Cilt/Volume 9 | Sayı/Issue 1 | Haziran/June 2020 | 83-110

Data-Driven Investment and Innovation Decisions for Entrepreneurs

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ABSTRACT

Purpose: This study aims to investigate the effect of financier selection options over the optimal actions of entrepreneurs in a Markov modulated setting.

Methodology: The problem in the paper is modeled by Markov decision process and solved using dynamic programming equation. The parameters are estimated using the inference from OECD statistics and the Global Entrepreneurship Monitor survey.

Findings: It was found that survival first entrepreneurs are prudent in taking growth or innovative actions. However, they become more aggressive if they also prioritize expected wealth, or they are financed by experienced venture capitals.

Practical Implications: The study reveals the importance of different financing schemes for entrepreneurs such as venture capital or business angels. Particularly by the guidance of experienced financiers, the early phase entrepreneurs can grow faster and safer.

Originality: In this study, we model both the financier selection and policy decisions of entrepreneur firms with different objective functions using a 2-state Markov process in a data-driven approach.

Keywords: Markov Decision Process, Entrepreneurial Finance, Innovative Decision Making, Survival First.
JEL Codes: C44, C02, L26.

Girişimciler için Veriye Bağlı Yatırım ve Yenilik Kararları

ÖZ

Amaç: Bu çalışmada, Markov sürecine bağlı bir ortamda yatırımcı seçim probleminin girişimci karar ve stratejilerine etkisinin incelenmesi amaçlanmıştır.

Yöntem: Makalede incelenmiş olan problem Markov karar süreci kullanılarak modellenmiş ve dinamik programlama yöntemi kullanılarak çözülmüştür. Problem parametrelerinin belirlenmesi için OECD istatistikleri ve Küresel Girişimcilik Araştırması sonuçları kullanılmıştır.

Bulgular: Öncelikli olarak firmalarının varlığını sürdürmesini amaç edinmiş olan girişimcilerin, büyümeye ya da inovasyona yönelik karar almada daha çekingen davranabilecekleri bulunmuştur. Fakat şirket büyüklüğünü de göz önüne alan bir amaç fonksiyonları olması durumunda, ya da deneyimli bir risk sermayesi yatırım şirketi ile iş birliği yapmaları halinde daha cesur kararlar alabildikleri ve firmalarının daha değerli olduğu sonucuna varılmıştır.

Sonuç ve Öneriler: Bu çalışma girişimciler için melek yatırımcılar ya da risk sermayeleri gibi farklı yatırımcı alternatiflerinin önemini göstermiştir. Özellikle deneyimli yatırımcıların yol göstericiliği ile erken dönem girişimcileri daha hızlı ve güvenli büyüme şansı elde edebilirler.

Özgün Değer: Bu çalışmada farklı tipteki girişimciler için hem finansör seçimi hem de karar süreçleri 2 durumlu Markov modelleri yardımıyla bir arada modellenmiştir. Bu yöntem girişimcilik literatürü için yenilikçidir. Ayrıca model parametreleri farklı araştırma verileri kullanılarak gerçek hayat değerlerine daha uyumlu olacak şekilde belirlenmiştir.

Anahtar Kelimeler: Markov Karar Süreci, Girişimci Finansı, Yenilikçi Karar Verme, Yaşam Önceliği.
JEL Sınıflandırması: C44, C02, L26.

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Araştırma Makalesi (Research Article)
Geliş (Submitted) : 23/02/2020
Düzeltme (Revision) : 02/05/2020
Kabul (Accepted) : 04/05/2020

1. Introduction

The key driver for economic growth in the modern environment is the innovative products and services derived by the start-up companies (Minniti and Lévesque, 2008; Baumol, 2002). Acs (2006) illustrates the mechanisms through which entrepreneurship drives economic growth. Out of different factors, innovation is the essential element for the success and growth of firms. Zhao (2005) states that entrepreneurship and innovation are highly correlated to each other, and through this interaction, they help economic growth.

Although many companies are founded each year, only a few ventures reach a significant size (Cassar, 2004). According to the European Startup Survey 2016 (Kollmann et al., 2016), a start-up company usually starts with the founder's or the friend/family money at the seed stage rather than getting large amounts of funding from investors. However, the resources of the founders are scarce. Therefore, for the entrepreneur, a fundamental strategic decision is the dilemma of whether to use the limited funds for the traditional activities such as short term robust development of the firm or to the innovation of new products or services (Osterwalder and Pigneur, 2010). The critical decisions made at this stage are the key to success.

In the last few decades, the venture capital industry has also become one of the leading factors for entrepreneurial finance and innovation. The industry giants such as Alphabet, Microsoft, Amazon, Apple, or Facebook all started as small start-ups and supported by the venture capitals. According to the data published by the National Venture Capital Association (2020), the yearly venture capital investments grew from $170 billion in 2005 to $444 billion in 2019. Venture capital backed companies employ 38% of the US workforce and account for the 85% research spending in the US (Gornall and Strebulaev, 2015). The economic growth due to start-up companies stems from the advances in venture capital opportunities.

Another source of capital is the angel investors, who are ready to invest in earlier stages of the start-up, but the assistance they can provide to business is usually limited. Collewaert and Sapienza (2016) state that even in some cases, the conflict between the angel investor and entrepreneur because of different priorities can affect the innovativeness of the firm. The support given by venture capital is well structured; however, it is usually hard for the entrepreneur to get

that support in the early stages. Other types of financing are government subsidies, incubators, bank loans, or crowdfunding (Kollmann et al., 2016). These are finance only options without extensive mentoring or taking part in management.

Start-ups use stage finance with different financing sources and different investment amounts in each round through their expansion periods (Gompers, 1995). Schwienbacher (2013) analyzes the effect of stage finance over the incentives of entrepreneurs and, therefore, why start-ups select various investors according to their needs at different stages of development.

In this study, we develop a dynamic optimization model for an entrepreneur that chooses between different types of investors at different stages. We assume that the state of the entrepreneur can be either traditional or innovative, and a firm changes the state through costly efforts by the entrepreneur according to a Markov chain. Different actions result in a trade-off between steady growth with low risk, risky high growth, or expensive innovation actions for an early-stage entrepreneur.

The contributions of this study can be summarized as follows. First, different databases from various sources are examined to estimate the model parameters. Second, the research question in entrepreneurship on how different decisions can affect investor choice and innovative capabilities is investigated. Besides, the growth patterns of start-ups through the usage of Markovian models, where the state variable defines the innovative strength of the firm, is analyzed.

The paper is organized as follows. In Section 2, we discuss the related literature. In Section 3, we introduce the data sources and the Markov decision model. We present the computational results in Section 4, and the conclusion in Section 5.

2. Literature Review

Entrepreneurial firms have the most crucial role in the development of pioneering industries, therefore, in economic growth, through their flexibility in the production of new products, or the adoption of new technologies which also increases productivity (Van Stel et al., 2005). However, most of the start-up firms are tight on capital resources. As Van Stel et al. (2005) state, nascent firms face difficulties attracting funding opportunities due to high risk.

The financial opportunities and needs of entrepreneurial firms are different at every stage, from seed to the mature, which is called the "financial growth cycle paradigm" by Berger and Udell (1998). Carpenter and Petersen (2002) state that at the initial stages, the start-up firm has information opacity; therefore, the firm will have difficulties in access to traditional external financing, such as bank debts. Hence, the entrepreneurs will either use internal funding from friends and family or business angel opportunities. Also, Gregory et al. (2005) empirically show that in the financial growth cycle, bank financing is usually available after the growth stage when there are steady income and track record of positive cash flow. However, Cassar (2004) argued that bank finance has also been used by many start-up companies during the early phases. Cunat (2007) empirically states that trade credit compared to other debt sources are practiced more as the company grows. In their analysis of manufacturing start-up firms in France, Hirsch and Walz (2019) fortify the importance of bank financing and trade credit in the initial stages of entrepreneur firms.

Venture capitals usually focus on firms during the development stage, which bears high return potential with the high risk involved (OECD, 2015). Keuschnigg (2004) stated that traditional funding sources such as financial institutions are not always interested in these high-risk firms or can impose higher risk premiums or guarantees from the owners; therefore, recent advances in the financing concepts such as venture capitals or business angels play an essential role at start-up financing.

In the area of entrepreneurial finance, the objective of both the entrepreneur and the investor is defined over the monetary terms (see Casamatta, 2003; Chemmanur and Chen, 2014; De Bettignies and Brander, 2007; Tavares-Gärtner et al., 2018). On the other hand, Burchardt et al. (2016) state that the investors and the entrepreneurs usually have different priorities due to imbalanced financing structures, and the entrepreneurs associate substantial non-monetary benefits with the existence of the firm and their role in it. Even Bergemann and Hege (1998) express that this misalignment can result in moral hazard problems. Archibald and Possani (2019) approach this problem assuming that, contradictory to the investor who optimizes the expected return on investment, the entrepreneur maximizes the survival probability of the company. They state that this inference is more acceptable for entrepreneurs that prioritize to fund their income from the company rather than a risky high growth strategy, who are

defined as "lifestyle" entrepreneurs. According to De Bettignies (2008), lifestyle entrepreneurs add up to 90% of all new firms; therefore, they constitute the largest part of the group.

According to Schwienbacher (2007), an unsuccessful entrepreneur will possess problems for future financing opportunities; therefore, the entrepreneurs' primary objective is the survival of the current firm. Empirically, Wennberg et al. (2016) explicate how the entrepreneurs make their decision based on survival and conclude these decisions are highly affected by the age of the venture where early phase companies are more concerned about survival. Camuffo et al. (2019) used an empirical approach and used data from entrepreneurs to analyze how they make strategic decisions and how their decisions affect the exit and failure probabilities. Since we examine the decisions of entrepreneurs in the early stages, we use the survival of the company as one of the objectives in our analysis.

The entrepreneurial activity in various countries differs due to institutional differences. Chowdhury et al. (2019) analyzed 70 countries and concluded that institutional dimensions such as regulations, availability of various financing options, or availability of human capital affect the quality and quantity of innovations. Similarly, Fredstörm el al. (2020) analyzed the effects of regulations among different countries. Lewis et al. (2020), on the other hand, analyzed the crowdfunding financier possibilities in different market environments. All these studies suggest that local factors are important drivers of entrepreneurial success. Therefore, we look at the differences in entrepreneurial environments through OECD statistics and Global Entrepreneurship Monitor surveys.

The entrepreneurial environment is one of the drivers of innovation. Li et al. (2019) showed that entrepreneurship and innovative factors have a high correlation, and innovative start-ups are the driving factors for the performance of the enterprises. Hacıoğlu (2019) discussed that for sustainable development, the innovation ecosystems are indispensable, and innovation technologies determine the competitive power of countries. Keskin (2018) stated that innovation is an opportunity for entrepreneurial businesses, and long-term innovation activity is the key to successful start-ups. We define the innovativeness of the firm as one of the states.

The Markovian structure has long been used to describe the business cycles in economic models (Pye, 1966) and the dynamic behavior of the financial mar-

kets (Costa and Araujo, 2008; Çanakoğlu and Özekici, 2009). In entrepreneurial portfolio management, Çanakoğlu et al. (2018) used a partially observable market structure for the environment. In all these studies, Markov models are used to model the market environment as a whole. Archibald and Possani (2019) used the Markov decision process to solve the dynamic of the model. However, in their model, there is no state variable except the value process. In this paper, we use the Markov definition through a state variable that defines the innovative capability of the firm.

3. Methodology

In this section, we first introduce the datasets we use to estimate the problem parameters and then present the dynamic model for decision making, where we define the different types of financier properties.

3.1. Data Analysis

In this paper, we use two main data sources, Organization for Economic Co-operation and Development (OECD) and Global Entrepreneurship Monitor (GEM) surveys

3.1.1. OECD Statistics

We used the data from the "Structural and Demographic Business Statistics" database from OECD (2020). This database is collected over OECD member states about the changes in the business environment. The statistics in this database are very detailed over each sector and include information about turnovers, production, employment, and churn ratios. We used the database to analyze the birth and death ratios over new enterprises to analyze and estimate the success probabilities for the entrepreneur firm.

The variables used for the estimation of success probabilities are the birth and death rates of all enterprises in the country, either with an employee or without an employee. The survival rates of the enterprises which are defined only for the new firms give information about the death rates of entrepreneurs. Another related variable is the ratio of entrepreneurs in the country.

These variables gathered from OECD (2020) for a sample of European coun-

tries are illustrated in Table 1 for 2015. The ratio of one-year-old companies varies between 7.78% in Spain to 13.35% in the UK. The first-year survival rates are around 80% for most of the sample countries except the UK. These findings show that the UK is more start-up friendly compared to the others. In year two, the UK still has the highest survival rate; however, after year three, the survival rates balance out between different economies. This phenomenon can be explained by the basis that, although the environment can help start-ups to survive in the seed stage or early phase; when an entrepreneur reaches a growth stage the probability of survival is more or less similar between countries depending on the capability of the entrepreneur rather than the environment. Therefore, in structured environments, more companies may reach to growth stage. However, the competition would be harsh, and the survival rates will even out after three years.

Table 1. Results for the OECD statistics

	France	Hungary	Spain	Turkey	UK	Bulgaria
Birth rate (%)	9.40	10.70	9.20	12.10	14.80	11.90
Death rate (%)	5.30	8.20	8.50	..	10.80	10.30
1-year survival rate (%)	81.60	79.00	76.60	84.70	92.10	80.80
2-year survival rate (%)	69.90	69.10	64.90	68.00	74.70	67.70
3-year survival rate (%)	60.00	53.20	54.10	56.90	58.90	59.70
Ratio of one-year-old (%)	9.24	11.75	7.78	10.69	13.35	11.15
Ratio of two-year-old (%)	7.48	7.22	6.30	8.13	10.69	7.18

3.1.2. Global Entrepreneurship Monitor

GEM is one of the most important databases for statistics regarding entrepreneurial activity throughout the world. GEM is a consortium of teams from participating institutions that carries out two main surveys in their national country. There are two main data sources. The first one is the "Adult Population Survey" (APS), where data is collected on entrepreneurship directly from individual entrepreneurs. The social attitudes towards entrepreneurship are analyzed using surveys applied to both the entrepreneurs and the general public using a sample of at least 2000 representatives in each country. The second data source is the "National Expert Survey" (NES), where a detailed questionnaire is filled by 36 experts in every participating country about the business environment of entrepreneurship in that country.

The NES questionnaire comprises several sections. The first section is composed of nine blocks of items, with several questions at each block, designed using the 9-level Likert scale, where one corresponds to completely false, and nine corresponds to completely true. The first block is related to the financial options for Entrepreneurs. We use the finance block to see the different types of funding available and their availability levels for investors according to the expert's opinion. The question of "*In my country, there is sufficient .... funding available for new and growing firms*" is asked for different funding opportunities to the participants. The types of funding considered in this paper are; i) equity, ii) debt, iii) government subsidies, iv) informal investors (family, friends and colleagues), v) professional Business Angels, vi) venture capitalists, vii) initial public offerings (IPOs), and viii) private lenders' funding (crowd-funding). The mean values for the usage rates of various financing alternatives using a Likert scale of nine points throughout different years are summarized in Table 2.

Table 2. Results for the National Expert Survey (financing) - Global Entrepreneurship Monitor

Financing Type	TR	USA	SP	IT	UK	GR	BR
Equity	4,67	**6.24**	3.89	4.33	5.17	3.37	4.02
Debt	4,51	5.08	4.25	4.28	5.12	2.7	**4.57**
Government subsidies	**4,97**	4.24	4.28	4.03	4.48	3.73	4.11
Family-friends	4,17	6.21	**4.72**	**4.75**	5.39	**4.00**	4.42
Business angels	4,73	5.84	3.92	4.31	5.64	2.90	4.39
Venture capitalists	4,35	5.95	3.61	4.14	5.31	3.31	3.67
IPOs	4,26	5.73	3.32	3.54	5.00	2.37	3.22
Crowdfunding	2,93	5.49	4.00	3.29	**6.10**	2.86	4.53

In different economies, different types of financing opportunities become more important. For example, in emerging economies like Turkey, some of the aforementioned financing opportunities are not available; therefore, government subsidies are one of the most important support for start-ups. In other Mediterranean countries, family and friends' money is the most important source of funding for entrepreneurs. However, in the US, the entrepreneurs use their equity, whereas in the UK, a new way of fund generation, crowdfunding is specified as the most important capital resource. In Brazil, bank debts are the main source of capital for start-ups. As a result, the business environment differs a lot between different economies, which should is reflected in the models developed.

The APS data is concentrated on entrepreneurial behavior and attitudes. In this survey, enterprises are divided into three different categories: nascent start-ups (business less than one year), baby businesses (between one and 3.5 years), and established businesses (over 3.5 years). A widely used index by GEM, "Total early-stage Entrepreneurial Activity" (TEA) incorporates the percentage of the population that is either nascent or baby business owner. The TEA index includes both the innovative start-ups and the newly established regular small firms. The value of TEA opportunity based is used to measure how nascent entrepreneurs identify the business opportunities at the markets as promising. These types of business owners are driven to entrepreneurship by opportunity instead of a lack of other work possibilities. Therefore, their businesses are expected to involve in more innovative opportunities.

Table 3. Results for the Adult Population Survey (selected titles) - Global Entrepreneurship Monitor

	TR	USA	SP	IT	UK	GR	BR
TEA	9.95	12.73	5.21	3.43	7.14	5.51	17.31
Necessity motive	30.25	21.21	29.17	18.66	16.11	23.41	28.60
Offer same product - Few	29.77	38.7	37.31	28.48	38.11	39.84	29.64
Offer same product - None	8.74	21.27	11.19	7.82	13.39	7.35	7.08
Latest technology (last year)	7.06	10.9	11.98	26.7	9.05	25.07	0
New technology (1 to 5 years)	22.91	18.33	17.04	19.98	19.3	23.68	0.54
Exit past year	6.36	3.75	1.91	1.9	1.92	5.03	4.7
Exit (%) problems	47.52	51.73	69.44	36.26	35.25	61.15	46.55
Exit (%) opportunity	14.17	16.08	8.86	10.94	34.66	6.42	15.81
Exit (%) other	38.31	32.19	21.7	52.8	30.09	32.43	37.64

The percentage of TEA is given in the first row of Table 3. The average percentage is around 9%, where the values are between 3.4% to 17.3%. The TEA is divided between necessity motive and opportunity motive, where the necessity motive entrepreneurs are between 15-30% of all the TEA. These entrepreneurs are lifetime entrepreneurs because they do not have any other choice. Therefore, for them, the survival of the business is very important, and it is the primary objective.

In the APS study, there are questions related to the products (or services) of the TEAs in terms of competitors. We assume that the companies that offer products where there are no competitors or only a few competitors can be included to be in the innovative state. The companies without competitors for the product are usually between 7-13% (The only exception being the USA with 21.3%), however when added with the case of few competitors, the total percentage of firms increases to around 40-50%. Another metric that can be used for innovativeness is the technological level of the enterprise. We assume that the companies using the latest (only available since last year) or new (available between 1 to 5 years ago) technology can be included in innovative companies. According to that assumption, the technologically innovative companies are between 30% to 50% (except Brazil where data seems to be inaccurate). Therefore, using either assumption, we can conclude that one-third to one-half of the companies are in the innovative state, whereas the remaining are regular firms.

Another information we used from the APS survey is the exit percentages and reasons for exit. The percentage of interviewees that exited from a business partnership is 2-6% or one-third to one-half of the TEA values. Around half of the exits are because of problems such as unprofitable firms or bankruptcies, whereas 20% are due to successful exits or better opportunities. The remaining are because of undisclosed personal reasons or retirement. Therefore, we can conclude that half of all exits are due to an unsuccessful business.

3.2. Model

In this study, we assume that the entrepreneur decides between different types of funding opportunities according to the different effort levels provided by the financier (investor/bank debt/…) and different payback structures. The conditions of the agreement are decided at the time of the decision, and we assume there is no moral hazard that both sides have perfect information about either the risk or the capabilities of the counterpart.

In the model, we consider an entrepreneur who is the owner and decision-maker of a start-up company. The decisions made by the entrepreneur at each stage are both financial and operational. The financial decisions can be summarized as the financier and amount of funding capital at each stage. For different types of financiers, the payback structure of the funding depends on the

amount of capital injected, effort spent, and the risk associated with the opportunity. At every stage of the problem, a different funding source can be selected.

The financial decisions relate to the amount and time of the capital invested by the financier, and the time and structure of back-payments from entrepreneur to financier. In particular, the financial decisions affect the way the firm is managed concerning the effort by the entrepreneur. Therefore, the initial investments and cash flow structure determine the payoffs for the entrepreneur and the financier. In addition to financial decisions, the entrepreneur performs operational decisions such as efforts. The operational decisions constitute the spending levels (efforts) at each decision-making epoch. There are two types of efforts that are traditional and innovative. The traditional efforts incorporate activities that include both daily activities and different levels of growth strategies. However, the innovative efforts are used to change the type of the firm from a traditional firm to an innovative firm. We model the decision-making problem using the undermentioned Markov decision process which represents the type of firm.

3.2.1. Markov Decision Process Model of Firm

We assume that the type of firm, defined through its state, represents the innovative capability of the firm. The profit and growth of the firm depend on the so-called "innovative capability". The innovative capability is represented by a stochastic process, where the states change randomly depending on the decisions of the entrepreneur. Modeling a stochastic process by a Markov chain is a reasonable approach where the next state of the firm depends only on the current state and the innovative effort taken by the entrepreneur. In this paper, we assume a two-state Markov chain where the states represent an innovative firm or a traditional firm. One should note that the model generated in this paper can be extended to multiple states more than two using a similar procedure.

We assume that Z_t denotes the type of the firm defined through its state at time *t,* where state '1' represents the innovative case and state '0' represents the traditional case. The Markov decision chain is the stochastic decision process $Z = \{Z_t ; t = 0,1,2 \ldots,\}$ where the transition probability matrix is defined as Equation (1) over a state space of $E = \{0,1\}$.

$$Q(i, j, d) = P\{Z_{t+1} = j \,|\, Z_t = j, d_t = d\} \quad (1)$$

In Equation (1), action $d_t = d$ denotes the operational decision taken at period t. $Q(i,j,d)$ is defined as the probability of being in state in period $t + 1$ given that the state was equal to i and the decision was d_t at time t. The operational decision influences the transition matrix because the transition of states depends on the innovative effort that is spent, which is represented through an action space.

3.2.2. Basic Setup

We assume that the entrepreneur deals with all the decisions through a time interval of T periods. However, the financier can only be in the game for only N periods. The contract between financier and entrepreneur determines the initial payment of C_0 by the financier and the payback amounts $-C_t$ at each period if the contract is debt-based or the percentage of ownership α if the contract is investment-based. Note that C_t for each period $0 \leq t \leq T$ represents the cash flow from the financier to the entrepreneur. That is the reason for the minus sign in front of the $-C_t$ in traditional bank debt. The model can easily be used for non-traditional financing structures such as staging with proper signs for the cash flow. For the investor type of financier, the ownership percentage α is also initially negotiated at the time of contract.

After securing the initial investment, the entrepreneur manages the firm throughout the planning horizon. At each period, depending on the state of the firm and the amount of capital at hand, the entrepreneur decides on the level of effort. We discretized the effort levels into M distinct levels with different growth patterns over changing return and risk structure, some of which also incorporate innovative actions. In particular, at each period the effort pays off either with a positive return for a successful company or negative return for an unsuccessful company. Also, at each period, the company either changes state or remains on the same state through the transmission matrix randomly according to the selected action.

The parameters depending on the decision are summarized as;

- $G(i, d)$: positive return (gain) for a type i firm if the firm is successful at a given period ($G(i, d) > 0$);
- $L(i, d)$: negative return (loss) for a type i firm if the firm not successful at a given period ($L(i, d) < 0$);

- $p(i, d)$: success probability of type i firm ($0 \leq p(i, d) \leq 1$:);
- $Q(i, j, d)$: probability that type i firm will be type j ($0 \leq Q(i, j, d) \leq 1$, $\sum_{j \in J} Q(i, j, d) = 1$).

If in a given period action d is chosen then the profit (increase in the total wealth) will be equal to $G(i, d)$ with probability $p(i, d)$, and $L(i, d)$ with probability $1 - p(i, d)$. Therefore, the expected profit for the firm can be calculated as the weighted average of success and failure returns using the success probability by Equation (2).

$$E[W] = p(i, d)\, G(i, d) + \big(1 - p(i, d)\big)\, L(i, d)$$
$$= p(i, d)\, \big(G(i, d) - L(i, d)\big) - L(i, d). \tag{2}$$

The profit is similar to a binomial distribution with return value equal to $G(i, d) - L(i, d)$ minus the value of $L(i, d)$. Therefore, we can use the variance of binomial distribution to derive the variance of the profit as Equation (3).

$$\big(1 - p(i,d)\big)p(i,d)[G(i, d) - L(i, d)]^2. \tag{3}$$

We assume, the decisions with lower expected profit either have lower variance, which represents the risk involved or has a higher probability of moving from a traditional state to an innovative state. For simplicity, we assume that the decisions and parameters associated are time-invariant; however, a time-dependent model can also be modeled similarly.

We define the sequences of the events is as follows. First, in the first period, the entrepreneur decides on the amount of investment needed and announces this to different financiers/investors, and the payback structure (cash flows or the partnership percentages) is gathered from the financiers. The entrepreneur selects one of the options. Then, including the first, at the start of each period entrepreneur chooses the decision for that period. Then, the outcome for the company at that period (successful or not) and the state of the company (innovative or regular) is observed. At each period, if there is a cash flow between the party's payments are performed. Finally, the current wealth of the firm is calculated and if the company is not bankrupt the next period decisions are taken. For a

bankrupt company, we assume that the probability of survival becomes zero, and the cash wealth will continue to be zero after the given period. The financier will not be able to collect any fee after the company becomes bankrupt.

3.2.3. Dynamic Programming Model

In this paper, we explore two objectives for the entrepreneur. In the first model we assume the entrepreneur has the objective of wealth maximization at the terminal time T through the actions from the decision space. Alternatively, we define another objective function where the objective is to minimize the probability of bankruptcy. The terminal utility function can be defined for either one of the two cases, and the dynamic programming equation can be solved for the corresponding case.

In this paper, we explore two objectives for the entrepreneur. In the first model, we assume the entrepreneur has the objective of wealth maximization at the terminal time T through the actions from the decision space. Alternatively, we define another objective function, where the objective is to minimize the probability of bankruptcy (or maximize the probability of survival). The terminal utility function is defined for either one of the two cases, and the dynamic programming equation is solved for the corresponding case. In particular, the utility function at terminal time for a wealth-maximizer entrepreneur is defined as Equation (4) whereas the utility function for the survival-first entrepreneur is defined as Equation (5).

$$U_w(x_T) = \begin{cases} x_T & x_T \geq 0 \\ 0 & x_T < 0 \end{cases}$$

$$U_S(x_T) = \begin{cases} 1 & x_T \geq 0 \\ 0 & x_T < 0 \end{cases}$$

The aim of the dynamic programming is to derive the optimal actions for each period and each state, and the corresponding expected utility function defined as the value function $v_t(i, x)$. At the terminal time T value function will be equal to the utility function $v_t(i, x_T) = U(x_T)$ for any state i. For time $t = T - 1$ we let $h_{T-1}(i,x,d)$ be the utility gathered for action at time period $T - 1$. Therefore, one can write the function as Equation (6) where Z_T is calculated using the Markov process and X_T is calculated by the gain/loss amounts and probabilities.

$$h_{T-1}(i,x,\mathrm{d}) = E^{d}[v_{T}(z_{T},X_{T})|Z_{T-1} = i,X_{T-1} = x,d_{T-1} = d\ ] \tag{6}$$

Therefore, for an appropriate utility function $U(x)$ either as in Equation (4) or Equation (5) the expected utility at time $T-1$ can be written as Equation (7).

$$h_{T-1}(i,x,\mathrm{d})=\sum_{j\in J} Q(i,j,d)\ \left[p(i,d)U\big(x+G(i,d)\big)+(1-p(i,d))U\big(x+L(i,d)\big)\right]. \tag{7}$$

The value function corresponds to the optimal action d^*, therefore, the value function at time $T-1$ is equal to Equation (8) where $h_{T-1}(i,x,\mathrm{d})$ is defined as in Equation (7). The optimal action can be found testing all possible actions since the action set is discrete.

$$v_{T-1}(i,x) = \max_{\mathrm{d}}\ h_{T-1}\,(i,x,d) \tag{8}$$

For time $t<T-1$, we similarly define $h_{t}(i,x,\mathrm{d})$ as the utility gathered (expected wealth for the wealth-maximizer entrepreneur and one minus the probability of bankruptcy for the safety-first entrepreneur) from action d, constrained by total wealth x at time t and optimal decisions d^* from $t+1$ to terminal time T. Also, assume that the type of the firm at time t is equal to i. Then one can define the optimal expected utility at time t as choosing the action d where Equation (9).

$$v_{t}(i,x) = \max_{\mathrm{d}}\ h_{t}\,(i,x,d) \tag{9}$$

Using the well-known dynamic programming principle of Bellman (1966) as Equation (10) where j is the state of firm for the next period.

$$h_{t}(i,x,d) = E^{d}\ [v_{t+1}(j,x_{t+1})] \tag{10}$$

The entrepreneur's optimal utility maximization problem in Equation (9) can be written as Equation (11) and since we defined the binary scenarios for each decision as positive return and negative return only, we can derive dynamic programming as Equation (12).

$$v_t(i,x) = \max_{d} E\left[\sum_{j\in J} Q(i,j,d)\ v_{t+1}\ (j,\ x_{t+1})\right] \tag{11}$$

$$v_t(i,x) = \max_{d} \sum_{j\in J} Q(i,j,d)\ \big(p(i,d)v_{t+1}(j,\ x_t + G(i,d)) + (1-p(i,d))v_{t+1}(j,x_t + L(i,d))\big) \tag{12}$$

Since, in our setting the number of next period possibilities and decisions are discrete, the solution for DP in Equation (12) can be found with a recursive solution procedure over the whole set of decisions at every time period.

3.2.4. Financier's Cash Flow Function

We assume the objective of the financier is to guarantee a risk-neutral return plus a risk premium for uncertain cash flow streams and cost for their effort in the case of value-creating financiers. In this paper, we assume that there is information symmetry between the parties, and we did not include a moral hazard problem.

We assume that there are three main types of finance sources. The first one is the fixed payment contracts. Bank debts and trade credits are included in this type of finance source. In this type of finance, C_0 is equal to the discounted value of payments with a discount factor that is a factor of the risk in the entrepreneur. Therefore, for a debt of N periods, the balance between the initial debt and payments can be written as Equation (13) where r is a risk adjusted discount rate.

$$C_0 = -\sum_{t=1}^{N} \frac{C_t}{r^t}$$

The second type of financier is the silent partner. These type of financiers own 100 x α percent of the company, however, does not contribute to the growth of the company and does not have any effect on the decisions. We assume that in-

vestment from family and friends, as well as business angels and crowdfunding, are included in this category. The business angels can contribute to the growth in some cases. However, in this situation, they should be analyzed in the third type of financier. For the silent partner, the expected payoff is equal to the expected value of the company at time T. In order to calculate the percentage, we assume Stackelberg game where the silent partner calculates the expected value for the company $E[V(T)]$ and expects to own 100 x α percent of the company where Equation (14) defines a limit for the silent partner ownership percentage

$$C_0 \leq \alpha \frac{E[V(T)]}{r^T} .$$

We assume that the entrepreneur is the strong party in negotiations for α, therefore, Equation (14) is satisfied as equality. During the contract building process, the silent partner calculates the value of the firm assuming the optimal actions, and calculated α as a result.

The third type of the financier contract analyzed in this paper is the venture capital. The venture capitals not only invest in the company financially but also sits on the board to participate in the decisions. They spend the effort to help the growth of the company. Therefore, they expect to gather higher amounts of stock percentage from the company. We assume that in the case of venture capital, there are alternative sets of decisions, where the venture capital firm spends extra effort. In these decisions, there is a cost for the venture capital firm related to the effort spent. This cost is paid by the venture capital therefore the total payoff from the partnership is expected to cover the initial capital and the expected costs of the efforts. Although the initial capital investment is certain, the effort spent and the associated cost is not certain since they depend on the decisions taken. As a result, we calculate the discounted expected value of the costs for the effort according to the optimal policy of the decision set. The inequality for the venture capital firm is expressed as Equation (15) where E[e(t)] cost of the expected effort spent by venture capital firm at time t. Similar Equation (14), we assume that Equation (15) is satisfied as equality.

$$C_0 + \sum_{t=1}^{N} \frac{E[e(t)]}{r^t} \leq \alpha \frac{E[V(T)]}{r^t} ,$$

Note that we are interested in the cases with two negotiating parties. Therefore, out of the financier options in Table 2, we did not include the cases of self-equity, IPO, or government subsidies in our analysis.

4. Computational Experiments

4.1. Design of Experiments

A series of computational experiments are designed to illustrate the effect of different strategies and investor selection for entrepreneurs. More specifically, we intend to answer the following questions:

- How do different financier types affect the value process of entrepreneurs.
- What is the impact of different objective functions for entrepreneurs?
- What is the impact of different market parameters over the decisions of start-up firms?

We develop a dynamic programming model for the decision-making problem of the entrepreneur and derive the corresponding investor preferences using survival and wealth maximization objective functions. We set the parameters using the inference form the datasets introduced in Section 3.1.

We model our problem for a time step of three months (quarters), which is a common practice both in terms of budget announcements and tax regulations in many countries. We analyze the problem for $T = 14$, which includes the nascent start-up and baby business phases according to the definition from GEM.

We assume that there are two states for a company, being the regular ($i = 0$) and innovative ($i = 1$) states. Also, we assume that there are three different decisions for the entrepreneur: the first decision being the regular decision, the second decision being the growth decision, and the third decision be the innovative decision. The regular decision has similar values for gain and loss outcomes, with a slightly higher gain probability. In the case of an innovative firm, the gain value per quarter increases, whereas the gain probability is the same for a traditional firm for regular decision.

The growth decision is risky, and although the probability is small in the case of loss, there is a big loss involved. This property explains the percentage of new companies that are closed in the early stages. If they follow a greedy strategy, then they can go bankrupt in the case of losses on consecutive periods. This risk does not disappear even for an innovative state company if it does not possess enough capital.

The innovative decision has costs like new product development or integrating into the new technology. Therefore, we assume that there is an extra cost either in the gain or in the loss case, compared to the regular decision for a traditional state company that did not transform into the innovative state yet. The probability of success is similar to regular decision. If the company transforms into an innovative state, then the costs needed for the innovation reduces. As a result, the loss $L(i,d)$, the gain $G(i,d)$, and the success probability $p(i,d)$ values for all states and decisions are written as follows:

$$G(i,d)=\begin{bmatrix}10 & 12 & 5\\ 15 & 17 & 20\end{bmatrix},\quad L(i,d)=\begin{bmatrix}10 & 50 & 15\\ 10 & 50 & 5\end{bmatrix},\quad p(i,d)=\begin{bmatrix}0.6 & 0.9 & 0.6\\ 0.6 & 0.9 & 0.6\end{bmatrix}$$

If the regular or growth decisions are selected, the firm transforms into an innovative state only by luck (1% probability). We have included this luck percentage to have an ergodic Markov chain. If an innovative firm selects regular or growth decisions, then the state of the firm changes to traditional eventually. If a traditional firm selects innovative action, then it changes to an innovative state on average five time quarters. That value is reasonable as an expected time for a company to develop a new product. The transition probabilities for the different decisions are given as follows:

$$Q(i,j,1)=\begin{bmatrix}0.99 & 0.01\\ 0.3 & 0.7\end{bmatrix},\quad Q(i,j,2)=\begin{bmatrix}0.99 & 0.01\\ 0.15 & 0.85\end{bmatrix},\quad Q(i,j,3)=\begin{bmatrix}0.8 & 0.2\\ 0.01 & 0.99\end{bmatrix}.$$

According to values in Q(i,j,1), Q(i,j,2) and Q(i,j,3), if a firm randomly selects a strategy, then it will be at an innovative state in one-third of the cases, which is consistent with the results of the GEM study introduced in Section 3.1.2.

In this section, we assume that a financier is selected by the entrepreneur at time 0, and decisions are made at each period in order to maximize the objective

function of the entrepreneur. The capital is received at time 0, and the execution is made for 3.5 years. In total, there are three different types of financiers, and two different objective functions, therefore, we analyzed six different cases, as described in Table 4.

Table 4. Description of regime switch models

Model ID	Financier	Objective of Entrepreneur
Model 1	Fixed payment debt	Maximize survival probability
Model 2	Fixed payment debt	Maximize wealth process
Model 3	Silent partner	Maximize survival probability
Model 4	Silent partner	Maximize wealth process
Model 5	Venture capital	Maximize survival probability
Model 6	Venture capital	Maximize wealth process

All the models are solved using the backward dynamic programming equation, through the calculation of value function for all integer-valued wealth possibilities and using linear interpolation of the value function for non-integer wealth possibilities.

4.2. Computational Results

We have first investigated the impact of the initial equities available for an entrepreneur defined by Model 1, as the choice of the utility function is survival probability, and financing is done using bank credit. We assumed that there is no inflation involved (all analysis is done using then-current dollar values), and the bank rates change between 1 % per quarter to 5 % per quarter. The company pays back all the credit in 14 periods with equal payments. We assumed two different initial total investments of 40 and 100. The results for survival probability vs the initial debt ratio (ε) is given in Figure 1. The 0% debt ratio corresponds to funding the business by personal funds, whereas 100% corresponds to full funding. As expected, the probability of bankruptcy increases as the funding percentage increases since the company needs to make regular payments for the debt. The survival probability decreases nearly linear when there are limited funds, however, when the funds are bigger, it drops more quickly with respect to the percentage of the debt. The optimal decision is the regular decision for the

zero-debt case, but the small-sized company ($X_0 = 40$) prefers to be innovative if the debt is more then 60%, whereas the bigger size company ($X_0 = 100$) prefers to be innovative, even when the debt is above 40%. The reason is that the company needs a higher income to pay for credit payments.

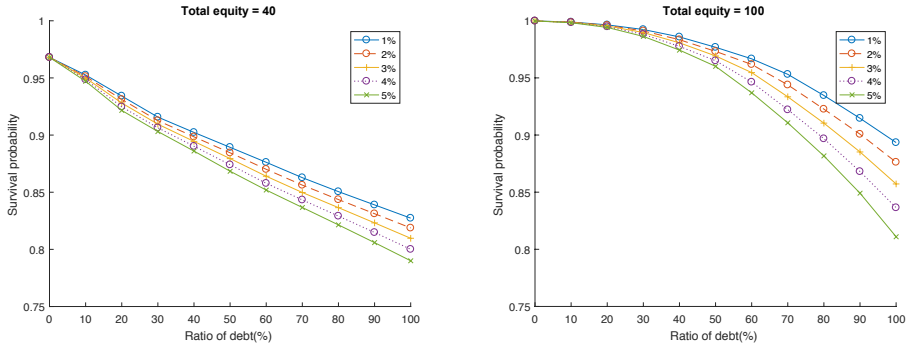

Figure 1. Survival probabilities for Model 1 in case of different debt ratios

In Figure 2 we present the results for Model 2 for different initial investments ($X_0 = 40$ on left, $X_0 = 100$ on right) for bank rates of 0% (no interest) to 4%. Similar to Figure 1, the x-axis represents the percentage of initial capital borrowed as debt whereas the y-axis represents the expected value of net final wealth gain ($X_T - (1 - \varepsilon)X_0$). If there is a free borrowing opportunity available, then it will be best to use as much capital as possible. However, there is a cost involved for borrowing which explains the downward trending curves as the rate of interest increases in both cases. For low levels of debt, the overall gain from the higher level of investment (equity=100) is higher however if bank credit is needed for the initial investment it will be better to start with the low level of investment if a higher premium is needed to be paid. The innovative action is the best initial action in all cases.

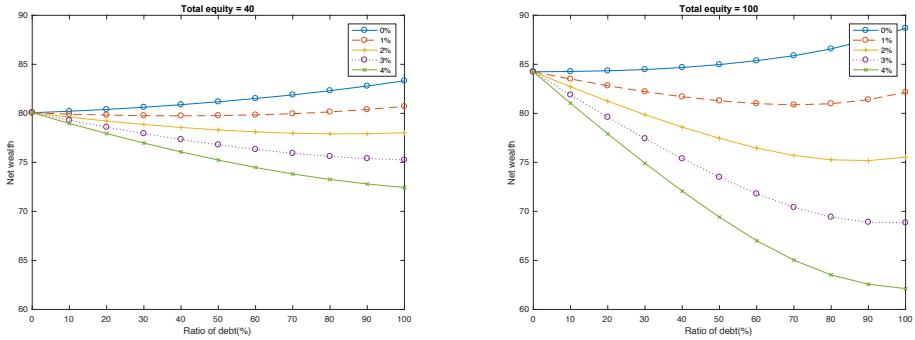

Figure 2. Wealth gain for Model 2 in case of different debt ratios

We also analyzed the optimal action for different time periods. Suppose that half of the initial investment is funded by bank credit (ε = 50%) of 14 quarters where the interest rate is equal to 1%. Also suppose that if the type of the firm is still traditional, then the optimal action changes to the growth decision after 7th period if X_0 = 40 and after 3rd period if X_0 = 100. A low value company does not want to take bankruptcy risk therefore sticks with the innovative action for longer. One should note that although innovative or growth actions are preferred by a company who wants to maximize wealth, either regular or innovative actions are preferred by a survival-first entrepreneur.

The Models 3 or 4 are similar to the first two models with ratio of debt, ε = 0% in terms of optimal decisions. The reason is, there are no intermediate payments to silent partners. If the initial equity is X_0 = 40 and the interest premium of the business angel is i=1% per quarter then for every 10% of initial cost paid the business angel expects to at least own 4.1% of the company. Therefore, if the business angel pays for the entire initial investment of 40, then they will have 41% share at the end. The final expected wealth is 121 therefore the expected gain for the entrepreneur will be equal to 70.8 without any initial investment. This is higher than the bank debt with interest rate greater than 3% per quarter. Therefore, if an entrepreneur does not have access to low rate bank credit it is better use silent partner.

For Models 5 and 6, the financier is selected as the venture capital. The venture capitals are experienced investors; hence they spend effort on the success of

the company. Therefore, we assume that the returns for decision or the success probabilities for innovative actions should be different from the ones used in Models 1-4. We assume that the venture capital will increase the revenue for growth action such as:

$$G(i,d)=\begin{bmatrix}10 & \mathbf{15} & 5\\ 15 & \mathbf{22} & \mathbf{25}\end{bmatrix},\ L(i,d)=\begin{bmatrix}10 & 50 & 15\\ 10 & 50 & 5\end{bmatrix},\ p(i,d)=\begin{bmatrix}0.6 & 0.9 & 0.6\\ 0.6 & 0.9 & 0.6\end{bmatrix}$$

where the bold terms are updated to describe the venture capital effort. Also, the transition probabilities for the venture capital firm are assumed to be as follows:

$$Q(i,j,1)=\begin{bmatrix}0.99 & 0.01\\ 0.3 & 0.7\end{bmatrix},\ Q(i,j,2)=\begin{bmatrix}0.99 & 0.01\\ 0.15 & 0.85\end{bmatrix},\ Q(i,j,3)=\begin{bmatrix}\mathbf{0.67} & 0.33\\ 0.01 & 0.99\end{bmatrix}$$

In the case of venture capital, the entrepreneur takes innovative decisions more frequently, and never takes the regular decision. Because of the cost of effort, the venture capital negotiates to take 4.6% of the firm at time T for every 10% of the initial cost $X_0 = 40$ paid. The final expected value of the company will be 164.9, therefore, the expected gain for the entrepreneur will be equal to 89, which is much better than both the angel investor and the bank debt. Also, the survival rates for the firm increases by 1.2%. Hence, one can conclude that the best of the three funding alternatives are the venture capital firms. The reason for this is, even for the survival-first entrepreneur, partnering with venture capital firms will make the best decision to be innovative action.

5. Conclusion

In this study, we aim to investigate the effect of financier selection options on the actions of entrepreneurs. We assume that there are three types of financiers: the constants payment bank credits, the silent partner financiers such as friends and family or business angels, and the active investors such as venture capital firms. We assume that the entrepreneur has several options from each investor alternative, therefore, he/she decides the optimal financier, whereas the financier does not have the negotiating power. Therefore, the entrepreneur offers the contract with the expected return just over zero. The entrepreneur also decides on the actions (regular, growth, or innovative) that determines the payoff

structure for the following period. We assume a Markov process to define the innovative capability of the firm, where the transition function is affected by the decisions of the entrepreneur.

In order to support the parameters used in the model, we analyzed the entrepreneurship studies from OECD statistics and the Global Entrepreneurship Monitor survey. In particular, we get the results for the percentage of innovative firms, bankruptcy rates in the start-ups, and financier availabilities and preferences by the entrepreneurs. Although there are some differences throughout economies, the parameters in our model are consistent with the intervals of values found in the studies.

We analyzed six scenarios over three different financier types and two different objective functions using computational analysis. As a result, we found out that safety first entrepreneurs tend to be conservative and cautious and do not take risky actions. Also, they do not tend to be innovative. However, this behavior changes if there are venture capitals that guide the inexperienced entrepreneurs rather than behave as a sole investor. In this case, the nascent entrepreneurs tend to be innovative.

The growth-oriented entrepreneurs, on the other hand, are more risk seeker. They tend to take risky or innovative actions if they have enough capital. But even for these types of entrepreneurs, advanced financier opportunities will be beneficial. The expected worth of the firm will be much higher if there is a partnership with a venture capital firm.

If venture capital funds are not accessible in the early stages, the presence of business angel funds will also be propitious. Silent partner investors will be preferred if the bank rates are high. Therefore, the presence of capital opportunities and entrepreneurial environment in a market will help the start-ups to access capital, and eventually, lower the capital cost in terms of the interest rates.

Our computational analysis unveils the importance of the entrepreneurial environment in a country. As the funding opportunities develop and diversify, entrepreneurs will evolve from small businesses to innovative firms. Therefore, it is very crucial for the government to establish an entrepreneurial ecosystem that will drive the innovation capabilities of entrepreneurs. As discussed in the literature section, innovative entrepreneurs are the fuel to sustainable economic

growth. Even the government subsidizes, or low rate credits are vital for nascent firms, which are just establishing a business.

As a summary, the study brings out the importance of different financing schemes for entrepreneurs, such as venture capital or business angels. Our results show that although the requested partnership rates for venture capital financing need to be higher, the overall value created will compensate for the difference. These financing schemes encourage survival-oriented lifestyle entrepreneurs to take growth or innovative actions. Particularly by the guidance of experienced financiers, the early phase entrepreneurs can grow faster and safer.

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