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Working Paper n. 03/2024

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On the main determinants of startup investment in developing countries

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Abstract: In this article, we study the timing of startup investment in developing countries. In particular, studying a representative firm and applying a real-option approach, we analyze the effects of taxation and risk on new business activities. It is worth noting that developing countries usually have four main features. Firstly, a firm's Earnings Before Interest and Taxes (EBIT) is likely to be more volatile than in developed jurisdictions. Secondly, in developing countries, firms can be affected by a higher risk of sudden death: this risk can be due to either political expropriation or the decision of multinational groups to stop their support to startups. Thirdly, the financial market shows higher inefficiencies, compared to developed countries. Fourthly, average statutory tax rates are higher than in developed countries. We show that a policy maker aiming at boosting new business activities must decrease both EBIT volatility and the sudden-death risk, as well as improving financial market efficiency. However, tax rate cuts have an almost negligible effect.

Keywords: business taxation; default risk; developing countries; numerical simulations; real options.

JEL Classification: H25, G33, G38.

Acknowledgements: We wish to thank Edward Hugh Cruickshank, Rosella Levaggi, Tim Messenger, Ilenia Gaia Romani and the participants of the 11th Annual MannheimTaxation Conference, organized by the ZEW on September 6-7, 2024, for their useful comments.

1. Introduction

The relationship between business taxation and financial stability, as well as the way they affect startup decisions have been studied in the literature. However, most articles focus on investment decisions by firms in developed countries, where the market structure is clearly different from that of developing countries that need further investigation. Accordingly, the World Bank states "*entrepreneurs in developing countries face many challenges in their journey to launch high-growth companies. Yet when they succeed, entrepreneurs can act as powerful agents of change – reducing inefficiencies, creating jobs, and boosting economic development*".[1]

Although startup firms are powerful economic agents, Singh and Hillemane (2023) argue that the establishment of highly innovative tech companies is still quite rare. Notwithstanding this aspect, Kowalewski and Pisany (2023) state that, even in developing countries, fintech startups are beginning to emerge.[2] Contrary to developed countries, new firms in developing countries may face some severe financing problems. For instance, Mazorodze (2023) uses a sample of 40 developing countries, over the 2010-2018 period, and finds that, despite difficulties in accessing credit, the availability of financial services is a crucial factor in fostering the emergence of startups. Quite interestingly, Munemo (2017), using a panel of 92 developing countries, studies the effects of financial market efficiency on the relationship between foreign direct investment (FDI) and business startup. He finds that, above a certain cut-off level, FDI stimulates new business activities in developing countries. In that case, many startups can exploit the support of their controlling multinational companies. Moreover, Brixiová et al. (2020) use firm-level data regarding 42 African countries and show that small- and medium-sized enterprises (SMEs) create more jobs if they benefit from formal financing.[3] This impact looks stronger for manufacturing firms than for service providers.

Since the literature mainly proposes empirical work on this topic, the aim of this article is therefore to provide a theoretical rationale underlying the empirical evidence. For this reason, we introduce a real-option model to describe a startup's investment decision. The real-option approach is particularly suitable to this end: it allows us to study both the rationale and the optimal choice of an economic agent, endowed with an investment opportunity. Investment entails an irreversible

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[1] For further details, see: https://www.worldbank.org/en/topic/innovation-entrepreneurship/brief/about-infodev-a-world-bank-group-program-to-promote-entrepreneurship-innovation. On the World Bank website there are many interesting examples.

[2] Kowalewski and Pisany (2023) have also found that the establishment of fintech companies is more likely in developed countries because they benefit from the support provided by an older and wealthier population. See also the articles quoted therein.

[3] See also the articles quoted in Brixiová et al. (2020), such as Asiedu et al. (2013) and Blancher et al. (2019).

decision and is affected by stochastic factors (Dixit and Pindyck, 1994). In addition, this parsimonious, yet rigorous, approach allows us to investigate how this decision is affected by exogenous variables (Comincioli et al., 2021). This feature is particularly useful, as we focus on the impact on startup decision of variables related to developing countries. To the best of our knowledge, this kind of model has never been applied to these countries.

In this article, we focus on four developing countries' peculiar features. Firstly, the economic environment is typically riskier: in particular we let EBIT volatility be higher than in developed countries. Secondly, there is a higher risk of sudden-death, related, e.g., to the possibility for multinationals' branches to be closed or relocated and for firms to be expropriated by the government. Thirdly, and crucially, access to financial markets is usually more difficult or costly with respect to developed countries. Finally, taxes are in principle useful determinants, since their average is higher than that of developed countries.[4]

A set of numerical simulations, based on realistic parameter values, is then run. As will be shown, tax rates have a negligible impact. This supports the existing tax policy implemented by developing countries: most of them apply high statutory tax rates. On the other hand, risk, in terms of both EBIT volatility and sudden death, has however a substantial effect. Finally, financial market inefficiencies also have a very important impact on early-stage activities.[5] As pointed out, to understand the effects of such determinants, we apply a real-option model. In our model, we let venture capitalists sustain the startup investment. Moreover, we assume that a new investor can borrow some money. This latter source is the only available external one, since startups have difficulties in finding other shareholders (apart from venture capitalists, if available), given either the lack or small size of stock markets.

The structure of the article is the following. Section 2 introduces a real-option model that describes a representative startup firm. Section 3 provides a numerical analysis that compares the behavior of startups in developed and developing countries. Finally, Section 4 summarizes our results and discusses their policy implications.

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[4] It is worth noting that these four features are the ones that differ the most between developed and developing countries.

[5] In order to evaluate the distortion caused by financial market imperfections, we follow both Sørensen (2017) and Comincioli et al. (2021). These studies however focus on mature firms operating in developed countries. Moreover, the former one applies a deterministic framework while the latter follows a stochastic approach.

2. The model

Let us consider a representative economic agent who can invest in a startup business. By paying a sunk cost I, a company is established and starts generating an EBIT.[6] Following Goldstein et al. (2001), we let the EBIT, denoted by Π, follow a Geometric Brownian Motion (GBM):

$$d\Pi = \mu\Pi dt + \sigma\Pi dz, \quad (1)$$

where $\Pi_0 > 0$ is its initial value, μ and σ are its drift and diffusion coefficients, accounting for both the deterministic growth and the volatility of the process, respectively. Moreover, dz is the increment of a Wiener process. According to Dixit and Pindyck (1994), we let the so-called dividend yield $\delta \equiv i - \mu$ be positive, where i is the risk-free interest rate.[7] Moreover, we introduce the following assumptions:

Assumption 1. The **startup** can borrow financial resources, thereby paying a non-renegotiable coupon C.

Assumption 2. Default occurs if EBIT falls to a trigger level $\overline{\Pi}$, which is optimally chosen by shareholders. In this case, the lender becomes the firm's owner.

Assumption 3. The cost of default is borne by the lender and is proportional to Π. Hence, given the scale parameter $\alpha \in [0,1]$, the lender will own a firm whose value is $(1-\alpha)$ times the before-default one.

Assumption 4. The access to financial markets is costly. Such a cost is proportional to the coupon: namely, it is equal to ωC, where ω is a scale parameter such as $\omega \geq 0$.[8]

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[6] For simplicity, we focus on a single business activity and disregard the positive externalities ensured by successful businesses.

[7] The choice of using a GBM rules out negative EBIT. This simplification does not affect the quality of results since we will show that default occurs when EBIT is positive. In addition, it is worth noting that, as the expected growth rate is $\delta - i$, all the following decisions are made under a risk-neutral measure. Indeed, according to Shackleton and Sødal (2005), by replacing the actual cash flows growth rate with a certainty-equivalent growth rate, we can evaluate any contingent claim on an asset. This condition is necessary to allow the early exercise of a start-up option, according to Bolton et al. (2019).

[8] It is worth noting that the lower (higher) the parameter ω, the higher (lower) the level of efficiency of financial markets.

Assumption 5. There exists a sudden-death risk, modeled as a Poisson process. Hence, the sudden-death probability at each time is λdt, where λ is the so-called mean arrival rate (Dixit and Pindyck, 1994).

The non-renegotiable coupon C, introduced by Assumption 1, is optimally chosen by the firm under a non-arbitrage condition. Assumption 2 introduces default risk and the ownership change: as pointed out, the lender becomes the firm's owner after default. Assumption 3 introduces the default cost, that is borne by the lender after default. Assumptions 4 and 5 allow us to focus on a startup in developing countries. On the one hand, Assumption 4 introduces inefficiencies in the financial market which may be due, for example, to the lack of good financial regulation as well as to usury and bribery. The parameter ω multiplied by coupon C accounts for all of these market imperfections. On the other hand, Assumption 5 introduces the risk of sudden death. This kind of risk is likely to be higher in developing countries.

In order to study a startup's decision, whose attractiveness depends on the expected future EBIT, we first calculate the Net Present Value $NPV(\Pi)$ of an investment project at the exercise time T. This value is given by the sum of equity $E(\Pi)$ and debt $D(\Pi)$, namely the value function, net of investment sunk cost I:

$$NPV(\Pi) = E(\Pi) + D(\Pi) - I. \quad (2)$$

The value of equity $E(\Pi)$ is the sum of shareholders' cash and venture capitalists finance (if available). As shown in the Appendix, $E(\Pi)$ before default (b.d.) and after default (a.d.) is:

$$E(\Pi) = \begin{cases} \frac{1-\tau}{\delta}\Pi - \frac{(1-\tau+\omega)}{r}C - \left[\frac{1-\tau}{\delta}\overline{\Pi} - \frac{1-\tau+\omega}{r}C\right]\left(\frac{\Pi}{\overline{\overline{\Pi}}}\right)^{\beta_2} & \text{b.d.} \\ 0 & \text{a.d.} \end{cases}, \quad (3)$$

where τ is the relevant tax rate and the discount rate is $r = \lambda + i$. Equity holders maximize (3) by setting the optimal default trigger EBIT:

$$\overline{\Pi}^* = \frac{\delta}{r}\frac{\beta_2}{\beta_2 - 1}\frac{1-\tau+\omega}{1-\tau}C < \mathrm{C}. \quad (4)$$

It is worth noting that if $\Pi < C$, equity holders can decide whether to default or issue new equity and let their firm operate. If, however, Π is too low, default is preferable.

As shown in the Appendix, the market value of debt $D(\Pi)$ is:

$$D(\Pi)=\begin{cases}\dfrac{C}{r}+\left[\dfrac{(1-\alpha)(1-\tau)}{\delta}\overline{\Pi}-\dfrac{C}{r}\right]\left(\dfrac{\Pi}{\overline{\overline{\Pi}}}\right)^{\beta_2} & \text{b.d.}\\ \dfrac{(1-\alpha)(1-\tau)}{\delta}\overline{\Pi} & \text{a.d.}\end{cases}. \quad (5)$$

Given (3) and (5), we can focus on the startup's problem, consisting in the maximization of $NPV(\Pi)$ with respect to investment timing T and the coupon C. As shown by Harrison (1985), the optimal choice of T is equivalent to the choice of the threshold level of Π, namely $\widehat{\Pi}$, above which investment is profitable. Following Panteghini (2007), we can therefore write the problem as follows:

$$\max_{\widehat{\Pi}\geq 0, C\geq 0}\left(\frac{\Pi}{\widehat{\Pi}}\right)^{\beta_1}\left[\frac{1-\tau}{\delta}\widehat{\Pi}+\frac{\tau-\omega}{r}C-\xi C\left(\frac{\widehat{\Pi}}{C}\right)^{\beta_2}-I\right], \quad (6)$$

where $\xi\equiv\left[(1-\tau+\omega)\frac{\alpha}{r}\frac{\beta_2}{\beta_2-1}+\frac{\tau-\omega}{r}\right]\left(\frac{r}{\delta}\frac{\beta_2-1}{\beta_2}\frac{1-\tau}{1-\tau+\omega}\right)^{\beta_2}$ lightens the notation. It is worth noting that term $\left(\Pi/\widehat{\Pi}\right)^{\beta_1}$ is the contingent value of one Euro. Hence, the objective functions in (6) is the contingent value of the *NPV*. As shown in the Appendix, problem (6) gives both the optimal coupon, i.e.:

$$C^*(\Pi)=\frac{r}{\delta}\frac{\beta_2-1}{\beta_2}\frac{1-\tau}{1-\tau+\omega}\left[\frac{\tau-\omega}{\left[(1-\tau+\omega)\alpha\dfrac{\beta_2}{\beta_2-1}+\tau-\omega\right](1-\beta_2)}\right]^{-\frac{1}{\beta_2}}\Pi. \quad (7)$$

The optimal threshold level of EBIT, above which investment is profitable, i.e.:

$$\widehat{\Pi}^*(\Pi)=\frac{\delta}{1+m}\frac{\beta_1}{\beta_1-1}\frac{1}{1-\tau}I, \quad (8)$$

where $m\equiv\frac{\tau-\omega}{1-\tau}\frac{\beta_2}{\beta_2-1}\frac{\delta}{r}\left(\frac{1}{1-\beta_2}\frac{\tau-\omega}{r\xi}\right)^{-\frac{1}{\beta_2}}$. Given these results, we can now calculate the contingent value of a startup's tax liability, i.e.,

$$R(\Pi) = \left(\frac{\Pi}{\widehat{\Pi}^*}\right)^{\beta_1} \left[\frac{\tau}{\delta}\widehat{\Pi}^* + \frac{\tau - \omega}{r} C^* - \xi C^* \left(\frac{\widehat{\Pi}^*}{C^*}\right)^{\beta_2}\right]. \quad (9)$$

The welfare function, which is given by the summation between the contingent values of $NPV(\Pi)$ and $R(\Pi)$, i.e.:

$$W(\Pi) = \left(\frac{\Pi}{\widehat{\Pi}^*}\right)^{\beta_1} \left[\frac{\widehat{\Pi}^*}{\delta} + 2\frac{\tau - \omega}{r} C^* - 2\xi C^* \left(\frac{\widehat{\Pi}^*}{C^*}\right)^{\beta_2} - I\right]. \quad (10)$$

In order to evaluate the welfare loss jointly caused by taxes, financial market inefficiencies and sudden-death risk, we set $\tau = \omega = \lambda = 0$ and define $W(\Pi)|_{\tau=\omega=\lambda=0}$ as the first best welfare. Using (10) we therefore define the welfare loss as:

$$WL(\Pi) = W(\Pi)|_{\tau=\omega=\lambda=0} - W(\Pi). \quad (11)$$

According to Sørensen (2017), the deadweight loss $DWL(\Pi)$ is defined as the ratio between the welfare loss $WL(\Pi)$ and the tax revenue $R(\Pi)$.[9] Using (11), we therefore obtain:

$$DWL(\Pi) = \frac{WL(\Pi)}{R(\Pi)}. \quad (12)$$

Finally, from the government's perspective, it is crucial to measure the probability of a startup investment within a given time. In line with Carini et al. (2020), we use the probability of investment within n periods:

$$P(t^* < 10) = \left(\frac{C}{\Pi_0}\right)^{\frac{2}{\sigma^2}\left(\mu - \frac{\sigma^2}{2}\right)} \Phi\left[\frac{ln\frac{\Pi}{\Pi_0} + \left(\mu - \frac{\sigma^2}{2}\right)n}{\sigma\sqrt{n}}\right] + \Phi\left[\frac{ln\frac{\Pi}{\Pi_0} - \left(\mu - \frac{\sigma^2}{2}\right)n}{\sigma\sqrt{n}}\right], \quad (13)$$

where $\Phi[\Pi]$ is the cumulative distribution function of a standard normal distribution. As explained by Sarkar (2000), volatility has a twofold effect. On the one hand, it raises the investment trigger point (and the optimal coupon), thereby reducing the probability of a startup business at a given time. On the other hand, a higher volatility makes investment more likely. For any given threshold point,

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[9] Here we denote $R(\Pi)$ by the tax revenue (instead of the tax liability) since we are focusing on the policy maker's point of view.

the probability that EBIT hits $\widehat{\Pi}^*$ rises. The net effect is therefore ambiguous and does require a numerical analysis.

3. Numerical results

In Section 2, we have dealt with a rather standard model, although we have added some relevant parameters that mainly characterize a startup in developing countries.[10] What matters however is the real value of parameters. For this reason, we calibrate our model. Table 1 contains the benchmark parameter values.

Table 1 Benchmark values of parameters used in the numerical simulations**.**

Parameter		Value(s)
Effective tax rate	τ	$0.20; 0.30$
EBIT's deterministic growth rate	μ	0.01
EBIT's volatility	σ	0.20; 0.30
Sudden-death risk	λ	0.00; 0.10
Credit market inefficiency	ω	$[0.00, 0.10]$
Interest rate	i	0.05
Cost of default	α	0.20
Investment sunk cost	I	100
Initial EBIT	Π_0	6

If we look at corporate tax rates (CITs) in developing countries, on average the statutory ones are higher than those levied in developed countries.[11] For instance, China has a standard tax rate is 25% (although, under certain conditions, the tax rate can be reduced to 15%); the Brazilian CIT is 34%; India's CIT stands at 34.94%. Other examples are then represented by South African and Kenyan CITs, equal to 27% and 30%, respectively. For this reason, we use $\tau = 30\%$ as a benchmark value. We also evaluate the numerical findings when the tax rate is closer to the average one applied by developed countries ($\tau = 20\%$). The risk-free interest rate is equal to $i = 0.05$. The drift $\mu = 0.01$

[10] It is worth noting that we focus on the variables that differ the most between developed and developing countries. Moreover, using the same model, with different calibrations, implies a reasonable assumption that the decision-making process is homogeneous across countries.
[11] See, e.g., Heckmeyer et al. (2024), who show that, on average, developing countries have higher tax rates.

is a realistic parametrization as the startup's EBIT is expected to grow over time.[12] Then, following Branch (2002) and Comincioli et al. (2021), we set $\alpha = 0.20$ and $\sigma = 0.20$. Moreover, we consider an additional scenario where $\sigma = 0.30$, to reflect the possible higher volatility of EBIT in developing countries. Then, we normalize the initial EBIT by setting $\Pi_0 = 6$ with $I = 100$, which coincides with the value of the tax-free perpetual rent $\Pi_0/(i - \mu) = 25$. According to Carini et al. (2020), the average value of EBIT is about 0.08. Using a lower starting value, we can therefore study startup's investment timing. If a firm's EBIT were high enough, investment would be made immediately. This case fits well with mature firms. However, it is less likely for a startup. Thus, we focus on the opportunity to invest in the future when, in the beginning, current EBIT is not high enough. Finally, in developing countries we must consider sudden-death risk. Then, we run our numerical simulations with λ equal to either 0 or 0.1. Since this parameter has a monotonic effect, we only focus on these two values (although we have also used other parameter values: robustness checks are available upon request). Table 2 shows the results of our numerical simulations with $\tau = 0.30$. As can be seen, an increase in both EBIT volatility and sudden-death risk leads to an increase in the default trigger point $\overline{\Pi}^*$. However, financial market inefficiencies (proportional to ω) slightly reduce $\overline{\Pi}^*$. This also implies that, *ceteris paribus*, financial market inefficiencies raise the default risk.

Let us next focus on the investment trigger point $\widehat{\Pi}^*$ and the probability of exercising the **startup** option within the arbitrary interval of 10 periods, namely, $P(t^* < 10)$. As can be seen, both EBIT volatility and sudden-death risk increase with $\widehat{\Pi}^*$. However, a change in parameter values has an ambiguous effect on probability $P(t^* < 10)$. For instance, if λ is low enough, an increase in both ω and σ reduces the investment probability. In other words, a higher EBIT volatility discourages the investment decisions, and therefore its probability decreases. As pointed out (see Sarkar, 2000), volatility causes two offsetting effects. On the one hand, volatility raises the investment threshold level of EBIT, thereby making investment less likely. On the other hand, a more volatile EBIT leads to an increase in the probability that it hits $\widehat{\Pi}^*$ sooner. If λ is low enough, the latter effect dominates the former one. The opposite is true when λ is high enough: in this case (i.e., when the former effect dominates the latter one), the investment timing is dramatically delayed by the sudden-death risk.

With regard to the optimal coupon, it can be seen that C^* approximately doubles when the sudden-death risk λ grows from 0 to 0.1. This means that, when λ is high enough, a startup may have

[12] We have run some robustness checks by using different parameter values. The effects are quite similar to the ones discussed in this paper. Of course, all numerical calculations are available upon request.

a shorter lifespan (due to either default or sudden-death) and, hence, decides to borrow more money. Of course, the higher the degree of financial market imperfections (the higher the parameter ω) the lower the coupon is. This is due to the fact that financial market imperfections raise borrowing costs.

As regards the contingent value of tax revenue, we can say that it is due to two offsetting effects. On the one hand, the contingent value of one euro, namely, $\left(\Pi/\widehat{\Pi}^*\right)^{\beta_1}$, is decreasing in $\widehat{\Pi}^*$. This means that the higher the threshold level of EBIT the lower the contingent value of one euro. On the other hand, given $\left(\Pi/\widehat{\Pi}^*\right)^{\beta_1}$, the higher the parameter ω the greater the amount of resources is. This result, which seems somehow surprising, is due to the fact that C^* is decreasing in ω. Hence, higher market imperfections lead to a decrease in the deductible coupon. Moreover, Table 2 shows that an increase in sudden-death risk causes a dramatic decrease in tax revenue: unless the government is more efficient than the private sector, sudden-death may cause a dramatic decrease in the contingent value of welfare. Looking at the welfare function, $W(\Pi)$, we see that it is increasing in volatility and decreasing in the sudden-death risk. In this latter case, sudden-death has a quite negative effect.

Table 3 shows the results of the same numerical simulation with the exception of a lower tax rate (20%). As can be seen, a startup's investment is made earlier. This is not surprising since a lower tax rate raises the contingent value of net profitability. However, we see that such a tax rate cut has a minor effect. The same result holds for the contingent value of the welfare loss and tax revenues. The most relevant effect regards $DWL(\Pi)$. As shown in Figure 1, there is a positive relationship between $DWL(\Pi)$ and ω (shown in the Tables 2 and 3). Moreover, the curves of Figure 1 are concave, which implies that, if the starting value of ω is low, an increase in financial market imperfections has a relevant effect on $DWL(\Pi)$ (and vice versa).

Table 2 Results of numerical simulations for different levels of credit market inefficiency (ω), sudden-death risk (λ) and volatility (σ) with $\tau = 0.30$.

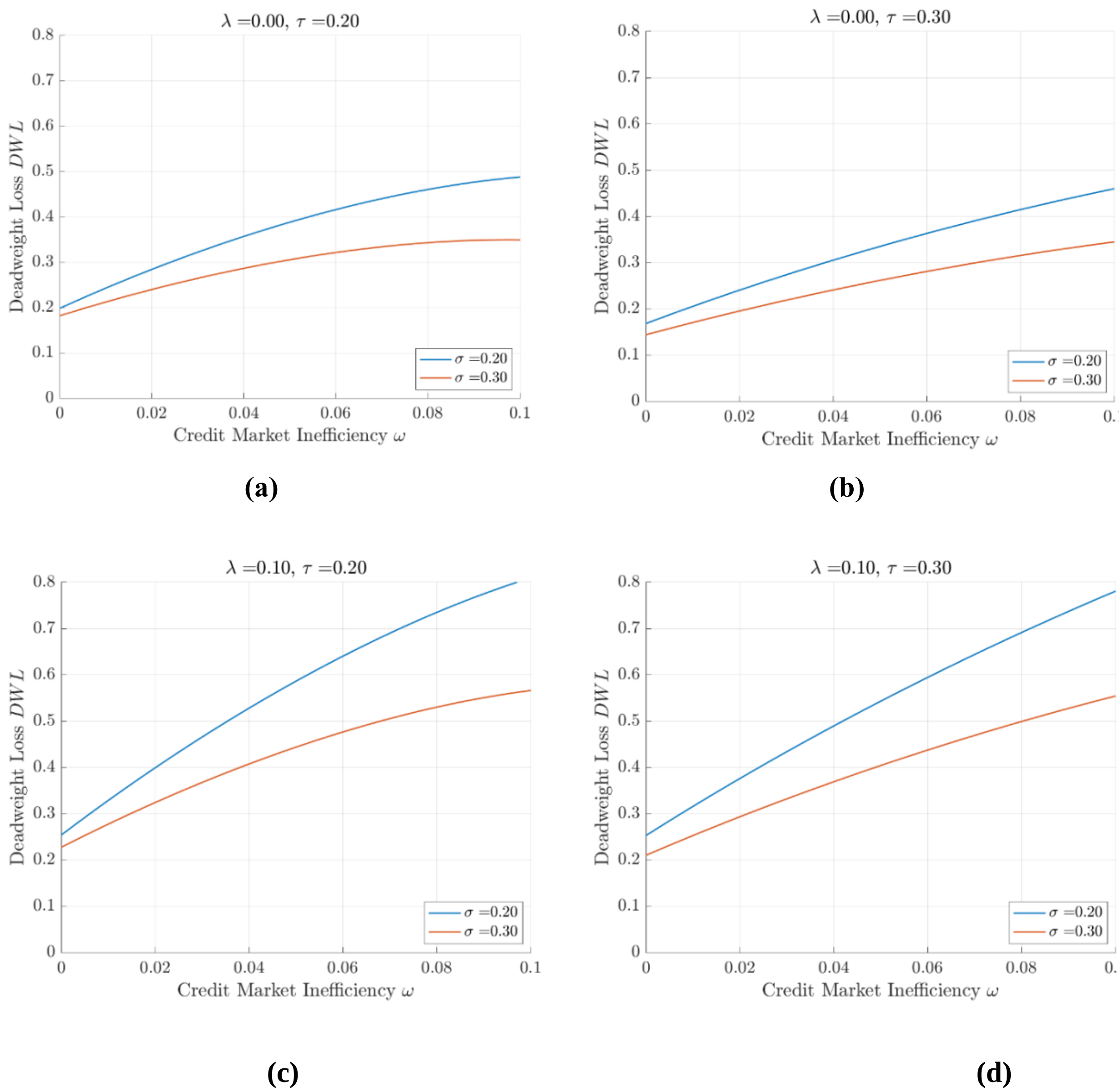
Credit access inefficiency	Variable	Scenario			
		$\boldsymbol{\lambda = 0.00}$		$\boldsymbol{\lambda = 0.10}$	
		$\boldsymbol{\sigma = 0.20}$	$\boldsymbol{\sigma = 0.30}$	$\boldsymbol{\sigma = 0.20}$	$\boldsymbol{\sigma = 0.30}$
$\boldsymbol{\omega = 0.00}$	$\bar{\Pi}$	4.65	5.38	13.16	13.76
	$\hat{\Pi}^*$	10.44	14.56	24.36	30.03
	C^*	10.11	15.88	19.73	24.73
	$P(t^* < 10)$	0.55	0.36	0.11	0.12
	R	14.46	16.65	0.33	0.86
	W	56.64	67.72	1.08	2.96
	WL	2.43	2.39	0.08	0.18
	DWL	0.17	0.14	0.25	0.21
$\boldsymbol{\omega = 0.05}$	$\bar{\Pi}$	4.64	5.25	13.41	13.79
	$\hat{\Pi}^*$	10.88	15.12	25.53	31.33
	C^*	9.43	14.46	18.78	23.12
	$P(t^* < 10)$	0.52	0.34	0.09	0.11
	R	15.00	17.34	0.34	0.88
	W	54.05	65.58	0.98	2.79
	WL	5.03	4.53	0.18	0.35
	DWL	0.34	0.26	0.54	0.40
$\boldsymbol{\omega = 0.10}$	$\bar{\Pi}$	4.53	4.96	13.47	13.53
	$\hat{\Pi}^*$	11.30	15.62	26.63	32.55
	C^*	8.63	12.82	17.68	21.26
	$P(t^* < 10)$	0.49	0.33	0.08	0.10
	R	15.50	18.01	0.33	0.89
	W	51.94	63.90	0.91	2.65
	WL	7.13	6.21	0.26	0.49
	DWL	0.46	0.34	0.78	0.55

Table 3 Results of numerical simulations for different levels of credit market inefficiency (ω), sudden-death risk (λ) and volatility (σ) with $\tau = 0.20$.

Credit access inefficiency	**Variable**	**Scenario**			
		$\boldsymbol{\lambda = 0.00}$		$\boldsymbol{\lambda = 0.10}$	
		$\boldsymbol{\sigma = 0.20}$	$\boldsymbol{\sigma = 0.30}$	$\boldsymbol{\sigma = 0.20}$	$\boldsymbol{\sigma = 0.30}$
$\boldsymbol{\omega = 0.00}$	$\bar{\Pi}$	3.97	4.34	11.78	11.84
	$\hat{\Pi}^*$	9.88	13.67	23.30	28.48
	C^*	8.63	12.82	17.68	21.26
	$P(t^* < 10)$	0.59	0.39	0.12	0.13
	R	10.37	11.81	0.25	0.63
	W	57.02	67.97	1.10	3.00
	WL	2.05	2.14	0.06	0.14
	DWL	0.20	0.18	0.25	0.23
$\boldsymbol{\omega = 0.05}$	$\bar{\Pi}$	3.74	3.90	11.57	11.24
	$\hat{\Pi}^*$	10.22	14.07	24.21	29.45
	C^*	7.66	10.83	16.33	19.00
	$P(t^* < 10)$	0.56	0.38	0.11	0.12
	R	10.94	12.52	0.26	0.65
	W	54.83	66.29	1.02	2.85
	WL	4.24	3.82	0.15	0.29
	DWL	0.39	0.31	0.59	0.44
$\boldsymbol{\omega = 0.10}$	$\bar{\Pi}$	3.30	3.15	10.90	10.02
	$\hat{\Pi}^*$	10.51	14.41	25.04	30.32
	C^*	6.38	8.26	14.53	16.00
	$P(t^* < 10)$	0.54	0.37	0.10	0.12
	R	11.71	13.51	0.26	0.69
	W	53.36	65.39	0.95	2.75
	WL	5.71	4.72	0.21	0.39
	DWL	0.49	0.35	0.81	0.57

Moreover, an increase in volatility (from $\sigma = 0.2$ to $\sigma = 0.3$) reduces $DWL(\Pi)$. In other words, the effect of the denominator of (12), namely, $R(\Pi)$, dominates that on the numerator, $WL(\Pi)$. Sudden-death risk exacerbates this effect: the gap between the blue and the red line dramatically increases when sudden-death is possible. Moreover, financial inefficiency has a tremendous impact on the magnitude of $DWL(\Pi)$. Since we cannot exclude the existence of tax competition, we therefore analyze the effects of a tax-rate decrease. In Figure 1, we also compare the effect of a tax-rate decrease from 0.20 (left panels) to 0.30 (right panels). This allows us to say that taxation has a minor impact on $DWL(\Pi)$.

Figure 1 Deadweight loss, represented as a function of credit market inefficiency (ω), for different levels of sudden-death risk (λ), volatility (σ) and tax rate (τ).



Not surprisingly, the existence of some sudden-death risk increases $DWL(\Pi)$ in a dramatic way, as opposed to the almost negligible effect of taxation. If we focus on volatility, we see that $DWL(\Pi)$ is decreasing in σ. This seems counterintuitive. However, as shown in (12), $DWL(\Pi)$ is the ratio between the welfare loss and revenue. Figure 1 therefore shows that the effect of σ on the denominator (revenue) dominates that on the numerator (welfare loss). Moreover, an increase in ω widens the gap between the blue and red curves. To sum up, while taxation has a minor impact on $DWL(\Pi)$, the converse is true for both financial market inefficiencies and the riskiness.

4. Conclusion

As we have shown, startup's decisions are dramatically affected by three out of four features that characterize developing countries. In particular, we have highlighted the crucial effect of risk, in terms of both EBIT volatility and sudden death, and of credit market inefficiencies. On the other hand, tax rate seems to have an almost negligible impact, while assuring the government to raise resources from established companies. These results are in line with the existing empirical literature (see, e.g., Mazorodze, 2023, and Munemo, 2017) and support developing countries' tax policy. We have also shown that, in order to boost startup investment, market inefficiency should decrease. In other terms, if a developing country's Government aims at increasing its number of startups, a decrease in riskiness and a more reliable financial market are crucial targets, rather than cutting tax rates.

Real-option models have a number of advantages, in particular the robustness of the quantitative approach and the ability to model uncertainty. Hence, they are a valuable tool to support decision-making. A *caveat* is however necessary. These models assume that economic agents make decisions based on rational evaluations of risk and returns, which might not fully capture behavioral complexity. Moreover, although we have considered riskiness according to different meanings in this paper, it still remains a simplified representation of the multifaced nature of uncertainty. Lastly, it is important to note that the model specification is the same for all developing countries, whose heterogeneity can be captured, however, by different calibration of parameters.

Despite these limitations, our model provides a theoretical rationale supporting the results of empirical literature about startups in developing countries. Our results, obtained numerical simulations, based on realistic data, can provide policy makers with a useful instrument aimed at better shaping their legislative system as well as tax policy.

A. Appendix

Following Comincioli et al. (2021) and using dynamic programming, at any time t the value of equity is:

$$E(\Pi) = \begin{cases} [(1-\tau)(\Pi - C) - \omega C]dt + e^{-idt}e^{-\lambda dt}\mathbb{E}[E(\Pi + d\Pi)] & \mathrm{b.d.} \\ 0 & \mathrm{a.d.} \end{cases}, \quad \text{(A.1)}$$

where the discount factor due to the risk-free interest rate appears together with the factor related to sudden-death risk. Following Panteghini (2007), the b.d. value of equity can be rewritten as:

$$E(\Pi) = \frac{1-\tau}{\delta}\Pi - \frac{1-\tau+\omega}{r}C + \sum_{i=1}^{2} A_i \Pi^{\beta_i}, \quad \text{(A.2)}$$

where $\beta_{1,2} = \frac{1}{2} - \frac{\mu}{\sigma^2} \pm \sqrt{\left(\frac{\mu}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}}$, with $\beta_1 > 1$ and $\beta_2 < 0$ are the solutions of the fundamental quadratic. According to Dixit and Pindyck (1994), the absence of financial bubbles implies that $A_1 = 0$. To find A_2 we exploit the value matching condition in correspondence of the default trigger point:

$$E(\overline{\Pi}) = \frac{1-\tau}{\delta}\overline{\Pi} - \frac{1-\tau+\omega}{r}C + A_2\overline{\Pi}^{\beta_1} = 0, \quad \text{(A.3)}$$

that gives (3). Similarly, at any time t, the value of debt is:

$$D(\Pi) = \begin{cases} Cdt + e^{-rdt}\mathbb{E}[D(\Pi + d\Pi)] & \mathrm{b.d.} \\ (1-\alpha)(1-\tau)\Pi dt + e^{-rdt}\mathbb{E}[D(\Pi + d\Pi)] & \mathrm{a.d.} \end{cases}, \quad \text{(A.4)}$$

Rearranging (A.4) therefore gives:

$$D(\Pi) = \begin{cases} \dfrac{C}{r} + \displaystyle\sum_{i=1}^{2} B_i \Pi^{\beta_i} & \mathrm{b.d.} \\ \dfrac{(1-\alpha)(1-\tau)}{\delta}\Pi + \displaystyle\sum_{i=1}^{2} F_i \Pi^{\beta_i} & \mathrm{a.d.} \end{cases}. \quad \text{(A.5)}$$

Since no financial bubbles exist, the equalities $B_1 = F_1 = 0$ hold. If the profit falls to zero, the value of debt is $D(0) = 0$. This means that $F_2 = 0$. To derive the value of B_2, we make the values of debt b.d. and a.d. equal at point $\overline{\Pi}$:

$$B_2 \overline{\Pi}^{\beta_2} = \frac{(1-\alpha)(1-\tau)}{\delta} \overline{\Pi}, \quad \text{(A.6)}$$

Rearranging (A.6) we therefore obtain (5). Let us next focus on problem (6). The first order condition with respect to C is:

$$\left(\frac{\Pi}{\widehat{\Pi}}\right)^{\beta_1} \left[\frac{\tau-\omega}{r} C - \xi(1-\beta_2)\left(\frac{\widehat{\Pi}}{C}\right)^{\beta_2}\right] = 0. \quad \text{(A.7)}$$

Thus, rearranging (A.7) gives the optimal ratio between C and $\widehat{\Pi}$:

$$\frac{C}{\widehat{\Pi}} = \left[\frac{\tau-\omega}{r\xi(1-\beta_2)}\right]^{-\frac{1}{\beta_2}}. \quad \text{(A.8)}$$

The first order condition of (6) with respect to $\widehat{\Pi}$ is:

$$\frac{(1-\beta_1)(1-\tau)}{\delta} + \frac{C}{\widehat{\Pi}}\left[(\beta_1-\beta_2)\xi\left(\frac{\widehat{\Pi}}{C}\right)^{\beta_2} - \frac{\tau-\omega}{r}\beta_1\right] + I\frac{\beta_1}{\widehat{\Pi}} = 0, \quad \text{(A.9)}$$

which, using (A.8), leads to (7) and (8).

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