able individuals indeed have a comparative advantage in choosing to become an entrepreneur of type H firms from too perspectives. On the one hand, having marginal greater ability is rewarded in a type H firm, even in a stationary environment (where the rate of technological progress is constant) whereas learning and adapting to new environments is rewarded in type L firms only when growth improves and provided that time is spent to "absorb" new technologies. On the other hand, technological progress exerts an erosion effect on the probability of success of a type L firm whereas it does not affect that of a type H firm.
In other words, we propose a model of "nascent "entrepreneurship (i.e. the entrepreneurs who are currently taking explicit steps to start a new business) in which individuals make the choice of creating a new venture and, as in Lazear's view of jack-of-all-trades, those who have sufficient knowledge in a variety of areas to put together the many ingredients needed for survival and success in a business will choose a type H firm, while those who have not these skills will choose to create a type L firm in which they will not be able to spread their ability advantage[9].

The firm's expected value V^θ depends on the ex ante continuation value V_c (in case of refinancing) and on the entrepreneur's adaptative capacity[10]

ρ^θ:

$$V^\theta = V_c \cdot \rho^\theta, \quad \theta = H, L$$

and **the entrepreneur's expected payoff** is defined as:

[9]Our definition of nascent entrepreneurship focuses on the ability to adapt to a changing environment but a more complete theory would encompass more individual characteristics like for example risk-aversion, previous employment status, regional characteristics or gender. Since we focus on the interplay between ability, technical change and credit condition, we rely on a more reduced-form to characterize entrepreneurship.

[10]This formulation may be related to the literature on entrepreneurial choices that dates back to Lucas (1978) or more recently Jovanovic (1994). In its most basic exposition, individuals are confronted with a choice of earning their income either from wages earned through employment in an incumbent firm or else from profits accrued by starting a new firm.

$$\pi^\theta = \lambda^\theta \cdot V^\theta, \quad \theta = H, L$$

where λ^θ denotes the probability of success of the current business, which is discovered privately by the entrepreneur after setting up the firm but before date 1. This probability represents a measure of the project's survival rate.

Type H firms are run by entrepreneurs able to make difficult decisions in complex environments. They adapt instantaneously to new environments and the time needed to learn new technologies is null. Their adaptative capacity depends only on their individual ability: $\rho^H = h(a_i)$ with $0 < h(a_i) < 1$, $h'(a_i) > 0$, and where the entrepreneur's ability a_i is distributed uniformly over the unit interval[11]. A type H firm's expected value is then defined as:

$$V^H = V_c \cdot h(a_i)$$

In type H firms, the most able individuals have the highest adaptative capacity whatever the rate of technological progress, the time needed to adapt to new technologies is null and the entrepreneur's available time is entirely devoted to run the firm. *The probability of success* of a type H firm is constant and defined by $\lambda^H = \lambda$, where $0 < \lambda < 1$. This assumption captures the idea that in type H firm, having marginally greater ability is rewarding, and that others factors such as luck or the technological environment do not affect the probability of success and survival on the market.

Definition 1. Rate of technical change The rate of technical change is denoted by γ where $0 < \gamma < 1$.

In type L firms, entrepreneurs do not have the same competence to take correct decision in rapidly changing environments and learning is necessary to adapt to the technological environment. We assume that the learning process involves an opportunity cost such that the higher the rate of technological progress γ, the higher the time spent learning the new environment, therefore the higher the adaptative capacity of type L entrepreneurs, but the lower the time remaining for running efficiently the project. We normalize entrepreneurs' time to 1, so that in L type firms, a fraction $\delta \cdot \gamma$ of this time is devoted to adapt to new technologies and the remaining fraction $1 - \delta\gamma$ is devoted to run the project. Given that the rate of technical change γ is such that $0 < \gamma < 1$, then the following restriction is imposed on the parameter δ:

[11]Qualitative results are not affected by a more general distribution function for ability as long as it is continuous.

Assumption 1. $0 < \delta\gamma < 1$

The adaptative capacity of entrepreneurs running type L firms is proportional to the rate of technological progress γ as follows: $\rho^L = \delta \cdot \gamma$. The firm's expected value then is defined as:

$$V^L = V_c \cdot \delta\gamma$$

In type L firms, entrepreneurs must spend time to learn and adapt to changing environments and the marginal return to ability is null. The higher the time spent learning, the higher the adaptativity, but the lower the time available for running the firm $(1 - \delta\gamma)$. In turn, *the probability of success* of type L firm is given by $\lambda^L = \lambda \cdot (1 - \delta\gamma)$. Hence, there is an erosion effect due to technological progress for type L firms which affects the business's probability of success (or survival).

We assume that the average project has a positive net present value:

Assumption 2. Project's positive net present value: $\lambda \cdot (2 - \delta\gamma) \cdot V^\theta > 1$

In sum, expected entrepreneurial payoffs are given by:

$$\pi^L(a_i) = \lambda \cdot (1 - \delta\gamma) \cdot \delta\gamma \cdot V_c \quad (1)$$

$$\pi^H(a_i) = \lambda \cdot h(a_i) \cdot V_c \quad (2)$$

At date 0, given the above expected payoffs, entrepreneurs choose to engage in a type H firm rather than in a type L firm if and only if, given their ability and the rate of technological progress, the expected payoff from running a type H firm is higher than the expected payoff from running a type L firm, that is:

$$\pi^H(a_i) \geq \pi^L(a_i) \Longleftrightarrow \lambda \cdot h(a_i) \cdot V_c \geq \lambda \cdot (1 - \delta\gamma) \cdot \delta\gamma \cdot V_c$$

Given that $0 < \lambda < 1$ and $0 < \delta \cdot \gamma < 1$, this inequality implies that there is a unique threshold level of ability, a^*, such that $0 < a^* < 1$. All individuals with ability above the threshold, a^* choose to run type H firm, while all individuals with ability below a^* run type L firms: $\pi^H(a^*)) \geq \pi^L(a^*))$, where:

$$a^* = h^{-1}(\delta\gamma(1 - \delta\gamma)) \quad (3)$$

Since the population mass is normalized to one and ability uniformly distributed over the unit interval, the number of type L entrepreneurs is a^* and the number of type H entrepreneurs is $1 - a^*$. Since function $h(.)$ is continuous and strictly increasing, the inverse function h^{-1} is also continuous and strictly increasing.

3.2 The development stage

At date 1, entrepreneurs choose whether to continue their initial business ($j = c$) or liquidate it and start a new one ($j = r$). Banks decide to refinance the entrepreneur or not.

We consider that the probability of success for refinanced firms is the same independently of firms' initial types. In other words, refinanced firms are closed down and a new business starts. Hence, the entrepreneur generates the same level of output whatever his ability. The probability that the business succeeds determines the distribution of payoffs that are generated at date 2. At this date, conditional on success, each entrepreneur running a firm of type θ will receive a net cash flow of $\pi_j^\theta = \lambda_j^\theta \cdot (V_j - R_j)$ where R_j and V_j represent the repayment to the bank and the value of each type of business. If the business is abandoned or fails at date 2, no repayments are made to the bank. The nonnegativity constraint on entrepreneur's cash flows requires the following assumption:

Assumption 3. Non-negative cash flows: $V_j \geq R_j$, $j = c, r$

The probabilities of success of each type of business enterprises are labelled λ_r for a refinanced firm, λ_c^H for a continuing firm of type H and λ_c^L for a continuing firm of type L. We assume that $\lambda_r = \lambda_c^L \cdot \kappa$, with $\kappa \leq 1$. Hence we have:

$$\lambda_c^H = \lambda > \lambda_c^L \geq \lambda_r \tag{4}$$

The expected payoff for each type of entrepreneur then writes:

$$\pi_c^H = \lambda_c^H \cdot (V_c - R_c), \quad \pi_c^L = \lambda_c^L \cdot (V_c - R_c), \quad \pi_r = \lambda_r \cdot (V_r - R_r) \tag{5}$$

with R_j and V_j the interest rates and the firms' values. We assume that a continued project has a positive net present value:

Assumption 4. Continued project's positive net present value:

$$(\lambda_c^H + \lambda_c^L)V_c > 1$$

After substituting for π_c and π_r from equations (**??**) and (**??**) in appendix (**??**), entrepreneurial payoffs from running each type of firm are given by:

$$\pi_c^H = \lambda_c^H \frac{1-\alpha}{\alpha} \cdot x_c - \lambda_c^H \cdot R_c \quad (6)$$

$$\pi_c^L = \lambda_c^L \frac{1-\alpha}{\alpha} \cdot x_c - \lambda_c^L \cdot R_c \quad (7)$$

$$\pi_r = \lambda_r \frac{\alpha}{1-\alpha} \cdot x_r - \lambda_r \cdot R_r \quad (8)$$

4 Equilibrium

4.1 Resources constraints

Firms differ in their type (H or L) and at date 1 and we can thus distinguish three categories of firms: those that need a refinancing, firms of type L that are continued and firms of type H that are continued. The population mass is normalized to one, there is a proportion $1 - a^*$ of type H entrepreneurs. We denote by H_c (respectively L_c) the fraction of entrepreneurs with type H (respectively type L) who continue their business. Since the number of entrepreneurs is normalized to 1, the resources constraints write:

$$n_c^H + n_c^L + n_r \equiv 1 \quad with \quad \begin{cases} n_c^H = (1-a^*) \cdot H_c \\ n_c^L = a^* \cdot L_c \\ n_r = (1-a^*) \cdot (1-H_c) + a^* \cdot (1-L_c) \end{cases} \quad (9)$$

where n_c^H (respectively n_c^L) is the number of type H (respectively type L) firms that are continued and n_r is the number of firms that are refinanced.

4.2 Refinancing decisions

We consider a first-time entrepreneur's decision to continue or abandon his initial business at date 1. An equilibrium is determined by the strategy (continuation or abandon) of a first-time entrepreneur who observes the probability of success of his current business and by the cost of capital, R_c and R_r for first-timers and second-timers. Entrepreneurs of type L choose to continue their business as long as the expected income, π_c^L, is higher than that of a refinanced firm, π_r. In equilibrium, this condition is binding, implying that the number of entrepreneurs of type L who choose to continue their business satisfies the following indifference condition: $\pi_c^L = \pi_r$. Regarding entrepreneurs of type H, the assumption that $\lambda_c^H > \lambda_c^L$ implies that $\pi_c^H > \pi_c^L$.

Refinancing decisions in turn satisfy the following rule:

$$\pi_c^H > \pi_c^L = \pi_r \tag{10}$$

This rule implies that, all firms of type H choose to continue and firms of type L are indifferent between continuing or refinancing, that is:

$$H_c = 1 \tag{11}$$

$$\pi_c^L = \pi_r \Longleftrightarrow \lambda_c^L \frac{1-\alpha}{\alpha} \cdot x_c - \lambda_c^L \cdot R_c = \lambda_r \frac{\alpha}{1-\alpha} \cdot x_r - \lambda_r \cdot R_r \tag{12}$$

Taking into account the resources constraints (**??**), the market clearing condition writes:

$$x_c = \lambda_c^H n_c^H + \lambda_c^L n_c^L, \quad x_r = \lambda_r n_r \tag{13}$$

Substituting for (**??**) into (**??**) finally allows determining the number L_c of firms of type L that choose to continue:

$$\Leftrightarrow L_c = \frac{\frac{\alpha}{1-\alpha}\kappa^2 + \frac{a^*-1}{a^*}\frac{1}{1-\delta\gamma}\frac{1-\alpha}{\alpha} + \frac{R_c-\kappa R_r}{\lambda(1-\delta\gamma)a^*}}{\frac{\alpha}{1-\alpha}\kappa^2 + \frac{1-\alpha}{\alpha}} \tag{14}$$

4.3 Banks' decision

Banks maximize their profits and offer interest rates to first-timer entrepreneurs (those who carry on the initial project until date 2) and to second-timers (the ones who ask for a refinancing at date 1). The loan contract is parameterized by R_c for the entrepreneurs who continue their initial project and by R_r for those who want to start again an investment project. At the beginning of the first period, if the loan contract specifies a promised repayment such that lenders get an expected return at least equal to the amount of the initial loan, \$1, the loans are granted. If banks receive repayment lower than the initial loan, they refuse to finance the entrepreneur's investment project. Banks set an identical single rate for both types since they can not distinguish between the two types of entrepreneurs at a time when the loan is granted.

The loan contract involves liquidation for all payment lower than the face value of the debt, R_c and R_r. Since liquidation destroys all profits from a project, including the entrepreneur's repayment, both lenders and borrowers receive zero payments whenever there is liquidation. This implies that entrepreneurs will honor their obligation of repayment whenever their projects deliver sufficient return and in equilibrium, there is liquidation only when the value of the project's cash flow is zero. Entrepreneurs behave as price takers, that is, they can not affect the interest rates charged by the bank. They always borrow from the competing bank offering the lowest interest rate.

We have shown that all firms of type H continue rather than refinance. In addition, the number of firms of type L that choose to continue (L_c) is given by equation (**??**). In that case, the number of type L firms which ask for a refinancing is given by: $a^*(1 - L_c)$. In comparison, the number of entrepreneurs who continue is given by $(1 - a^*) \cdot H_c + a^* \cdot L_c$. We now have to determine equilibrium interest rates charged by the bank in period 2.

For a second-timer, in a competitive financial market the bank's break-even rate satisfies:

$$R_r = \frac{1}{\lambda_r} \tag{15}$$

where λ_r is the probability of success for a type L second timer, so that the entrepreneur can meet his obligation of repayment toward the bank.

At the first period, banks charge an interest rate R_c prevailing for first-timers. The bank's break-even rate for a loan made to a randomly selected entrepreneur at the first period insures that the unconditional probability of success $\lambda_c^H + \lambda_c^L$ equals the initial investment. Solving for R_c yields:

$$R_c = \frac{1}{\lambda_c^H + \lambda_c^L} \tag{16}$$

Note that $R_c < V_c$ from assumption 4. From equation (**??**) we get $\lambda_c^H > \lambda_c^L \geq \lambda_r$. In turn we have $R_c < R_r$, which implies that the interest rates charged for a failed entrepreneur who restarts a project is greater than the prevailing interest rates for a first timer entrepreneur.

The incentive compatibility constraint ensuring that type L firms with a low probability of success choose to continue is:

$$a^* L_c \lambda_c^L (V_c - R_c) > a^*(1 - L_c)\lambda_r(V_r - R_r)$$

In equilibrium, second-time entrepreneurs can refinance their business only if, $R_r < V_r$. Otherwise, no feasible payment allows the creditor to break even. If, $R_r > V_r$, entrepreneurs willing to start again their business are unable to refinance.

Consequently, the incentive compatible constraint can be rewritten as: $a^* L_c \lambda_c^L (V_c - R_c) > 0$, which holds from assumption 4. Hence, the market does not refinance failed businesses. This situation arises when the expected value of the initial business for failed entrepreneurs is negative, i.e., $\lambda_c^L \cdot V_c < 1$.

Without altering the qualitative result of the model but to simplify exposition we will consider for the rest of the paper that $h(a_i) = a_i$, that is:

$$a^* = h^{-1}(\delta\gamma(1-\delta\gamma)) = \delta\gamma(1-\delta\gamma) \tag{17}$$

Definition 2. Equilibrium

An equilibrium in this economy is characterized by equations (**??**), (**??**), (**??**), (**??**), (**??**) *and* (**??**) *defining the values of* a^*, n_c^H, n_c^L, n_r, H_c, L_c, R_c*and* R_r, that is:

1. At date 0, all individuals with ability below a^* *run type L firms, with:*

$$a^* = \delta\gamma(1-\delta\gamma)$$

2. At date 1, the number of firms of type L that choose to continue is given by:

$$L_c = \frac{\frac{\alpha}{1-\alpha}\kappa^2 - \frac{1-a^*}{a^*}\frac{1}{1-\delta\gamma}\frac{1-\alpha}{\alpha} + \frac{R_c - \kappa R_r}{\lambda(1-\delta\gamma)a^*}}{\frac{\alpha}{1-\alpha}\kappa^2 + \frac{1-\alpha}{\alpha}}$$

3. The interest rate charged to continued businesses is given by:

$$R_c = \frac{1}{(\lambda_c^H + \lambda_c^L)} = \frac{1}{\lambda(2-\delta\gamma)}$$

4. The interest rate charged to refinanced businesses is given by:

$$R_r = \frac{1}{\lambda_r} = \frac{1}{\lambda\kappa(1-\delta\gamma)}$$

Lemma 1: *A continuation equilibrium exists if:*

$$a^* L_c \lambda_c^L (V_c - R_c) > a^*(1-L_c)\lambda_r(V_r - R_r)$$

If $R_r > V_r$*, entrepreneurs willing to start a new business at date 1, are not refinanced.*

5 The cleansing effect of growth and the selection of business enterprises

This section derives the main results of our model. We first analyze the optimal decision of firm entry and exit when the rate of technical change is exogenous. This allows characterizing how ability-biased technical change affects firm turnover and firm quality. We then endogenize the rate of technical change to examine the reverse relationship, that is how firms entry and exit affect the economy's growth rate. This feedback loop from firm turnover to growth is crucial to understand the contribution of firm turnover to productivity growth and therefore to provide a complete analysis of firm churning and selection.

5.1 Exogenous technological change

When technical change is exogenous the model allows analyzing how the economy's exogenous growth rate influences firm churning from a comparative statics perspective. In particular, we examine which type (quality) of firm project is more likely to be created and successful following an exogenous increase (or decrease) in the growth rate. The following propositions develop the model's analytical results and are illustrated with numerical simulations in appendix **??**.

Proposition 1 describes the impact of growth on entry decisions, that is on the projects quality in the first stage (pre-entry decision).

Proposition 1. Growth and firms' types.

Faster growth, in the sense of a higher rate of technical change increases (respectively decreases) the number of entrepreneurs that choose to run type H firms when $\gamma > \widetilde{\gamma} = 1/2\delta$ *(respectively* $\gamma < \widetilde{\gamma} = 1/2\delta$*).*

Proof: see appendix **??**. □

Proposition 1 states that above a threshold level, as the rate of technological progress γ increases, the number of entrepreneurs running a type H firm $(1 - a^*)$ increases as well. Hence, faster technical change induces a selection effect on the number of type H projects that are undertaken in the first period. Type H firms are considered as high-adaptative because they are run by entrepreneurs able to take the correct decision in difficult situations. As the rate of technological change accelerates, this confers a comparative advantage to entrepreneurs running a type H firm compared to those running a type L firm. In other words, a higher growth rate increases the entry rate of high quality firms above a threshold growth level.

This proposition captures the stylized fact that a change in technology affects which agents have a comparative advantage in entrepreneurship. Assuming that innovative activities are more likely to be undertaken by type H entrepreneurs, the view that technological progress favors skilled agents is supported by a considerable literature on skill-biased technical change (see Acemoglu, 2002 or Hornstein et al., 2005). In our model, rapid technological progress increases the comparative advantage of the most able entrepreneurs to run firms and endogenously raises the number of type H firms. Moreover, this result is also in line with the evidence showing that innovation-prone environnements tend to affect the quality distribution of entrepreneurship. Gompers, Lerner and Scharfstein (2004) observe that individuals who work in areas where they are more exposed to a network of venture capitalists (such as Silicon Valley and Massachusetts) are more likely to spawn new firms.[12] Here, individuals who work in fast-growing environments are more likely to create high quality firms.

To analyze the impact of growth on the refinancing (post-entry) decisions, we need to examine its effect on interest rates. The impact of the growth rate on the cost of capital is summarized in the following proposition.

Proposition 2. Growth, interest rates and composition effects

The interest rates charged to failed entrepreneurs who restart their initial business, R_r is greater than the prevailing interest rates for first timer entrepreneurs, R_c. Both interest rates are increasing in the rate of technical change.

Proof: $R_r > R_c$ is obtained using equations (**??**) and (**??**). The derivative of R_r and R_c with respect to γ is immediate (see appendix **??** for details). □

Note first that both interest rates, R_r and R_c, are increasing with the rate of technical change: growth spurts increase the cost of capital for all firms. Interestingly, this growth-induced credit cost is driven by ability-biased entrepreneurship. Indeed, equations (**??**) and (**??**) imply that faster technological change increases the relative return to ability for high quality firms (compared to low quality firms). This improved comparative advantage translates into a lower probability of success for low quality entrepreneurs (due to the erosion effect that affects the business's

[12]The authors show that firms located in Massachusetts have spawning levels of 24% and this level increases by 38% for Silicon Valley. This is consistent with the literature on agglomeration economies that shows that there might be knowledge spillovers across individuals, and individual productivity may be higher in areas where human capital is more concentrated (Glaeser et al., 1992).

probability of success) and for refinanced firms. This higher failure risk then exerts an upward pressure on interest rates. In other words, faster growth erodes entrepreneurs' ability to run correctly type L or refinanced firms, the failure risks and interest rates of which adjust upward.

The fact that ability-biased technical change affects business creation through the cost of capital yields an interesting implication in terms of credit rationing. Indeed, the interest rate charged to first timer entrepreneurs is lower than the interest rate charged to second timer entrepreneurs, which suggests that the cost of capital rises when the credit history of an entrepreneur includes a failure. Because of the uncertainty about the borrower's type, lenders downgrade their beliefs about the borrower's quality when default occurs. High-quality borrowers therefore expect a lower cost of capital than low-quality borrowers. The latter then are more likely to be credit-rationed (Stiglitz and Weiss, 1981). For many entrepreneurs, building up a good credit history through hard work and smart investing is crucial as borrowers with unfavorable credit histories (e.g. past bankruptcies and delinquent payments) typically have poorer access to credit and at poorer terms (Vercammen, 1995). In particular, recently created firms have short credit history and therefore lower credit ratings than firms which have been trading for a long time. As a result, the latter benefit from a lower cost of capital. Available empirical evidence reveals that in fact, an established firm with a good track record is less likely to have its credit rating downgraded than a recent start-up, without an established credit record (Japelli and Pagano, 2000). Our result supports the fact that the cost of capital increases with early failures.

We know examine the impact of the growth rate on the post-entry decision to continue the initial project or liquidate the firm and ask for a refinancing. We know from equation (**??**) that high quality firms will always continue whatever the level of technical change. An increase (or a decrease) in the growth rate will however affect the number of low quality projects that are refinanced, as described in the following proposition.

Proposition 3. Selection and the cleansing effect of growth

Faster growth, in the sense of a higher rate of technological change, reduces the number of entrepreneurs of type L that choose to continue their initial business when $\gamma > \widetilde{\gamma} = 1/2\delta$.

Proof: see appendix **??**. □

Proposition 3 states that when the rate of technical change is above the threshold level $\widetilde{\gamma}$, the number of entrepreneurs of type L that continue their initial business decreases when growth accelerates. The exit rate of low quality firms is therefore higher[13]. Moreover, we know from (??) that the number of type H entrepreneurs who continue their initial business is maximal ($H_c = 1$). Hence, the average value of businesses and the pool of entrepreneurs are of high quality[14]. This result implies a self-selection mechanism both at the ex-ante (choice of quality) and post-entry (refinancing) decision stage and can be interpreted in several directions.

A first interpretation of this self-selection process is that growth induces a cleansing effect on entrepreneurial activity. Given that there is a threshold level above which self-selection occurs, only countries or sectors (like ICT sectors) with the highest rates of technical change will experience the highest entry rates of high quality firms. On the contrary, for lower levels of growth, the number of high quality projects will decline as growth increases. This result suggests a U-shaped relationship between the entry rate of high quality firms and the exit rate of low quality on the one hand, and the economy's technological dynamism (measured by its growth rate) on the other hand. This result is supported by recent empirical evidence reported in Wennekers et al. (2005). Using data from the Global Entrepreneurship Monitor from 36 countries, these authors indeed observe a U-shape relationship between the country's rate of entrepreneurial creation and its level of innovation.

Another interpretation of this self-selection process is to consider that entrepreneurial dynamism is favored by a tolerant business climate toward failure. Here, social norms and failure tolerance might affect entrepreneurship in the sense that when business failure is weakly stigmatized, terminating a project does not damage entrepreneurs' reputation and low productivity (quality) projects are more easily liquidated. In this sense, the impact of a higher growth rate on the number of low quality projects that are continued could be interpreted in the light of a low stigma toward failure: when growth reduces the number of continued L type projects, business failure seems less stigmatized. This mechanism is in line with a large body of evidence. In particular, the American's entrepreneurial regime seems to consider failure as a valuable entrepreneur's learning experience (Saxenian, 1994), whereas the fear of failure would prevent more than 35% of Europeans from starting a new business (Global Entrepreneurship Monitor, 2002).

[13] In the simulations (??), for all negative values the optimal decision is simply $L_c = 0$. This illustrates the fact that no low-adaptative firms are continued when entrepreneurs receive bad news about the firm's future prospects.

[14] Note that for $\gamma < 1/2\delta$, we do not have a simple analytical result and this case is only illustrated graphically with numerical simulations, which are reproduced in appendix ??.

Finally, this self-selection process may also be interpreted in the light of learning models (see e.g. Jovanovic, 1982). In these models of firm dynamics, only by starting a new firm and observing the subsequent performance is a nascent entrepreneur able to learn about her endowment of entrepreneurial talent and entrepreneurs with lower skills ultimately exit, which resembles a simple creative destruction mechanism. Here, an acceleration in the growth rate will accelerate learning, thereby improving the selection process. Both at the theoretical and at the empirical level, a considerable literature (in an endogenous growth or labor economics perspective) supports this effect of growth on entrepeneurial learning by means of a creative destruction process (see e.g. Aghion and Howitt, 1992; and Mortensen and Pissarides, 1998).

We have analyzed so far the impact of growth on the creation and destruction of businesses of different quality. Under exogenous technical change, we have shown that rapid technological growth affects the comparative advantage of entrepreneurs, induces self-selection and filters out the least efficient types for high levels of growth both ex-ante and at the post-entry refinancing decision stage. We now turn to the analysis of endogenous technical change. This extension of the model will allow examining the contribution of entrepreneurship to economic growth and the feedback loop from business turnover to technological dynamism.

5.2 Endogenous technological change

In this section we endogenize the rate of technological change to analyze the feedback mechanism from the allocation of entrepreneurial talents to innovation and growth. Formalizing this mechanism is crucial since business turnover can contribute up to 30% of aggregate productivity growth in OECD countries (OECD, 2003).

As before, there are two periods (or stages): entrepreneurs develop their business idea in the research stage and production occurs in the development stage. The final good sector and the intermediate goods sector are described in appendix **??**. We now assume that the rate of technological progress is a positive linear function of the number of type H entrepreneurs who pursue their business idea over both stages:

$$\gamma = \varepsilon \cdot \lambda_c^H n_c^H \quad \text{with} \quad \varepsilon > 0 \tag{18}$$

This assumption captures the idea of learning-by-doing: as entrepreneurs of type H are the most able to adapt and spread their ability advantage, they contribute to increasing knowledge and growth in the economy.

Given the equilibrium values obtained in section **??**, we can substitute for the values of λ_c^H and n_c^H to get the following endogenous growth rate:

$$\gamma = \varepsilon\lambda(1 - \delta\gamma + \delta^2\gamma^2)$$

The existence of a positive equilibrium rate of technological progress requires a further restriction on the value of the parameter ε:

Assumption 5.

$$\varepsilon < \widetilde{\varepsilon} \equiv \frac{1}{\lambda(1 - \delta + \delta^2)}$$

This assumption provides a sufficient condition for the existence of a positive solution to the above equation that governs the growth rate in this economy.

Proposition 4. Endogenous technological progress

Under Assumption 1 and 5, there exists a unique equilibrium rate of technological progress $\widehat{\gamma} \in (0, 1)$ *such that*

$$\widehat{\gamma} = \frac{1 + \varepsilon\lambda\delta + \Delta^{1/2}}{2\varepsilon\lambda\delta^2} \quad \textit{with} \quad \Delta = ((1 + \varepsilon\lambda\delta)^2 - 4\varepsilon^2\lambda^2\delta^2 > 0.$$

The equilibrium rate of technological change increases with the probability of success of the business project (λ) and the spillover rate of learning-by-doing (ε) and decreases with the adaptative capacity of entrepreneurs of type L (δ).

Proof: see appendix **??** □

It is not surprising that the rate of technological change positively depends on the spillover rate of learning-by-doing (i.e. on the increase in the efficiency of the learning process) and on the projects' probability of success (i.e. on the learning externality or learning curve). More interestingly, since the probability of λ also affects the composition of the pool of entrepreneurs in the first period (it reduces the ability threshold $a^\star$ above which individuals choose to run type H projects), there is a positive feedback loop on the quality distribution of entrepreneurial types. A rise in λ improves the overall quality (survival rates) of projects, which affects interest rates (see proposition 2) and translates into a better ex-ante selection of high quality types (more high quality projects are chosen ex-ante) and a better post-entry selection of low quality projects (less low quality projects are refinanced ex-post), which fosters the growth rate. In other words, under endogenous technical change, higher survival rates improve the ex-ante and post-entry quality distribution of entrepreneurship via the credit-growth channel and the positive relationship between entry rates of high quality firms and exit rates of low quality firms.

While the main mechanisms from growth to business turnover are the same as in the model with exogenous technical change, the novelty here lies in the mechanisms from business dynamics to growth. The contribution of firm turnover to aggregate growth indeed relies on a multiplier effect: any parameter that positively influences growth and/or the returns to high quality projects will increase the number of ex-ante high quality projects and decrease the number of post-entry low quality refinanced projects. In turn, the ability threshold of high quality ventures goes down implying higher quality projects ex-ante, and the cost of capital increases ex-post implying higher post-entry entrepreneurial quality. This has a multiplicative impact on growth. This positive feedback loop suggests a strong correlation between entry rates of high quality (high productivity) firms, exit rates of low quality (low productivity) firms and a high contribution of business turnover to aggregate productivity growth. Those three mechanisms are largely supported by recent empirical evidence in OECD countries. The positive link between high quality (or productive) entering firms and low quality exiting firms is confirmed by the observation of a positive correlation between entry and exit rates in OECD countries, together with the fact that exiting businesses have lower productivity than incumbents or entrants (Brandt, 2004; Foster et al., 2005).

Finally, we can note that the rate of technical change decreases when the spillover rate of learning-by-doing ε goes down, which occurs for instance due to knowledge obsolescence. Through its negative impact on the rate of technological progress, knowledge obsolescence hence negatively affects the comparative advantage of type H entrepreneurs. This leads to a higher stigma of failure and thereby a higher number of entrepreneurs of type L who choose to continue their initial business.

Finally, the higher the marginal adaptativity cost of type L entrepreneurs δ, the lower the rate of technical progress. A higher value of δ increases both the adaptative capacity of type L firms and the erosion effect on the probability of success. Overall, the erosion effect dominates and an increase in δ affects business creation by improving the comparative advantage of type H entrepreneurs and reducing the number of entrepreneurs of type L firms who choose to continue their business.

6 Conclusion

This paper analyzes the quality distribution of firm turnover by focusing on the complementarity between credit conditions, technological environment and individual ability to run firms. We develop a two-stage project development set up in which growth affects the ex-ante and post-entry quality distribution of entrepreneurship. We show that rapid technological change affects business dynamics via three main channels. First, an acceleration in the growth rate improves the comparative advantage of individuals in running high quality firms. Above (below) a threshold level, the number of entrepreneurs who choose to run the most efficient projects increases (decreases) with the growth rate. Second, a higher rate of technical change increases the failure risks of low quality entrepreneurs, which raises the cost of capital for new ventures. Lastly, above the threshold level, faster growth reduces the number of low quality firms who choose to continue their initial business. This cleansing effect on entrepreneurial activity highlights that higher levels of growth may reduce the stigmatization of failure: when failure is considered as part of the learning process, entrepreneurs abandon more easily an inefficient project. Moreover, when technological change is endogenous, the correlation between entry rates of high quality (high productivity) firms, exit rates of low quality (low productivity) firms and the contribution of business turnover to aggregate productivity growth are reinforced.

Our approach focuses on the complementarity between technical change and ability to create and run a business venture to explain the quality distribution of nascent entrepreneurship in an economy. To explain the large divergence in the rates of nascent business creation across countries (from 12.4% in the US to 5.5% in Germany and France, and below 4% for most other European countries) our model focuses on a specific characteristics of nascent entrepreneurship based on the adaptability to a changing environment. Several extensions could be considered to enlarge this analysis. In particular, introducing other factors such as competition between firms could yield insightful results and constitutes an area for our future research.

7 Appendix

7.1 Description of the development stage

In the development stage, we consider an economy composed of two sectors: a final good sector and an intermediate goods sector. Intermediate goods are used as factors of production in the final good sector. The final good is the numeraire, it is produced in a competitive environment using two different types of intermediate goods: goods produced by continued firms (labelled c) and goods produced by refinanced firms (labelled r).

The production function is a Cobb-Douglas:

$$y = x_c^{\alpha} x_r^{1-\alpha}, \quad 0 < \alpha < 1 \tag{19}$$

where y is the final good, x_c is the quantity of continued firms' goods and x_r is the quantity of refinanced firms' goods.

The profit maximization problem by a representative firm in this sector leads to the following inverse demand for inputs:

$$p_c = \frac{\partial y}{\partial x_c} = \alpha x_c^{\alpha-1} x_r^{1-\alpha} \tag{20}$$

$$p_r = \frac{\partial Y}{\partial x_r} = (1-\alpha) x_c^{\alpha} x_r^{-\alpha} \tag{21}$$

where p_c denotes the price of continued firms' goods and p_r the price of refinanced firms' goods. Consequently, the equilibrium price of each intermediate good, x_c and x_r is given by its marginal product.

Intermediate goods are produced using final good as input. Given the inverse demand for intermediate goods in the final good sector (**??**) and (**??**) and given that the price of the final good is normalized to 1, the optimization program for continued firms, c and for refinanced firms, r writes:

$$\max_{x_c} p_c x_c - x_c = \alpha x_c^{\alpha} x_r^{1-\alpha} - x_c.$$

$$\max_{x_r} p_r x_r - x_r = (1-\alpha) x_c^{\alpha} x_r^{1-\alpha} - x_r.$$

from where we obtain the profit-maximizing prices and the flow of profits for each type of business:

$$\begin{aligned} p_c &= \frac{1}{\alpha}, \quad p_r = \frac{1}{1-\alpha} \\ V_c &= \frac{1-\alpha}{\alpha} \cdot x_c, \quad V_r = \frac{\alpha}{1-\alpha} \cdot x_r \end{aligned} \tag{22}$$

7.2 Proofs

7.2.1 Proof of Proposition 1

The proof is made for a general set of functions $h(.)$, in particular when h(x)=x as in (**??**).

Note that function $h(.)$ is continuous and strictly increasing. Then, the inverse function, h^{-1} is also continuous and strictly increasing. From equation (**??**) we get

$$\frac{\partial a^*}{\partial \gamma} = h^{-1'}(\delta\gamma(1-\delta\gamma)) \cdot \delta(1-2\delta\gamma)$$

where $h^{-1'}(.) > 0$.

Given that the number of entrepreneurs that choose to run type H firms is equal to $1-a^*$, we have

$$\frac{\partial H}{\partial \gamma} > 0 \Leftrightarrow (1-2\delta\gamma) < 0$$

7.2.2 Proof of Proposition 2

(i) After simple manipulation, the interest rates defined by equations (**??**) and (**??**) write:

$$R_r = \frac{1}{\lambda\kappa(1-\delta\gamma)}$$
$$R_c = \frac{1}{\lambda(2-\delta\gamma)}$$

After some simple algebra we have

$$R_r - R_c = \frac{1-\delta\gamma+1-\kappa(1-\delta\gamma))}{\lambda\kappa(1-\delta\gamma)(2-\delta\gamma)}$$

We thus get $R_c < R_r$, which implies that the interest rates charged to a failed entrepreneur who restarts his project is greater than the prevailing interest rates for a first timer entrepreneur.

(ii) The derivative of R_r and R_c with respect to γ is immediate from equations (**??**) and (**??**): both interest rates are increasing in the rate of technical change.

7.2.3 Proof of Proposition 3

Substituting for (**??**) and (**??**) into (**??**) and rewriting yields :

$$L_c = \Lambda \cdot \{\Phi - \Psi(a^*(\gamma), \gamma) - \Omega(a^*(\gamma), \gamma)\}$$

where given (**??**)

$$\begin{aligned}
a^*(\gamma) &= \delta\gamma(1-\delta\gamma) \\
\Lambda &= \frac{1}{\frac{\alpha}{1-\alpha}\kappa^2 + \frac{1-\alpha}{\alpha}} \\
\Phi &= \frac{\alpha}{1-\alpha}\kappa^2 \\
\Psi(a^*(\gamma), \gamma) &= \frac{1-a^*(\gamma)}{a^*(\gamma)} \frac{1}{1-\delta\gamma} \frac{1-\alpha}{\alpha} \\
\Omega(a^*(\gamma), \gamma) &= -\frac{R_c - \kappa R_r}{\lambda(1-\delta\gamma)a^*(\gamma)} = \frac{1}{\lambda^2(1-\delta\gamma)^2(2-\delta\gamma)a^*(\gamma)}
\end{aligned}$$

Deriving with respect to γ then gives:

$$\begin{aligned}
(L_c)' &= \frac{\partial L_c}{\partial \gamma} = \Lambda\{-(\Psi)' - (\Omega)'\} \\
(\Psi)' &= \frac{\partial \Psi(a^*(\gamma), \gamma)}{\partial \gamma} = \frac{1-\alpha}{\alpha} \frac{-(a^*)'}{(a^*)^2} \frac{1}{1-\delta\gamma} + \frac{1-\alpha}{\alpha} \frac{1-a^*}{a^*} \frac{\delta}{(1-\delta\gamma)^2} \\
(\Omega)' &= \frac{\partial \Omega(a^*(\gamma), \gamma)}{\partial \gamma} \\
&= \frac{-(a^*)'(1-\delta\gamma)(2-\delta\gamma) + a^*\delta(1-\delta\gamma) + 2a^*\delta(2-\delta\gamma)}{\lambda^2(a^*)^2(1-\delta\gamma)^3(2-\delta\gamma)^2} \\
(a^*)' &= \frac{\partial a^*(\gamma)}{\partial \gamma} = \delta(1-2\delta\gamma)
\end{aligned}$$

¿From these equations, we can state that whenever $(a^*)' < 0$, then $(L_c)' < 0$. In other words, when $\gamma > 1/2\delta$, L_c decreases with the growth rate γ. The opposite case where $\gamma < 1/2\delta$ does not yield a simple analytical result and is only illustrated graphically with numerical simulations, reproduced in appendix **??**.

7.3 Numerical simulations with exogenous technical change

To run the numerical simulations, the parameters values are then given as follows: $\alpha = 0.97$, $\delta = 5$, $\lambda = 0.9$, $\kappa = 1$. The following figures illustrate the links we established between the different variables explored in this paper. They also serve as an illustration of the propositions stated above.

We then get the following curves corresponding to the different effects highlighted in propositions 1 to 3. Figure a and b draw a^* and H as functions of γ. We observe that a^* is a inverted-U shaped curve and H is a U-shaped curve. Regarding figure c, plotting Lc: when $\gamma > \widetilde{\gamma} = 1/2\delta = 0.10$, L_c decreases with the growth rate. On the other hand, when $\gamma < \widetilde{\gamma} = 1/2\delta = 0.10$, L_c first increases (stigmatization is high) and as γ gets closer to the threshold value $\widetilde{\gamma}$, it starts decreasing (stigmatization starts decreasing).

Figure a

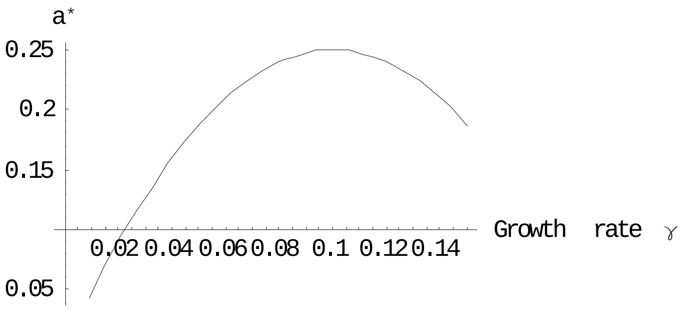


Figure b

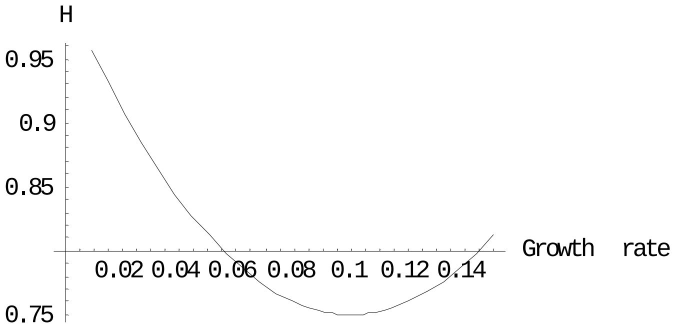
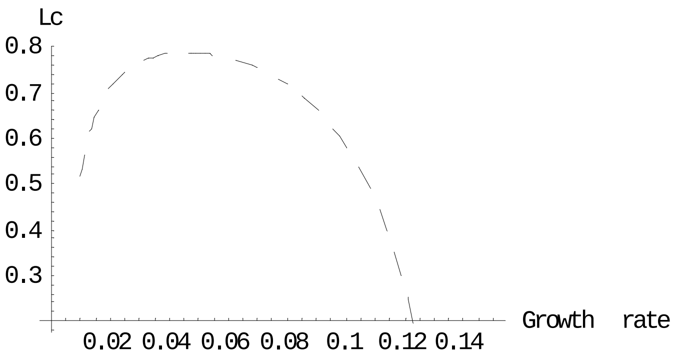


Figure c



7.4 Proof of Proposition 4

The rate of technological progress is governed by the equation $\gamma = \varepsilon\lambda(1-\delta\gamma+\delta^2\gamma^2)$. Let analyze the function $\phi(\gamma) = \gamma - \varepsilon\lambda(1-\delta\gamma+\delta^2\gamma^2)$.

We have a quadratic equation in γ that has either no real root or two real roots. Hence, the necessary and sufficient condition for the existence of an equilibrium value of γ (that solves $\phi(\gamma) = \gamma - \varepsilon\lambda(1-\delta\gamma+\delta^2\gamma^2) = 0$) is that the discriminant Δ of this quadratic equation be positive:

$$\Delta = ((1+\varepsilon\lambda\delta)^2 - 4\varepsilon^2\lambda^2\delta^2 > 0$$
$$\Leftrightarrow \varepsilon < \frac{1}{\lambda\delta}$$

which is always the case under assumption 5:

$$\varepsilon\lambda < \frac{1}{1-\delta+\delta^2} = \frac{1}{(1-\delta)^2+\delta} < \frac{1}{\delta}$$

Among the two possible real roots, only one is strictly positive and acceptable as an equilibrium growth rate. This solution writes:

$$\widehat{\gamma} = \frac{1+\varepsilon\lambda\delta+\Delta^{1/2}}{2\varepsilon\lambda\delta^2}$$

where Δ is the discriminant defined above.

To further ensure that the equilibrium growth rate $\widehat{\gamma}$ lies in the interval $(0,1)$, let analyze the following equations:

$$\begin{aligned}
\phi(0) &= -\varepsilon\lambda < 0, \quad \phi(1) = 1-\varepsilon\lambda(1-\delta+\delta^2) \\
\phi^{'}(\gamma) &= 1+\varepsilon\lambda\delta - 2\delta^2\varepsilon\lambda\gamma, \quad \phi^{'}(0) = 1+\varepsilon\lambda\delta > 0 \\
\phi^{''}(\gamma) &= - \; 2\varepsilon\lambda\delta^2 < 0
\end{aligned}$$

Under assumption 5, $\varepsilon < \frac{1}{\lambda(1-\delta+\delta^2)}$, we get: $\phi(1) = 1-\varepsilon\lambda(1-\delta+\delta^2) > 0$. Furthermore,

$$\varepsilon\lambda < \frac{1}{1-\delta+\delta^2} = \frac{1}{(1-\delta)^2+\delta} < \frac{1}{\delta}$$

and

$$\varepsilon\lambda < \frac{1}{\delta} \Rightarrow 1 + \frac{1}{\varepsilon\lambda\delta} > 2$$

Finally, under assumption 1, $0 < \delta\gamma < 1 \Rightarrow 2\delta\gamma < 2$, we therefore get

$$2\delta\gamma < 2 < 1 + \frac{1}{\varepsilon\lambda\delta} \Rightarrow 1 + \varepsilon\lambda\delta - 2\delta^2\varepsilon\lambda\delta > 0 \Leftrightarrow \phi^{'}(\gamma) > 0$$

In sum, we have shown that under assumption 1 and 5, the equation governing the rate of technological progress $\phi(\gamma) = \gamma - \varepsilon\lambda(1 - \delta\gamma + \delta^2\gamma^2)$ is such that:

$$\phi(0) < 0, \quad \phi(1) > 0, \quad \phi^{'}(\gamma) > 0, \quad \phi^{'}(0) > 0, \quad \phi^{''}(\gamma) < 0$$

Hence, the rate of technical change $\widehat{\gamma}$ that solves $\phi(\gamma) = 0$ exists, is unique and such that $\widehat{\gamma} \in (0, 1)$.

To illustrate the static comparative of $\widehat{\gamma}$ with respect to the parameters of the model, some numerical simulations are reported below. The parameters values are then given as follows: $\alpha = 0.97$, $\delta = 5$, $\kappa = 1$. The variable $\widetilde{\varepsilon}$ corresponds to the threshold level defined in assumption 5: $\varepsilon < \widetilde{\varepsilon} \equiv \frac{1}{\lambda(1-\delta+\delta^2)}$

Table I: Rates of technological change for different values of λ, δ and ε

δ	λ	$\widetilde{\varepsilon}$	ε	γ
2	0.9	0.37	0.3	0.204
5	0.9	0.053	0.03	0.024
20	0.9	0.003	0.029	0.0025
5	0.9	0.053	0.05	0.038
5	0.8	0.059	0.05	0.034
5	0.8	0.059	0.03	0.021

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