

An Investigation into Public Finance for Potential High Growth Sustainable Start-ups: The Case of France

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Abstract:

The French private equity ecosystem is characterised by the presence of Bpifrance, a state investment bank (SIB) which has structured and streamlined the sector since its creation in 2013. On the demand side, this research questions the influence of Bpifrance, as a direct public investor with sustainable venture capital objectives for environmental and social public good. France's venture capital market is examined on the length of time between early-stage venture capital funding rounds and the ability of funded ventures, including those with deep tech and sustainable development goals (SDGs), to progress along the stages of the finance escalator. To answer this question, data was collected from Dealroom, a platform that provides investment information on a large number of startups in different countries over their lifecycle. An event history analysis is conducted on a sample of 3,741 French ventures that raised their first seed funds between 1990 and 2023. The results confirm the impact of Bpifrance and the various public programmes that accompanied it on the structuring of the French venture capital ecosystem. On the other hand, the results question the ability of Bpifrance to support start-up companies with disruptive social and/or environmental innovations that require patient capital and significant risk-taking.

Key Words: Deep Tech, Entrepreneurial Finance, Financial escalator, Government Venture Capital (GVC), State Investment Bank (SIB), Sustainable Development Goals (SDG)

Introduction

Globally, public finance has played a critical role in nurturing potential high growth (PHG) start-ups. This is particularly evident in the more mature economies of Europe, North America, Asia and Oceania. Lerner (2010) presents a compelling case for public support to fund start-up innovation, which underpins the Schumpeterian model of economic growth that has been developed during the first part of the 20th century and that has led to higher standards of living (Cowling, Sclip and Velliscig, 2025). Today, as we face environmental and economic crises relating to depleting resources, including food, water and material shortages through extreme climate events, underlining the need for green low carbon economic transition, start-up innovation is paramount to the efficient development of economies. As Owen et al., (2018; 2023) suggest, start-ups are nimble and sometimes rapid innovators from which a small number of PHG ‘unicorns’ can make globally transformative sustainable changes to improve planetary prosperity.

However, entrepreneurial finance studies reveal that the course of innovative start-up development is frequently problematic (North et al., 2013). This stems from the high levels of information asymmetries which exist between entrepreneurs and their prospective financiers (Carpenter and Petersen, 2002) and particularly for disruptive ‘deep tech’ (Nanda, 2020) which experiences long periods of pre revenue and high investment requirements for prototyping during the so-called ‘valley of death’ period (Mazzucato and Semieniuk, 2018). This has led to the widespread strategic mobilisation of state investment programmes, typically operated through state investment banks (SIB) and government appointed organisations tasked with addressing private market finance gaps (Lerner, 2010). Essentially, the state intervenes where there is a perceived private investment market failure to adjust the risk-reward balance for these investors and ensure that viable start-up innovations are sufficiently funded (Oakey, 2003; Bai et al., 2022). As many studies suggest, public intervention can take many forms and is often criticised for underperforming the private sector (e.g., Lerner, 2010; Munari and Toschi, 2014; Owen and Mason, 2017 and 2019, Cumming and Johan, 2016, Murray, 2022) and unintended consequences, principally relating to substituting and crowding out the private sector (Leleux and Surlemont, 2003; Cowling and Liu, 2023).

In Europe, France is the second largest start-up venture capital market (after the UK) valued at €8.1bn in 2024 (In Extenso Innovation Barometer) and totalling €47.4bn including private equity. The French private equity ecosystem is characterised by the presence of Bpifrance, a SIB, which has structured and rationalised the sector since its creation in 2013 (Bpifrance report, 2023; Report of Cour des Comptes, public auditing agency, 2023). France has also invested heavily into sustainable startups, notably through initiatives such as La French Tech, Bpifrance’s sovereign wealth Investment Fund and France Relance Covid-19 recovery investment plan, with green tech into energy, circular economy and sustainable mobility becoming a €4bn cornerstone of Frances’s startup finance market in 2024 (STATS, 2025).

This paper examines the case of France’s sustainable startup investment market. It seeks to explain start-ups’ development dynamics by pointing out the role of public direct funding in the financial lifecycle paradigm of entrepreneurial firms (Berger and Udell, 1998). We are not only interested in the study of the use of different financing instruments and the change in the composition of funding sources over time as outlined by Hirsch and Walz (2019), but also in the analysis of the length between two adjacent funding rounds as a signal of growth and

profitability opportunities (Li, 2008). From an entrepreneurial firm's perspective, time is critically important in order to maintain market niche and first mover status and also to bring longer horizon capital intensive deep tech innovation to commercialisation (O'Reilly, Mac an Bhaird and Greene, 2024). From the entrepreneurial finance demand side, this research raises the overriding research question: What is the impact of direct public funding on the development dynamics of young innovative ventures? And, more specifically, does public venture capital funding exert any influence on the timing of the transition from one stage of funding to another in the finance escalator of start-ups (North et al., 2013)? The transition to a new stage of funding, and not just a new round of funding, is seen as a progression in the life cycle, meaning that the start-up is able to grow by reaching a new stage of development.

This general research question can be divided into three sub questions, which explore the paper's interest in the operation of public VC finance policy for public social and environmental good (Mazzucato and Penna, 2016; Owen, 2023) and whether such policies address the deep tech venture valley of death (Nanda, 2020) which has been critical in holding back cleantech low carbon and environmental solutions (Mazzucato and Semieniuk, 2018; O'Reilly et al, 2024; van der Schans et al, forthcoming):

- 1. Does direct public funding increase the likelihood of moving from one funding stage to the next?**
- 2. Is it more likely that a start-up will move from one funding stage to the next if it has committed to achieving at least one of the UN's Sustainable Development Goals (SDGs)?**
- 3. Is it less likely for a start-up with a Deep Tech innovation to move from one funding stage to the next?**

To address these questions, we collect data from Dealroom (<https://dealroom.co/>) a platform which provides investment information on a large set of start-ups in various countries over their actual lifecycle, i.e. from the date of creation to the date of the last funding round. We use a sample of 3,741 French start-ups receiving (early stage) seed capital between 1990 and 2023. Our analysis follows three steps. First, we derive the financial escalator of each firm from the data. We then perform event history analysis in two further steps to evaluate the contribution of Bpifrance on the change from one funding stage to a new stage on the finance escalator and the length of time between two funding stages. Our objective is to study the progression of start-up financing along the finance escalator, taking into account the technology developed, the coverage of SDGs, the presence or absence of Bpifrance as a shareholder and other variables that may explain the dynamics of this progression. Our focus is the start-up early-stage financing which forms the basis of the pyramid of PHG development and growth, but is often far from exit, particularly for deep tech which may take over a decade to commercialise and exit (Owen and Vedanthachari, 2023). Therefore, lacking data on exits and investment return (van der Schans et al., forthcoming), we follow the guidance of North et al., (2013) and Owen et al., (2019, 2021) to explore the stage development progress of PHG ventures. We do so by developing a unique duration analysis of the French start-up markets to assess the progression of public Bpifrance funded and alternative funded start-ups through early-stage development, their funding round amounts, the public good SDGs that they cover and the type of technology they develop.

The paper is organized as follows. We first review the literature on state intervention in entrepreneurial ecosystems. Secondly, we analyze the role of Bpifrance in the French venture capital market since its creation. Thirdly, we present data and the methodology used to answer our research questions. We then discuss our findings and conclude.

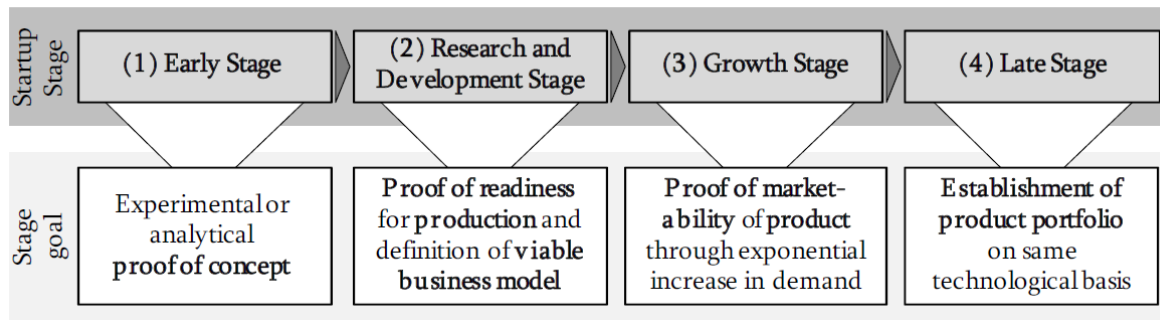
1. State intervention in entrepreneurial ecosystems

External finance is the lifeblood of business and particularly for potential high growth (PHG) start-ups which offer the large-scale market opportunities that can fuel economic growth (Lerner, 2010). Since Macmillan (1931) first reported a finance gap for UK early-stage innovation, it has been globally recognised that private market investment gaps exist, due to a combination of information asymmetries (Carpenter and Petersen, 2002) and mis-match between the quality and volume of the demand for external finance and the supply of risk finance (Owen et al., 2019), typically in the form of equity which provides an agreed sum of investment in return for a share of business ownership. This has given rise to contemporary entrepreneurial finance ecosystem approaches which seek to understand the interactions of different actors – entrepreneurs, financiers and market supporters (Owen and Mason, 2019; Burström et al., 2023) and how policymakers can create a more efficient and fluent finance escalator (North et al., 2013, Quas et al., 2022) to progress PHG start-ups.

The finance escalator model is based on the life cycle model of Berger and Udell (1998), which explains that financial needs and financial providers change as the firm develops, because the asymmetry of information is expected to diminish as the firm demonstrates its ability to increase sales, create jobs and enter new markets. At the beginning of the life cycle, the lack of relevant information is such that convincing the first external capital provider is a challenge. As time goes on, another challenge is to move up the life cycle in order to move up the financial escalator. In the literature, the different stages are often defined as pre-seed, seed, early growth and late growth. Regarding more specifically deep tech start-ups, Schuh et al., (2022a) provide the following scheme (Figure 1).

At each of these stages, the type of capital provider may change (Murzacheva and Levie, 2020) particularly to accommodate the increasing amounts required at later stages (Figure 2). To attract new funding, PHG start-ups need to demonstrate their ability to create value in the future, and this is more difficult for long horizon innovations that may involve deep technology and, notably, with respect to emerging environmental ‘green’ technologies such as renewable energy and carbon capture (Owen, 2023). Moving from one stage to another, for example from seed to early growth (or from seed to series A and then series B), is a major challenge for PHG start-ups, particularly at the European level, where studies point to the lack of sufficient scale private or public investment funds (Alperovych et al., 2020; Quas et al., 2022), when compared to the larger, more mature US VC market (Arundale, 2020).

Figure 1. Life cycle stages of deeptech start-ups



Source: Schuh et al. (2022a), p. 9

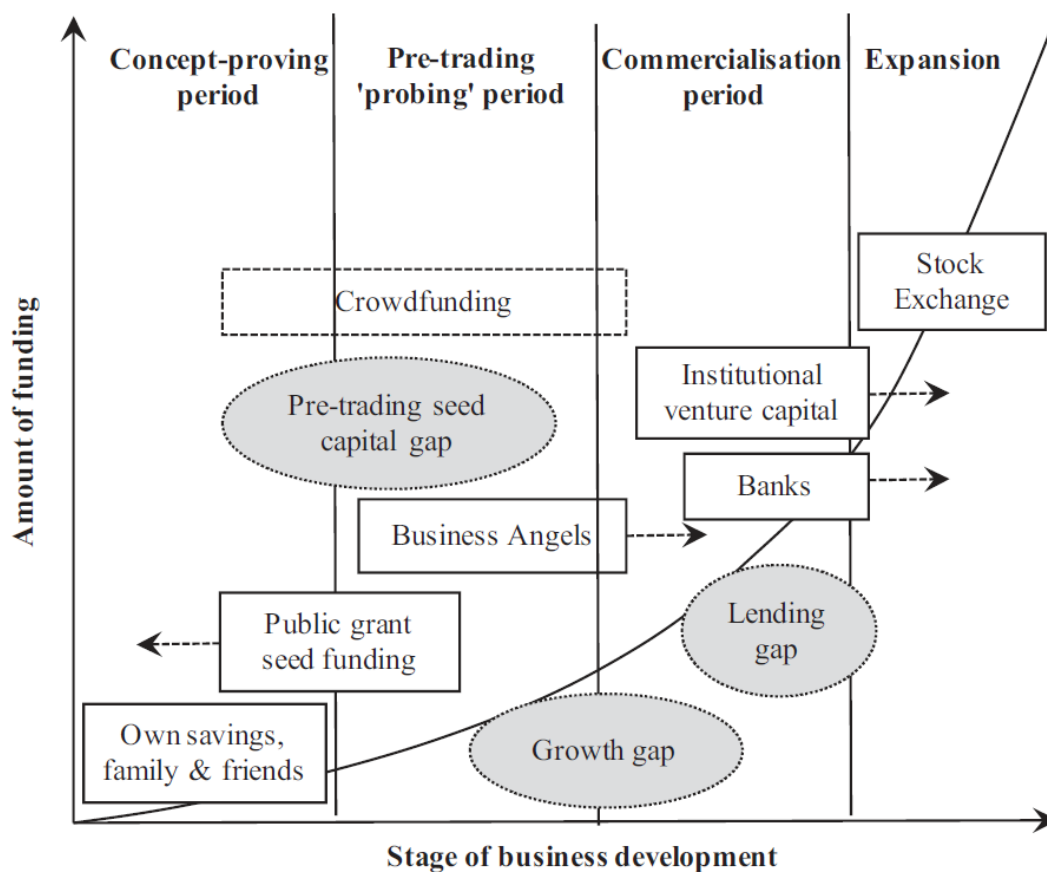
The challenge for governments has been to develop appropriate policy instruments to address the financing requirements of PHG start-ups, particularly during the higher risk earlier stages, when information asymmetries are greatest (Hsu, 2004) and higher information opacity between entrepreneurs and potential financiers exists (Berger and Udell, 1998). From an ecosystem viewpoint, this requires the provision, not just of an adequate and suitable supply of finance, but also a strong pipeline of PHG start-ups (Mason and Brown, 2013) and an adequate support agency service to ensure investment readiness and connectivity between entrepreneurs and financiers (Aernoudt, 2017; Alperovych et al., 2020; Mukherjee et al., 2024).

Lerner (2010) highlights the central role of government venture capital (GVC) as a policy instrument to foster start-up innovation and economic growth. Providing examples of good practice, tracing the lineage of US VC development from the 1950s, through to more recent programmes in Israel and New Zealand. Lerner (2010) is sceptical of direct public investment and argues for state intervention at arms-length, through fund of funds mechanisms. This approach favours utilising private-led commercial investment skills over public bureaucratic decision making and has been widely adopted by contemporary European, North American, Australian and Asian countries – and most notably by the UK’s flagship Enterprise Capital Funds (Baldock, 2016).

Key to GVC success is the creation of a start-up support structure which matches entrepreneurs to investment and provides sufficient sized funds to enable the most promising PHG start-ups to flourish (Baldock, 2016; Owen and Mason, 2017; Owen et al, 2019). Following the start-up innovation finance escalator, this requires the attraction of early-stage private investment to match initial grant funding and incubation support, and follow-on invest to enable innovation progression, through early commercialisation and further scale-up (North et al., 2013; Quas et al., 2022; Owen et al., 2023). Lerner (2010) and Murray (2021) offer clear GVC good practice guidance. Both favour attracting experienced private fund managers through co-investment programmes which aim to encourage earlier-stage and larger amounts of private equity investment, including international inward investment, through adjusting the risk-reward ratio via public investment taking a share of the risk. Owen (2023) provides the example of Innovate UK’s Investment Accelerator programme which matched public grant funding with seed VC in strategic public good innovation sectors such as health and cleantech. Lerner (2010) and Murray (2021) also prefer Limited Partner (LP) structured funds which are time limited (typically 10-12 years) and which have clear strategic aims, rather than evergreen funds, which tend to suffer mission creep and underperform (e.g. Finland’s Finnvera regional funds).

Additionally, Lerner (2010), Baldock (2016) and Cumming and Johan (2014) highlight the importance of GVC supporting follow on funding into better performing start-ups. This requires GVC to be of sufficient scale (Arundale, 2020, suggest funds of at least €50m, based on a US-European comparative study) and to be able to access further public co-funding to develop scalable second funds to facilitate follow-on investment into the better performing portfolio companies and follow them through to successful, more optimal exits (Cumming and Johan, 2014).

Figure 2. Stage of business development and finance escalator model



Source: Murzacheva and Levie (2020), p. 188

Whilst Lerner's (2010) GVC model has been widely adopted, since it supports a more commercially driven approach to GVC which can offer returns to the public purse, there are concerns that this can lead to public agencies, such as SIBs being too commercially driven, giving rise to potential for cherry-picking and crowding out private investment (Leleux and Surlmont, 2003). Lerner (2010), Baldock (2016) and Owen (2023) advocate regular audit/evaluations to ensure that GVC programmes are providing additionality and adjusting to changes in the finance escalator's gaps which occur during financing and economic cycles (Lee et al., 2015).

In this respect, sustainable/green finance through cleantech PHG start-ups has been particularly problematic (Gaddy et al., 2016). Studies such as the Rowlands review (2009) and British Business Bank's Small Business Equity Tracker (2022) in the UK, as well as Gaddy et al.

(2016) in the US, consistently demonstrate that long horizon, deep tech and particularly cleantech funding experiences present high risk, high venture failure rates and persistent and extensive private funding gaps (Harrer and Owen, 2022, Owen, 2023). They underline the argument of Mazzucato and Penna (2016) and Mazzucato and Semieniuk (2018), that a substantial public funding mechanism is required, such as a SIB, in order to provide the strategic, long horizon (often 10-20 years) and deep pocket public funding to provide the often multi million Euro capital investment required to de-risk and leverage private investment and realise cleantech commercialisation. Owen and Vedanthachari (2023) present the example of the UK's engineering biology cleantech market, where public-private co-investment with longer horizon capital expenditure intention has been highly successful in delivering shorter horizon software investment but has failed to attract UK GVC funding for larger-scale investment into longer horizon hardware prototyping. This 'patient capital' deep tech funding gap (van der Schans et al, forthcoming) threatens to slow down the process of global cleantech solutions (e.g. the emergence of more resource-efficient synthetic biotech materials and products), as well as the loss of commercial returns to the home market through overseas investment and trade sale exits (O'Reilly, Mac an Bhaird and Greene, 2024).

Whilst cleantech provides a clear example of the need for largescale strategic public investment, through agencies such as SIBs (Mazzucato and Semieniuk, 2018), the combination of the high risk and large long horizon investment required has led to repeated questions as to what combination of policies and GVC instruments are most appropriate, including direct versus indirect co-financing (Lerner, 2010; Murray, 2020), greater access to institutional investors such as pension funds, and the implementation of more appropriate longer horizon private investor incentives such as tax breaks and VC upside preference for co-funders (e.g. UK Enterprise Capital Funds offer private investors a higher proportion of returns, compared with public investors, as opposed to typical EU *pari passu* practices) or downside loss protection (such as through the share of public-private investment, which is often capped at 50%).

Deep tech start-ups offer advanced, cutting-edge technologies that are often based on scientific breakthroughs and innovations (Nanda, 2020; Owen and Vedanthachari, 2023). They require considerable research and development effort and a long gestation period before they can be commercialised. They have the potential to deliver transformative change in many industries and to address major challenges, such as environmental sustainability. However, as Romme et al., (2023) point out, Europe suffers from a lack of capacity to transform these scientific advances into successful ventures. This is a challenge and not surprisingly, in 2019 France launched the 'Deeptech Plan', which aims to make the country a major player in disruptive innovation on an international scale. Bpifrance was given the task of supporting the deep tech private equity market. In 2022, this plan was given a new impetus thanks to the resources deployed as part of 'France 2030'. At the same time, Bpifrance became the 'Bank of climate'.

2. The French VC market and the role of Bpifrance

Bpifrance, also known as Banque Publique d'Investissement, was created in 2013 from a number of public institutions in charge of support for ventures and their financing, particularly for innovation. Its main objective is to provide financing and investment support to French businesses, particularly SMEs. It provides various types of financing and support: loans,

guarantees, grants, advisory services, equity investment, venture capital. Bpifrance has a mandate to support the French government's economic and industrial policy, and it works closely with other public actors and private partners. Bpifrance invests either directly in the capital of ventures at all stages of their development or indirectly through existing private and regional funds (acting as a fund of funds).

The specific features of Bpifrance's investment activities are firstly the distinction between direct and indirect investment. According to Dealroom and Bpifrance website, as a direct investor (innovation and development capital), at the end of January 2025, Bpifrance had 1,390 ventures in its portfolio (with 3,221 co-investors) and €35bn in assets under management (€7bn of which is innovation capital). Bpifrance's Capital Innovation and Capital Development teams invest €2bn to €3bn in direct equity each year. Indirect investment relates to Bpifrance's fund of funds business. Currently €17bn are invested in more than 600 partner funds, including 136 regional funds. The teams in charge of fund of funds deploy €1bn to €1.5bn in partner funds annually. Furthermore, Bpifrance also acts as a minority investor alongside other family, industrial or financial shareholders. For direct equity investments, Bpifrance is involved in the governance of companies (e.g. supervisory board, board of directors). For fund of funds, Bpifrance invests alongside mainly private investors and also plays an active role in governance.

Bpifrance makes equity investments aligned with its strategic public good priorities that are innovation, sustainability, and social impact. Over the past 10 years, Bpifrance has helped to boost French venture capital, with a seven-fold increase in the amount of innovation support and venture capital in France with a reinforcement of all market segments, from seed to late stage (Bpifrance 10-year report). The audit report published in 2023 by "la Cour des Comptes" highlights that Bpifrance's direct and indirect investment activity has made it possible to increase the deal flow of start-ups and to structure French private equity, ensuring a continuum of financing for ventures throughout their life cycle.

Thus, France presents a particularly important case for at least two reasons. First, the French state has promoted policies which aim to make France a leading start-up nation and a Greentech innovator with an emphasis on deep tech (i.e. 'Deeptech' programme launched in 2019 and run by Bpifrance). Second, between 2014 and 2021 the French state appeared as one of Europe's leading state investors with €3.8bn invested in the support of start-ups (rapport de la Cour des comptes, 2023). Notably, France has seen high levels of public funding for early-stage innovative ventures, operated since 2013, through Bpifrance as the decentralised 'one-stop-shop' for start-up and scaleup finance across 50 locations. In particular, the flagship 'French Tech' programme, which has supported the government's vision of France as a leading start-up nation, has focused on selective and intensive public investing in home growth tech over the past decade. Bpifrance's private equity business has been ranked by Pitchbook as one of the world's leading management companies in 2023. It is considered one of the top three players in terms of deal volume worldwide (alongside KKR and Ares) and the leader in Europe, where its main investment interests are located.

Although Bpifrance is often portrayed as a success story, the audit of its investment activities invites a more cautious reading. Drawing on France Invest statistics, the audit suggests that since 2019 (including the COVID-19 period), close to half of firms backed by French venture and growth funds have also received public financing in some form (with Bpifrance involved either directly or indirectly, including via fund-of-funds channels). At the same time, private markets have shown strong fundraising capacity in recent years. In line with Lerner's (2010)

guidance on public VC, this context motivates examining whether some state interventions should be adjusted to reduce potential crowding-out and concentrate on segments where additionality is highest. This makes our research question on Bpifrance as a GVC especially timely.

3. Sample description and methodology

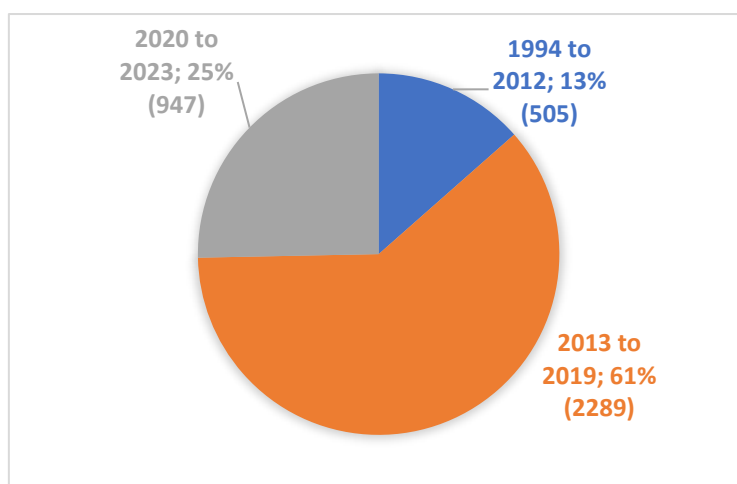
3.1. Data and sample description

The paper is based on the analysis of secondary data provided by Dealroom, which has the most extensive data coverage of France's equity markets and public start-up investment.

Dealroom offers the possibility of tracing the financing of a venture since 1990. The data was extracted from Dealroom on 10th June 2023 and initially covers a sample of 3,741 start-ups that received their first seed funding between January 1990 and June 2023. As the objective is to analyse the subsequent funding rounds and the start-up's ability to move up the finance escalator, it is necessary to stop in December 2019 to give the start-up time to raise at least one new round of funding.

Over 60% of start-ups (Figure 3) received seed funding between 2013 and 2019. It can be seen that 25% of seed fundraising concerns the period 2020-2023. Over this period, these are seed funds raised in a following round of financing for ventures that received their first seed financing between January 1990 and December 2019.

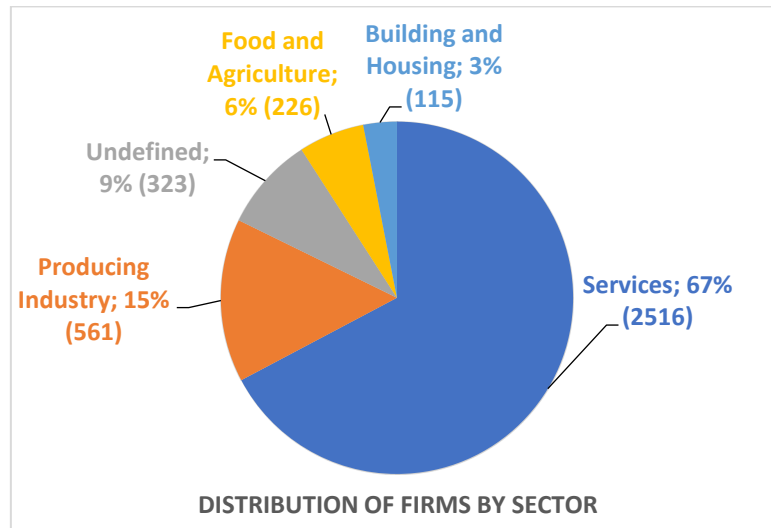
Figure 3. Distribution of firms by Seed Year



Source: Author's calculations

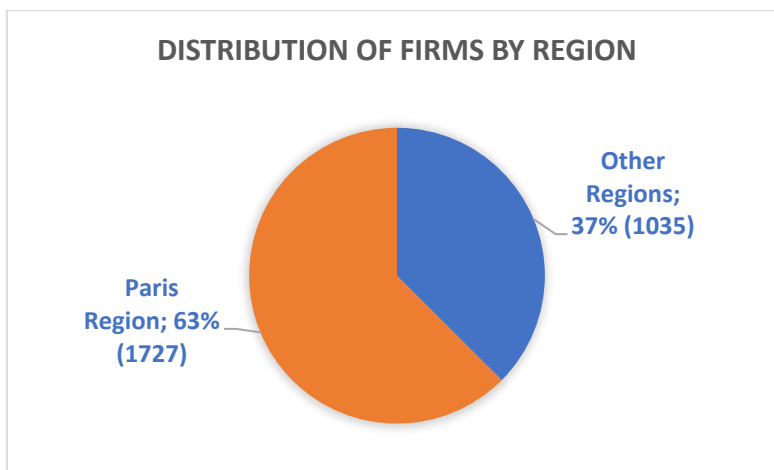
Most companies (61%) operate in the services sector (Figure 4), with a predominant presence in the software industry. About two thirds of the startups for which the data were correctly recorded are located in the Paris region. (Figure 5).

Figure 4. Distribution of firms by sector



Source: Author's calculations

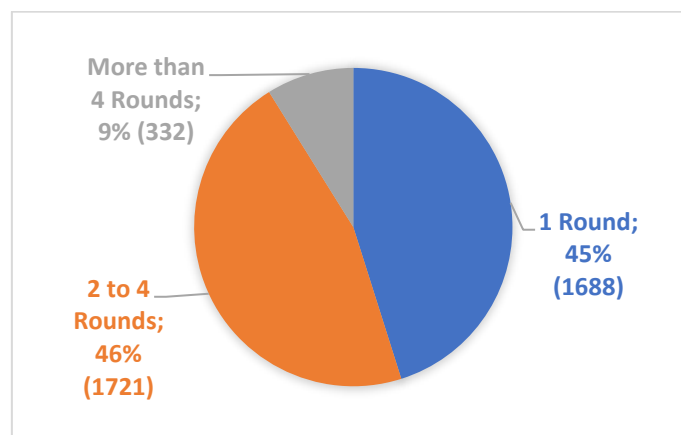
Figure 5. Distribution of firms by region



Source: Author's calculations

By using information on total rounds number (Figure 3), almost half (45%) of startups in the full sample have only experienced one funding round and a relatively small proportion (9%) of firms have experienced more than four funding rounds (Figure 7).

Figure 6. Distribution of firms by total rounds number



Source: Author's calculations

For each round, the Dealroom platform may provide the date, the type of investor and the stage of development reached by the start-ups. The investment round types given by Dealroom are used to standardize rounds based on the funding amount:

- Grant
- Angel: when only angel investors made investment
- Seed: For €1-4 million deals
- Series A: for €4-15 million deals
- Series B: for €15-40 million deals
- Series C: for €40-100 million deals
- Acquisition: Majority stake (50-100%), acquired, controlling stake, (acquisition amount = valuation if no mention of stake %).
- Early VC: When the round type is not mentioned and the amount is between 2 and 20 million
- Late VC: Rounds type not mentioned after Series A, B...or round happening 5 years after launch date

We examine the first four rounds of external finance recorded by Dealroom to examine startup progression by stage within a sufficiently robust deal numbers setting, given that there is steep drop-off in reporting at each round (van der Schans, forthcoming). Table 1 presents the four first rounds of funding by investment stage types.

The number of companies decreases over time, across rounds, as fewer companies are raising funds, either because they do not want to raise more money or because they cannot raise it. It should be noted that information is missing for an increasing number of companies as funding

rounds progress. We can see that the first (typical earlier venture capital market stage) round includes mostly Seed (89.47%), but also some Series A and B and even larger VC rounds. This complicates interpreting the data. The 'angel' type only appears when the business angel(s) is (are) the only one(s) funding the round in question. We note that the type 'grant' appears consistently across all four rounds. These are young companies that are developing technological innovations and are eligible for grants (which extend beyond proof of concept to support R&D but typically remain within the realm of seed stage), in particular at European level through the EIC (European Innovation Council). Having made these clarifications, we can see that for each of the first four rounds the most important typical round stage is seed, but this declines in each round as those receiving follow-on funding rounds progress to later round type stages. This trend towards later stage funding is further supported in the distribution of round type funding which progresses from almost all (93.34%) in round one to just under one third (30.83%) in round four being within the realm of seed stage finance (relying on grants, angels and smaller scale seed investment).

Table 1. Evolution of investment round types

Round type	Round 1		Round 2		Round 3		Round 4	
	Number	%	Number	%	Number	%	Number	%
Grant	81	2.16	124	6.04	85	7.5	85	8
Angel	64	1.71	68	3.31	0	0	24	2.12
Seed	3347	89.47	956	46.54	337	29.74	128	20.71
Series A	17	0.45	282	13.73	151	13.33	89	14.4
Series B	2	0.05	26	1.27	86	7.59	69	11.17
Series C	0	0	2	0.10	12	1.06	20	3.24
Early VC	83	2.22	329	16.02	189	16.68	83	13.43
Late VC	2	0.05	28	1.36	26	2.29	17	2.71
Acquisition	0	0	112	5.45	104	9.18	60	9.71
Others	62	1.66	52	2.53	39	3.44	18	2.91
Round type not given	83	2.22	74	3.6	103	9.09	24	3.88
Not available	0		1688		2609		3124	
Total	3741	100	3741	100	3741	100	3741	100

Source: Author's calculations

Analysis of the sample also reveals the most important investors and their diversity. The 3,741 startups in the sample were financed by 1,332 players. Among these players, Bpifrance is the most prominent investor at the first four rounds of funding (Table 2; note that information is missing for 513 companies).

Table 2. Ranking of the five most prominent investors

Ranking	Round 1		Round 2		Round 3		Round 4	
	Name	No. of	Name	No. of	Name	No. of	Name	No. of

		start-ups		start-ups		start-ups		start-ups
1	Bpifrance	90	Bpifrance	103	Bpifrance	86	Bpifrance	63
2	HEC Incubator	77	Techstars Stockholm	41	Techstars Boston	39	Kima Ventures	30
3	Agoranov	60	Paris&Co	39	Kima Ventures	29	Paris&Co	26
4	Techstars Paris	38	Kima Ventures	37	Agoranov	28	Agoranov	18
5	Kima Ventures	37	Agoranov	29	Paris&Co	23	Wilco	16

Source: Author's calculations

As the number of investors is very large, each one does not finance that many startups. However, Bpifrance emerges as the most prominent investor in each round, in the sense that Bpifrance is the investor present in the largest number of start-ups in each round. Kima Ventures is a private investor that is one of the top five investors in each round. Then there are the incubators and accelerators (both public and private), which are playing an increasing role in the financing of start-ups. The figures presented here need to be qualified. These players provide little funding, but they are very present. They are part of the ecosystem and help to make it more dynamic. It should be noted that Dealroom provides the amount raised in each round and the list of investors, but not the amount contributed by each investor. This is why we look at the number of companies funded rather than the amount invested.

3.2. Methodology: Event history analysis

To understand the dynamics of start-up financing, therefore, we need to be able to study how and why a start-up develops more or less quickly. A number of studies have already been carried out in this area, but they remain rare (Hetchavarria et al., 2016; Keogh and Johnson, 2021; Adjei, 2021; O'Reilly et al., 2024; van der Schans et al, forthcoming) and none of them takes into account the type of external shareholder, let alone the impact of the GVC.

3.2.1. The three steps of the methodology

In this study, we use survival analysis to examine the dynamics of start-up financing over time. We model changes in financing type between successive funding rounds as state transitions in a duration framework. The event indicator (EVT) equals 1 when the financing type changes between two consecutive rounds (e.g., SEED in round t and SERIES A in round $t + 1$), and 0 otherwise. Observations with $EVT = 0$ are treated as right-censored at the end of the corresponding interval: when the next funding round is observed in the data, censoring occurs at the date of that round; when no subsequent round is observed within the study period, censoring occurs at the end of the observation window. When a subsequent round is recorded but its financing type is missing, we right-censor the observation at the date of that recorded round, since a financing-type change cannot be assessed beyond that point with the available information. This approach relies on the standard independent (non-informative) censoring assumption. Missing information in subsequent rounds may arise for several reasons: a start-up may cease operations, may no longer be tracked by Dealroom between rounds, may not

disclose its financing type, or may simply not raise another round during the observation period. Consistent with this, 45% of the sample (1,688 start-ups) records only one funding round (Figure 7). We focus on the first four funding rounds, which capture the core early-stage financing trajectory and cover 91% of the start-ups in our dataset (Figure 7). Table 1 shows that seed capital and early-stage VC are, respectively, the most frequent first and second financing types received, while other sources (e.g., grants, angel capital, Series A) vary in rank across rounds.

The methodology used is divided into three steps. In the first step, we construct the event variable between the first and second funding rounds (EVT1), then between the second and third (EVT2), and finally between the third and fourth funding rounds (EVT3). In each case, this event variable takes the value 1 or 0¹.

Table 3 shows the distribution of event variables between two funding rounds for the 3,741 start-ups in the sample². We observe that the proportion of start-ups experiencing a change in the funding type decreases at each round, from one-third of companies between the first and second rounds (EVT1) to 12% between the third and fourth rounds (EVT3).

Table 3: Distribution of event variables

	EVT1	EVT2	EVT3
Missing initial funding type	2% (83)	0%	0%
EVT=0 (no observed change; right-censored)	65% (2422)	79% (2973)	88% (3296)
EVT=1 (observed chang)	33% (1236)	21% (768)	12% (445)
Total in % (Number of Firms)	100% (3741)	100% (3741)	100% (3741)

*Note: “Missing initial funding type” indicates start-ups for which the financing type of the first observed round is not available. **EVT = 1** denotes an observed change in financing type between two rounds. **EVT = 0** denotes no observed change and is treated as right-censored at the end of the interval (next round date if observed; otherwise end of the observation window).*

In the second step, we compute the duration between two funding rounds, from the first to the fourth round, regardless of any change in the funding type at each round. Table 4 summarizes key measures of central tendency and dispersion for the duration between two adjacent funding rounds.

Table 4. Key measures for transition duration between two funding rounds

Time duration	RD1 to RD2	RD2 to RD3	RD3 to RD4
No subsequent round observed (Nb of firms)	1688	2609	3124

¹ The algorithm implemented to code these variables is available upon request.

² We do not consider start-ups that received initial funding after December 2019.

Missing date (Nb of firms)	6	3	1
Outliers (Nb of firms)	30	4	3
Reported (Nb of firms)	2017	1125	613
Total (Nb of firms)	3741	3741	3741
Average (in months)	23,68	21,90	21,29
Standard-Deviation (in months)	22,59	20,53	19,50
Median (in months)	17	16	16

Note: “Outliers” refers to durations that exceed plausible bounds because the month of at least one round date is missing (year-only dates), which leads to an artificially large computed time between rounds.

We find that the average duration time tends to decrease over successive rounds, from 23.68 months between the first and second rounds to 21.29 months between the third and fourth rounds. The standard deviation of the duration time also tends to decrease with each round, with high values close to the mean. These values reveal a strong heterogeneity among start-ups regarding the duration time between two stages of development.

In the third step, we develop Cox regression models to assess the effects of the amount of resources raised in the previous funding round, the presence of a state investment bank (herein Bpifrance) between two funding rounds or among the investors, the nature of the technological innovation, a business plan addressing at least one of the Sustainable Development Goals (SDGs), controlling for geographic location, the business sector and the seed year.

3.2.2. Description of the variables

The dependent variable is a combination of a dichotomous event variable (EVT) describing changes in the type of financing between two funding rounds and a continuous duration variable (T) measuring in months the time elapsed between two funding rounds.

In this analytical framework, duration models are used to study the probability of changing states (i.e., type of funding) between two dates (i.e., funding rounds) by defining an instantaneous risk function whose functional form may be known (parametric model) or unspecified when it is assumed to be common to all statistical units, and only individual characteristics explain differences in risk among individuals (semi-parametric model). In the Cox proportional hazards model, these differences in risk are measured by the hazard ratio.

To study the dynamics of start-up evolution between the first and fourth funding rounds, we successively develop three regression models. Each model examines changes in funding type and duration between two consecutive rounds: EVT1 and T1 (first to second), EVT2 (second to third), and EVT3 and T3 (third to fourth).

The four independent variables test the effects of factors likely to contribute positively or negatively to changes in the funding type and the duration between two stages of development in the start-up funding cycle.

Among the variables considered, the funds raised in the previous round is a continuous quantitative variable used to empirically test the existence of a financial escalator. Indeed, a startup's growth within a funding cycle is reflected by increasingly larger funding rounds. In this context, the amount raised in the previous round would positively influence changes in the type of funding and the duration through a ratchet effect, whereby the amount raised in the subsequent round cannot be lower than the amount raised in the previous round due to the ever-growing financing needs. Not surprisingly, the amount of funds raised at each round increases over successive rounds from an average amount at the first round of K€1,04, at the second round of K€3,27, at the third round of K€6,48 and at the fourth round of K€11,2.

We operationalize Bpifrance's involvement using two distinct dichotomous variables (1=yes, 0=no). The first set of indicators (BPIRD1–BPIRD3) captures direct participation by Bpifrance in the immediately preceding round ($t-1$), allowing us to test a lagged effect on the start-up's subsequent funding dynamics. The second indicator, BPIPRES, is also a dichotomous variable that captures Bpifrance's presence in any surrounding round within the four-round observation window—that is, in the round immediately before the focal round ($t-1$) or in one of the subsequent rounds ($t+1$ or $t+2$)—thereby measuring whether state involvement in the firm's financing trajectory around the focal round is associated with different outcomes.

The presence of a public actor can have contradictory effects on the growth and financing duration of start-ups. On the one hand, a positive impact can be expected since the presence of a public actor can act as a lever to attract new investors and meet growing funding needs. On the other hand, the presence of a public actor may be justified to address the financing needs of start-ups with high growth potential but whose projects have longer realization timelines, potentially causing them to remain in each funding stage for longer. As seen in Table 2, Bpifrance is the most prominent investor at each round.

The nature of the developed innovation is an important variable to consider. Deep Tech innovations, based on complex scientific and technological advances, require significant investments in R&D, leading to high capital needs. Their lack of rapid profitability makes them less attractive to private investors. Deep Tech aims to address major societal challenges and can span various industries such as energy, space, robotics, and healthcare. Since they are hardware-based, these innovations have a significantly longer development time compared to non-Deep Tech innovations due to scientific validation, complex prototyping, regulatory requirements, and industrial infrastructure. A 'Deeptech Plan' was launched in France in 2019 to accelerate this segment of the private equity market and enable these ventures to grow and become sustainable. Dealroom classify 'Deep Tech' start-ups as those whose "...technology is based on tangible engineering innovation or scientific advances and discoveries applied for the first time as a product, often aiming to solve society's biggest issues." Of all the ventures in the sample, 25% developed a disruptive technology based on scientific research and requiring a great deal of research and development over a long period.

Innovations aligned with the Sustainable Development Goals (SDGs) are essential as they tackle urgent global challenges such as climate change, resource scarcity, and social inequalities. They can focus on reducing CO₂ emissions, developing alternatives to fossil fuels, water-saving technologies, or circular economy solutions, while also promoting social inclusion and poverty reduction. Some of these innovations fall into the Deep Tech category. This type of innovation is strongly encouraged to accelerate the transition towards a more

sustainable economic model. It should be noted that the assessment of the sustainability of a business model can be carried out in a way different from the declared SDGs covered. For example, Bpifrance, recognised as the bank for the climate, has been carrying out an annual study of French Greentech since 2022. The definition adopted by Bpifrance (annual Greentech report, 2024) is based on the European green taxonomy which states that: “*a Greentech is a company offering an innovative solution (a product, a service or a process) that improves the environmental impact of companies or end consumers, by significantly contributing to at least one objective of the European taxonomy: climate change mitigation, adaptation to climate change, sustainable use and protection of aquatic and marine resources, transition to a circular economy, pollution prevention and reduction, protection and restoration of biodiversity and ecosystems.*” In the sample, less than 10% of start-ups have a business model that meets at least one of the SDGs.

Three control variables are added to our regression models. Firstly, we control for the seed year (Figure 3) as Bpifrance has been created as of the end of 2012 with the aim to rationalize the use of public funds and build a more efficient public-private venture capital market in France. Secondly, we consider a distinction between the service sector and other industries to account for the importance of the start-up's sector of activity, as the service sector is predominant in the sample (Figure 4). Thirdly, we account for the geographical location of the start-up, distinguishing between the Paris region and the rest of France. In Europe, Paris is the second-largest city for venture capital investments after London. However, France has a policy aimed at enabling all regions to finance start-ups, making it relevant to control for results based on geographic location. As seen in figure 5, almost two-third of start-ups in the sample are located in the Paris region.

3.2.3. Cox model and validity tests

The Cox proportional hazards model must satisfy two hypotheses to ensure that the estimates and their interpretations are not biased.

The first hypothesis relies on the functional form of the relationship between continuous quantitative variables and the instantaneous hazard function. This form should ensure that a one-unit change in the value of the continuous variable has a constant effect on the hazard ratio, which is identical across all values of the variable. For example, the effect of a €1 increase in the amount of funds raised should be the same on the probability of a change in the funding type at €50,000 as it is at €100,000. If this hypothesis is not satisfied, the effect of the amount of funds raised would vary for different amounts, making it impossible to interpret the effect of this variable.

To address this, one solution is to discretize this continuous variable around a threshold value (e.g., its median value) and interpret its effect by distinguishing between two subpopulations: one with values for the amount of funds raised above the median (MTRD=1) and another with values below the median (MTRD=0). This continuous variable, transformed into a dichotomous variable, also allows for the application of a stratified Cox model, enabling comparison of the effect of other explanatory variables between the two subpopulations.

To verify this hypothesis, Martingale residuals are calculated and then simulated as a function of the continuous variable under the assumption that it exhibits the appropriate functional form, using the PHREG command in SAS. Based on these estimates, a Kolmogorov test is performed

to determine whether the calculated residuals and the simulated residuals follow the same distribution. Under H_0 , the null hypothesis states that at least one distribution of the simulated residuals is identical to the distribution of the observed residuals. If H_0 is accepted, the conclusion would be that the variable exhibits the appropriate functional form. The Kolmogorov test leads to the acceptance of the null hypothesis in the first regression model, and the rejection of the null hypothesis in the second and third regression models (See Appendix 1). In conclusion, the relationship between the instantaneous hazard function and the amount of funds raised in the previous round only exhibits the appropriate functional form in the first model.

Due to the rejection of the hypothesis on the functional form of the relation between the amount raised and the hazard function, the former has been transformed into a dichotomous variable, based on its respective median value in the second round ($MTRD2=1$ if the second-round amount is above its median value, or $MTRD2=0$ otherwise) and the third round ($MTRD3=1$ if the third-round amount is above its median value, or $MTRD3=0$ otherwise).

The second hypothesis is that the ratio of instantaneous risk functions between two start-ups is constant over time. In other words, the individual characteristics used to estimate the instantaneous risk functions only determine the level of risk, with no impact on the risk profile over time. Failure to respect this assumption would imply that one or more individual characteristics of start-ups change over time. To remedy this, the models would either have to be adjusted by associating a time indicator variable with the variables under consideration, or a parametric model would have to be estimated by choosing, from among the known instantaneous risk functions, the one that best describes the risk profile over time.

The validity of the constant proportional hazards hypothesis is tested for the variables describing the amount of funds raised in the first, second and third rounds transformed into dichotomous variables ($MTRD1$, $MTRD2$, $MTRD3$), the presence of Bpifrance in the previous round and among the investors ($YES=1$ or $NO=0$), the nature of the technological innovation ($DEEPTech: YES=1$ or $NO=0$), and a business plan meeting at least one of the sustainable development goals ($SDG: YES=1$ or $NO=0$).

To this end, the residuals of a score are calculated and then simulated for each explanatory variable and for each start-up as a function of duration, using the PHREG command in SAS. Using these estimates, a Kolmogorov test is performed to determine whether the two distributions follow the same distribution. Under H_0 , the null hypothesis is that at least one of the distributions of simulated scores is identical to the distribution of calculated scores. If H_0 is accepted, the conclusion would be that the variable under consideration respects the condition of constant proportionality of risks.

The Kolmogorov test leads to accept the null hypothesis for all the independent variables in the first regression model, to reject the null hypothesis for the amount of funds raised in the second round in the second regression model, and to accept the null hypothesis for all the explanatory variables with the exception of the nature of the technological innovation and the sector of activity in the third regression model. In conclusion, our tests lead to conclude that the hypothesis of constant proportionality of risks is not respected for the amount of funds raised in the second regression model, and for the nature of the technological innovation and the sector of activity in the third regression model. The former conclusion prompts the use of a stratified Cox model with the variable $MTRD2$ to compare the effect of other explanatory

variables between the two subpopulations (MTRD2=1 versus MTRD2=0) in the second regression model. For the latter the two variables have been removed from the third regression model.

4. Findings and discussion

We start from an initial dataset of 3,741 start-ups. In the Cox transition framework, the number of firms contributing to each model declines mechanically across later transitions because, for each round-to-round analysis, the risk set includes only start-ups that have reached the starting round. Accordingly, 1,001 firms are at risk for the transition from the first to the second round, 486 for the transition from the second to the third round, and 215 for the transition from the third to the fourth round. Start-ups that do not experience the next round within the observation period are treated as right-censored rather than removed from the study. In addition, the effective estimation sample for a given specification may be further reduced due to missing information required to construct the survival outcome or covariates—most importantly the time elapsed between rounds (Table 4) and, where applicable, the amount raised in the relevant round. The reported models are therefore estimated on the subset of start-ups that belong to the relevant risk set and have non-missing time-to-event (or censoring time) information and covariates used in that specification.

Table 5 : Cox regression models between the first and the second funding round

Model 1	EVT1xT1											
Specification	(a)			(b)			(c)			(d)		
Independent and Control Variables	HR	SE	p value	HR	SE	p value	HR	SE	p value	HR	SE	p value
First round amount (in thousand euro)	1.024	0.02183	0.2680	1.028	0.02187	0.2129						
First round amount (MTRD1=1 above the median or MTRD1=0 Otherwise)							1.103	0.09066	0.2776	1.098	0.09017	0.2995
Seed Year (SYEAR=1 after 2012 or SYEAR=0 Otherwise)	1.817	0.12762	<0.0001	1.812	0.12675	<0.0001	1.800	0.12749	<0.0001	1.794	0.12670	<0.0001
BPI Presence in the first round (YES=1 or NO=0)	1.105	0.17727	0.5733				1.081	0.17854	0.6628			
BPI Presence among investors (YES=1 or NO=0)				1.272	0.10807	0.0262				1.255	0.10806	0.0354
Type of technological innovation (DEEPTech=1 or DEEPTech=0)	1.230	0.10126	0.0408	1.200	0.10228	0.0748	1.235	0.10105	0.0370	1.206	0.10200	0.0661
Business plan in line with SDG goal (SDG=1 or SDG=0)	1.076	0.16756	0.6638	1.088	0.16740	0.6125	1.062	0.16775	0.7201	1.075	0.16750	0.6662
Geographical location (PARIS REGION=1 or PARIS REGION=0)	1.154	0.09870	0.1455	1.202	0.10036	0.0672	1.157	0.09875	0.1409	1.203	0.10047	0.0654
Business sector (SERVICES=1 or SERVICES=0)	1.080	0.10667	0.5196	1.094	0.10647	0.3975	1.077	0.10671	0.4897	1.089	0.10652	0.4230
Goodness of Fit												
Wald Chi-2		29.351			33.8928			29.5176			33.6425	
p value		0.0001			<0.0001			0.0001			<0.0001	
-2LOGL		5701.816			5697.359			5701.713			5697.627	
Sample size		1001			1001			1001			1001	

Note : In model 1 specifications (a) and (b), the amount of funds raised is described by a continuous variable, while in models (c) and (d), the amount of funds raised is described by a dichotomous variable that takes the value 1 if the amount of funds raised by a start-up is greater than the median and the value 0 otherwise. Specifications (a) and (c) assess the effect of Bpifrance's presence in the first funding round, while specifications (b) and (d) consider Bpifrance's presence in any surrounding round. Reported coefficients are presented as hazard ratios (HR = exp(coef)). SE denotes the standard error of the estimated coefficient. *** p < 0.01, ** p < 0.05, * p < 0.10.

Table 6 : Cox regression models between the second and the third round

Model 2	EVT2xT2											
Specification	(a)			(b)			(c)			(d)		
Independent and Control Variables	HR	SE	p value	HR	SE	p value	HR	SE	p value	HR	SE	p value
Second round amount (in thousand euro)												
Second round amount (MTRD2=1 above the median or MTRD2=0 Otherwise)												
Seed Year (SYEAR=1 after 2012 or SYEAR=0 Otherwise)	1.752	0.15847	0.0004	1.695	0.15830	0.0009	1.783	0.15991	0.0003	1.725	0.15953	0.0006
BPI Presence in the second round (YES=1 or NO=0)	0.700	0.19719	0.0700				0.709	0.19825	0.0834			
BPI Presence among investors (YES=1 or NO=0)				1.031	0.13242	0.8166				1.012	0.13331	0.9301
Type of technological innovation (DEEPTTECH=1 or DEEPTTECH=0)	0.990	0.13155	0.9400	1.002	0.13108	0.9859	1.040	0.13454	0.7733	1.050	0.13449	0.7166
Business plan in line with SDG goal (SDG=1 or SDG=0)	1.246	0.19898	0.2697	1.241	0.19920	0.2788	1.250	0.19878	0.2610	1.247	0.19904	0.2681
Geographical location (PARIS REGION=1 or PARIS REGION=0)	0.991	0.13398	0.9442	1.037	0.13342	0.7868	0.992	0.13501	0.9534	1.034	0.13444	0.8027
Business sector (SERVICES=1 or SERVICES=0)	1.097	0.13971	0.5059	1.091	0.14011	0.5353	1.058	0.14127	0.6909	1.049	0.14191	0.7370
Goodness of Fit												
Wald Chi-2		15.6825			12.2892			16.2032			13.0980	
p value		0.0156			0.0558			0.0113			0.0415	
-2LOGL		2813.008			2816.534			2421.563			2424.808	
Sample size		486			486			486			486	

Note: The amount raised in the second round is the only variable for which our diagnostic tests indicate a violation of the Cox model assumptions (proportional hazards and/or functional form). Therefore, the continuous measure of second-round amount is excluded from specifications (a) and (b). In specifications (c) and (d), we instead estimate a stratified Cox model using an indicator of second-round amount relative to the median (MTRD2 = 1 if the amount raised in round 2 is above the median; 0 otherwise) as the stratification variable. This allows the baseline hazard to differ between the two subpopulations (below-median vs above-median second-round amounts), while estimating the effects of the other covariates within strata. Reported coefficients are presented as hazard ratios (HR = exp(coef)). SE denotes the standard error of the estimated coefficient. *** p < 0.01, ** p < 0.05, * p < 0.10.

Table 7 : Cox regression models between the third and the fourth funding round

Model 3	EVT3xT3											
Specification	(a)			(b)			(c)			(d)		
Independent and Control Variables	HR	SE	p value	HR	SE	p value	HR	SE	p value	HR	SE	p value
Third round amount (in thousand euro) Third round amount (MTRD3=1 above the median or MTRD3=0 Otherwise)							0.662	0.17999	0.0217	0.647	0.17996	0.0155
Seed Year (SYEAR=1 after 2012 or SYEAR=0 Otherwise)	1.787	0.22468	0.0098	1.760	0.22572	0.0123	1.788	0.22466	0.0097	1.754	0.22567	0.0128
BPI Presence in the third round (YES=1 or NO=0)	0.951	0.27509	0.8540				0.966	0.27554	0.8987			
BPI Presence among investors (YES=1 or NO=0)				1.394	0.19089	0.0817				1.441	0.19227	0.0575
Type of technological innovation (DEEPTech=1 or DEEPTech=0)												
Business plan in line with SDG goal (SDG=1 or SDG=0)	0.898	0.26479	0.6836	0.821	0.27071	0.4663	0.973	0.26850	0.9193	0.877	0.27488	0.6341
Geographical location (PARIS REGION=1 or PARIS REGION=0)	0.973	0.20871	0.8963	1.019	0.21109	0.9274	1.067	0.21353	0.7630	1.121	0.21565	0.5976
Business sector (SERVICES=1 or SERVICES=0)												
Goodness of Fit												
Wald Chi-2		6.7292			9.6715			11.9711			15.5277	
p value		0.1509			0.0463			0.0352			0.0083	
-2LOGL		1127.812			1124.911			1122.622			1119.153	
Sample size		215			215			215			215	

Note: The amount of funds raised in the third round, described by a continuous variable, does not satisfy the functional form of its relationship with hazard function in the Cox model. It is therefore dropped from model 3 specifications (a) and (b). The variables describing the nature of the developed innovation (DEEPTech) and the business sector (SERVICES) do not meet the proportional hazards assumption and are also removed from all specifications of model 3. Once transformed into a dichotomous variable, the amount of funds raised in the third round satisfies the constant proportional risks assumption in the Cox model. Reported coefficients are presented as hazard ratios (HR = exp(coef)). SE denotes the standard error of the estimated coefficient. *** p < 0.01, ** p < 0.05, * p < 0.10.

We begin by analysing the results for the four independent variables and then move on to the three control variables.

Among the independent variables, Bpifrance related measures appear to be the most informative in explaining the speed at which start-ups move up the financial escalator. By contrast, the amount raised in the previous round, regardless of the specification considered, has no effect except between the third and fourth rounds. Business models aligned with the SDGs are not associated with statistically significant differences in stage progression. Finally, the type of technological innovation (DEEPTech) increases the likelihood of moving to a higher stage of funding only between the first and second round. Across the following rounds, this impact is no longer statistically significant.

Between the first two rounds, when Bpifrance is present in a surrounding round (BPIPRES), the estimated hazard ratio is around 1.25-1.27 (Table 5 specifications b and d), indicating a higher instantaneous rate of progressing to a higher funding stage. A similar positive association is found between the third and fourth rounds, where the hazard ratio is approximately 1.39-1.44 (Table 7, specifications b and d), although statistical support is weaker (marginal significance). Taken together, these patterns suggest that Bpifrance's influence is more structural and diffuse throughout the financing process than being strictly tied to immediate, round-to-round 'accompaniment' effects. This interpretation is also consistent with the fact that our dataset only captures direct equity participations and is unable to fully observe Bpifrance's broader fund-of-funds channel and other financial support provided.

By contrast, when Bpifrance participates directly in the *previous* round (BPIRD variables), the estimated effect is not statistically significant at early and late transitions. Moreover, in the second-to-third round transition (Model 2), Bpifrance's direct presence in the second round is associated with a hazard ratio below one (around 0.70, Table 6), suggesting slower stage progression at that specific transition. Rather than being interpreted as a "negative" public effect, this result can plausibly reflect *additionality and selection into support*: the second-to-third round transition is often described as a friction point (equity gap), and public investors may be more likely to step in for firms facing greater uncertainty or more difficult follow-on conditions. In that case, a lower hazard would capture underlying risk and longer maturation cycles rather than an adverse causal impact of public investment.

Regarding the amount raised, the results do not support the interpretation that more money leads to faster progression. The amount raised shows no systematic association with progression at the first two transitions. At the later transition (from the third to the fourth round), the dichotomised third-round amount (MTRD3) is associated with hazard ratios below one (around 0.65; see Table 7, specifications c and d). This suggests that start-ups that raise a relatively large amount in the third round may experience a change in funding type more slowly within the observation window. One possible explanation is that larger funding rounds may finance a longer scaling-up period (or follow-on financing within the same stage), thereby postponing the next change in funding type rather than accelerating it.

Being recognised as a deep tech start-up at the beginning of the life cycle is associated with faster early progression (Table 5), consistent with a "start-up bonus" driven by selection and signalling (label effects) in the seed-to-early-stage transition. However, the absence of significant differences at later transitions suggests that deep tech ventures face constraints beyond initial funding (such as scale-up requirements, capital intensity, and longer

development cycles) precisely where patient capital and specialised follow-on capabilities become critical.

The lack of a significant association for SDG alignment is noteworthy given policy emphasis on sustainable ventures. However, SDG tagging may be an imperfect proxy for sustainability intensity, mission strength, or impact measurement quality. These likely limits interpretation, and further work using more granular sustainability measures would be valuable.

Analysis of the results for the control variables allows us to better understand the role of Bpifrance and to highlight the specificities of the French early-stage venture capital market.

Receiving funding after 2012 is positively and significantly associated with faster stage progression across transitions. In the Cox specifications, the estimated hazard ratios indicate that start-ups first funded after 2012 have a substantially higher instantaneous rate of reaching a new funding stage than those first funded before January 2013 (typically around +70% to +80%, depending on the transition and typically significant at conventional levels). This pattern is consistent with the maturation of the French early-stage ecosystem during the 2010s and is in line with institutional assessments that highlight the strengthening of entrepreneurial finance infrastructures in France (Cour des Comptes, 2023). However, as multiple factors evolved simultaneously over this period (including market conditions, the policy environment, the investor base and data coverage), the 'post-2012' effect should be interpreted as an association between time period and cohort, rather than as evidence that any single reform or actor directly caused faster progression.

The Cour des Comptes report also notes that, since 2019, a significant proportion of ventures receiving venture or development capital have benefited from public funding, either directly or indirectly (Cour des Comptes, 2023). In our sample, Bpifrance is among the most frequently observed investors across rounds. Nevertheless, its prominence must be interpreted in the context of a large and diverse base of early-stage capital providers, including incubators and accelerators, which play a key role at the pre-seed and seed stages (Venâncio & Jorge, 2022). Importantly, these descriptive patterns (high public presence alongside many other actors) do not by themselves establish whether public involvement mainly crowds in private capital (through a catalytic role involving signalling, syndication and risk-sharing) or crowds out private investors (through a substitutive role where public money replaces private money). Distinguishing between these mechanisms requires evidence beyond investor presence.

Finally, we find that the economic activity sector (SERVICES) is not significantly associated with stage progression across specifications. With regard to geographical location, a positive effect of being located in the Paris region appears only at the earliest transition and at a 10% threshold (Table 5, specifications b and d), suggesting that any location advantage is concentrated in early network access and syndication patterns rather than persisting mechanically across later rounds.

Conclusion

This study is particularly timely, within the French context and more broadly within ongoing European debates about the role of GVC and SIBs in addressing the funding gaps for PHG

start-ups (Murray, 2020; Arundale, 2020; Quas et al., 2022) and supporting long horizon deeptech and cleantech sectors (Mazzucato and Semieniuk, 2018; Schuh et al., 2022b).

Overall, our results are consistent with the view that Bpifrance has contributed to structuring the French early-stage financing market and facilitating stage progression, particularly when its presence is observed in *surrounding rounds* of the financing trajectory. At the same time, the evidence also suggests persistent friction at mid-stage transitions, particularly between the second and third rounds, where public intervention may focus on firms that are more difficult to finance. In this context, the negative correlation observed in the presence of direct Bpifrance involvement in the second round can be reasonably interpreted as an additionality pattern rather than crowding out: Bpifrance appears to intervene where private follow-on financing may be more limited.

Our results also reveal a more nuanced picture for deep tech and sustainable ventures. While deep tech exhibits faster early-stage progression, this advantage does not persist at later stages. This aligns with the idea that scaling up “hard” innovation requires more patient capital and specialised follow-on capabilities. Similarly, SDG alignment does not have a measurable effect in our models, which is likely due to limitations in SDG measurement rather than sustainability being irrelevant to financing outcomes. Taken together, these findings suggest that market expansion alone may not be sufficient, and that more targeted mid-stage instruments and capabilities may be required for hard tech, deep tech and green innovations.

This research has limitations. Firstly, our Bpifrance indicators only capture direct equity participations and are unable to observe Bpifrance’s fund-of-funds channel. This channel may also influence private market development and syndication dynamics. Secondly, the estimated associations should not be interpreted as causal effects, since public investors may select firms with specific (unobserved) risk profiles, particularly at friction points such as the transition from the second to the third funding round. Third, our outcome captures *changes in funding type* between rounds within a four-round window; some firms may scale through follow-on rounds within the same stage, which would mechanically appear as slower “stage change” even when performance is strong. Finally, SDG alignment is measured through Dealroom tagging, which may not reflect the depth of sustainability strategy or impact measurement, potentially attenuating estimates.

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Appendix 1: Kolmogorov test results on functional form

Upper bound test for the functional form				
Variable	Absolute value maximum	Resample	Seed	Pr > MaxAbsVal
First round amount (AMTRD1)	17.5125	50	27513	0.4600
Second round amount (AMTRD2)	20.1621	200	27513	0.0300
Third round amount (AMTRD3)	16.8942	200	27513	0.0300

Appendix 2: Kolmogorov test results on constant proportional risk in the specification c and d of the first regression model

Upper bound test for the proportional hazards (specification c)				
Variable	Absolute value maximum	Resample	Seed	Pr > MaxAbsVal
First round amount (MTRD1)	0.7969	200	27513	0.3950
year	1.0666	200	27513	0.1650
BPIRD1	0.8565	200	27513	0.3850
deep	1.1010	200	27513	0.1100
SDG	0.9812	200	27513	0.3000
re_g	0.5817	200	27513	0.7750
sect	0.8017	200	27513	0.5150

Upper bound test for the proportional hazards (specification d)				
Variable	Absolute value maximum	Rehearsals	Strain	Pr MaxAbsVal >
mtrd1	0.7890	200	27513	0.4000
year	1.0606	200	27513	0.1650
BPIPRES	0.4773	200	27513	0.9300
deep	1.1169	200	27513	0.1050
SDG	0.9490	200	27513	0.3250
re_g	0.5801	200	27513	0.8000
sect	0.8120	200	27513	0.5000

Appendix 3: Kolmogorov test results on constant proportional risk in the specification c and d of the second regression model

Upper bound test for the proportional hazards (specification c)				
Variable	Absolute value maximum	Rehearsals	Strain	Pr MaxAbsVal >
mtrd2	1.4659	200	27513	0.0050
year	0.8363	200	27513	0.3600
BPIRD2	0.3737	200	27513	0.9750
deep	0.8458	200	27513	0.4200
SDG	0.7002	200	27513	0.5050
re_g	1.0367	200	27513	0.2150
sect	0.5888	200	27513	0.7900

Upper bound test for the proportional hazards (specification d)				
Variable	Absolute value maximum	Rehearsals	Strain	Pr > MaxAbsVal
mtrd2	1.4698	200	27513	0.0050
year	0.8529	200	27513	0.3400
BPIPRES	0.9615	200	27513	0.2400
deep	0.8127	200	27513	0.4600
SDG	0.7075	200	27513	0.5050
re_g	1.0577	200	27513	0.2000
sect	0.5663	200	27513	0.8250

Appendix 3: Kolmogorov test results on constant proportional risk in the specification c and d of the third regression model

Upper bound test for the proportional hazards (specification c)				
Variable	Absolute value maximum	Rehearsals	Strain	Pr > MaxAbsVal
mtrd3	0.5967	200	27513	0.7650
year	0.5221	200	27513	0.8150
BPIRD3	0.6010	200	27513	0.7350
deep	1.3427	200	27513	0.0700
SDG	0.8774	200	27513	0.4200
re_g	1.0724	200	27513	0.2000
sect	1.5633	200	27513	0.0150

Upper bound test for the proportional hazards (specification d)				
Variable	Absolute value maximum	Rehearsals	Strain	Pr > MaxAbsVal
mtrd3	0.5368	200	27513	0.8650
year	0.4875	200	27513	0.8800
BPIPRES	0.7791	200	27513	0.4600
deep	1.2803	200	27513	0.1100
SDG	0.8564	200	27513	0.4650
re_g	1.0939	200	27513	0.1950
sect	1.4736	200	27513	0.0250