# Waiting for the Payday?

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# Waiting for the payday? The market for startups and the timing of entrepreneurial exit♣

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**Abstract**

Most technology startups are set up for exit through acquisition by large corporations. In choosing when to sell, startups face a tradeoff. Early acquisition reduces execution errors but later acquisition both improves the likelihood of finding a better match and benefits from increased buyer competition. Startups' exit strategies vary considerably: Some startups aim to sell early; others remain in stealth mode by developing the invention for a late sale. We develop an analytical model to study the timing of the exit strategy. We find that startups with more capable founding teams commit to a late exit, while those with less capable founding teams commit to an early exit. Finally, startups with founding teams of intermediate capabilities remain flexible: they seek early offers but eventually sell late. If trying the early market is so costly that startups have to make a mutually exclusive choice between early and late sale, startups sell inefficiently late. Instead, if they can collect early offers at no cost before deciding on the timing of sale, there are too many early acquisitions.

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*"Ninety per cent of the startups I see are built for sale, not for scale" Ajay Royan (Mithril Capital).*[1]

## 1. Introduction

For many inventions the journey to commercialization begins in a startup. Following a period of incubation and development, the invention can be passed on to an incumbent via an acquisition.[2] There are some natural inflection points in the lifecycle of a startup when it can be acquired (Graebner and Eisenhardt, 2004). Bill Janeway, a veteran venture capitalist from Warburg Pincus writes that:

> *…(t)he responsible entrepreneur and VC are charged with asking themselves the same question at each step along the way: The technology does "light up"—do we sell now?, We have three credible customers who will testify that they have bought our offering and will buy more—do we sell now?, We have access to another round of capital but it will be dilutive and Business Risk looms—do we sell now?".*[3]

As this quote indicates, deciding to take the venture to the next stage is a question of the first order importance for startups. Given the high failure rate among technology startups (Gage, 2012), delay could have dire effects on survival. Moreover, because many innovators acquire inventions by buying startups (see, for instance, Arora et al., 2016), the timing of the startup sale is important also for the efficiency of the division of innovative labor (Arora et al., 2001; Gans and Stern, 2010).

The exit strategies of startups differ substantially. Some startups focus on early sale. For instance, Ecton Inc. was founded in 1996 with the goal of developing a portable Doppler echocardiography machine. After raising $2.5 million from private investors, it focused on product and technology development, with little attention to marketing, distribution and sales. It was acquired in 1999 by Acuson for $40 million (Christensen and Cape, 1998). Others remain in stealth mode working on the transition from invention to innovation and becoming visible to potential buyers only at a later stage. For instance, Siri, the virtual

[1] https://www.economist.com/business/2018/06/02/american-tech-giants-are-making-life-tough-for-startups

[2] The National Venture Capital Association reports that in 2016 acquisitions accounted for 82% of venture capital-backed exits in the US (https://nvca.org/pressreleases/2017-nvca-yearbook-highlights-busy-year-venture-industry-nvca/). Cunningham (2017) shows that out of the 83 startups in the US medical devices industry that exited, 71 were acquired. Mathisen and Rasmussen (2016) also identify acquisitions as the most frequent exit strategy in the case of successful Norwegian startups.

[3] William Janeway, Warburg Pincus. https://medium.com/the-wtf-economy/enterprise-software-death-and-transfiguration-99eb1d3fc4c0

assistant now built into the operating system of iPhones, remained in stealth mode for more than two years, then marketed the technology as an app before being acquired two weeks later by Apple.[4]

Other startups opt for a more *flexible strategy*: they entertain early offers, reject them if they are not sufficiently attractive, and eventually develop the invention into an innovation with a view to a possible late exit. For instance, in 2002, PopCap, an online game developer, was offered and rejected an offer of $5 million from Microsoft, and then was acquired by Electronic Arts for $1.3 billion in 2011.[5] However, this flexibility may not always be positive: Qwiki, an automated video startup, founded in 2011, received an offer from Google of $100 million a few months after its launch. Turning down the offer, Qwiki raised an additional $10 million while securing a contract with Microsoft Bing. Two years later the company was acquired by Yahoo for $50 million only.

In this paper, we build a model to rationalize the different exit strategies chosen by startups and investigate the determinants of the timing of startup sale.[6] We use the model to interpret the existing facts and evidence, derive empirically testable implications, and analyze the efficiency of the equilibrium between buyers and sellers. We analyze the tradeoff between reducing execution errors by selling early and improving the likelihood of finding a better match and benefiting from more buyer competition by delaying the sale. To anticipate our model, we assume that startups are more prone than incumbents to errors in developing an invention into an innovation. For instance, startups may hire the wrong people, develop the product for the wrong market or try to develop it for too many markets and fail, or simply run out of money. Established firms have routines for developing and commercializing inventions which makes them less prone to execution failures, and deeper pockets to protect them against a run of bad luck.[7] On the other hand, early stage markets tend to have fewer buyers than late stage markets because, for instance, acquisition of an early stage startup requires absorptive capacity (Cohen and Levinthal, 1989). Early stage startups have unproven technology, and only firms able to evaluate, develop, and commercialize the invention will buy an early stage startup. The small number of potential buyers hurts the startup in two ways: a good match is less likely, and the buyers compete less fiercely for the startup.

[4] https://www.telegraph.co.uk/technology/apple/7650361/Apple-acquires-Siri-the-virtual-personal-assistant.html
[5] https://www.visualcapitalist.com/turning-down-billions-grading-15-tech-companies-that-declined-big-takeover-offers/
[6] We focus on exit through acquisition by an incumbent which is the most common exit route for successful startups. We therefore do not consider IPOs which have been the subject of numerous studies in the finance literature (see, for instance, Banninga et al., 2005; Pastor and Veronesi, 2005).
[7] Åstebro and Serrano (2015) document the importance of access to complementary assets. If a startup partners with an incumbent firm with complementary assets, they find that the probability of commercialization doubles, and that expected revenues increase by 29%, at the sample mean.

This creates a tradeoff for the startup: Create and capture more value by being acquired when the invention is more mature but run a greater risk of failing due to poorer execution.

Our micro-foundation for the choice of the exit strategy relies on the assumption that startups are resource constrained, particularly in terms of time and attention of the founder(s). Their limited resources can be allocated between: a) trying the early market, and b) developing the invention for the late market. Thus, if searching for early buyers – trying the early market – requires a significant amount of resources, the startup will have fewer resources to develop the invention for the late market. This generates three exit strategies: Startups can choose the early market and not invest in developing the invention (de facto *committing to the early market*). They can choose to remain in stealth mode and dedicate all their resources to developing the invention (de facto *committing to the late market*). Finally, they can both try the early market while also developing the invention (*flexibility*). Solving for the equilibrium in the market for startups, we find that the relationship between flexibility and founding team's execution capabilities is non-monotonic. Whereas founding teams with intermediate execution capabilities dedicate resources to both finding an early buyer and developing the invention, more capable and less capable founding teams focus on just one activity thereby committing to an exit timing. Even if searching for early buyers requires no investment of time or other resources, a startup with low execution capability may choose to commit to the early market. In addition, we show that startups are less likely to sell early when developing absorptive capacity is more expensive, venture capital is more abundant, and intellectual property (IP) protection is weaker.

We then analyze the efficiency properties of the equilibrium outcome. The early and late markets differ in terms of both value creation (i.e., the total expected profits of the firms in the market), our benchmark for efficiency, and value capture (the split of the value among the firms in the market). We show that the efficiency properties of the market outcome crucially depend on whether startups have to commit to an exit strategy or they are flexible. When startups have to commit, they tend to sell late relative to the efficient timing: Because sellers capture a larger share of the value created in the late market due to tougher competition among buyers, some startups choose a late sale when an earlier one would have created more total value. Somewhat surprisingly, when startups are flexible, they tend to accept too many early offers relative to what would be efficient. The intuition is that a startup and the highest bidder trade when an early deal offers more value capture to them than their expected value capture in the late market. Since they ignore the expected value capture of other late buyers, which may acquire the startup should it wait for a late sale, there is too much early trade.

The rest of paper is organized as follows. Section 2 summarizes the contribution of our paper vis-à-vis existing work. Section 3 describes the baseline model, analyzes the endogenous choice of the exit strategy, and derives a set of testable empirical implications. Section 4 investigates how the efficiency of the exit timing decision depends on the exit environment i.e., whether the startup has to make a mutually exclusive choice between early and late, or is flexible. Section 5 discusses some potential extensions of the baseline model. Section 6 summarizes our results and concludes. Omitted proofs of the formal propositions and further robustness checks are provided in the online Appendix.

## 2. Background literature

In an inductive study of 12 technology-based ventures, Graebner and Eisenhardt (2004) find that some startups are extremely proactive in finding buyers (for instance, they generate lists, talk to potential buyers, hold auctions), while others minimize these efforts and even discourage deals. Graebner and Eisenhardt (2004) also provide qualitative evidence that startups have different execution risks, which affects their exit timing.

Most papers in the literature on exit timing build on the assumption that information about the quality of a startup is revealed over time and that this results in greater value capture for the startup. Daley and Green (2012) propose a model which features asymmetric information about startup type and includes the arrival of information across time. They demonstrate a market inefficiency: the market can dry up because “high type” startups wait for information arrival while “low type” startups wait so as to be pooled with high type startups. Daley and Green (2012) assume that all buyers have the same valuations whereas we assume that buyers’ valuations have an idiosyncratic component which generates differences in matching benefits across buyers. Also, Daley and Green (2012) consider only flexible startups and thus do not analyze the efficiency properties of the equilibrium in different exit environments.

In the context of movie scripts, Luo (2014) develops a model in which early products (ideas) are more difficult for buyers to assess and enjoy weaker IP rights compared to final products (scripts). Luo finds that both the best and the worst ideas are sold late but for different reasons. Sellers with a high quality idea wait for the late market where the expropriation risk is muted and value capture is greater. However, lower quality ideas cannot be sold in the early market because potential buyers prefer to delay their development investment until more information about the true value of the idea is revealed. Compared to Luo (2014), we focus on understanding startups’ timing of sale and the efficiency of the market outcome and comparing these across different exit environments.

Ransbotham and Mitra (2010) study a model where information revelation over time reduces a “winner’s curse” problem and increases the expected sales price. However, value creation from an acquisition decreases over time because integration problems between the buyer and the startup become more severe. Our model captures a different tradeoff: the possibility of a better match in the late market versus a greater likelihood of failure during the transition to a later stage. Furthermore, differently from Ransbotham and Mitra (2010), we derive the subgame perfect equilibrium of the model, explore the efficiency properties of the market outcomes, and study the decision of startups to pursue a given exit strategy.

Allain et al. (2016) study how the timing of technology licensing in the pharmaceutical industry depends on the number of buyers and the competition among them in both the market for technology and the downstream product market. They assume that sellers are over-confident about the quality of their technology, and delay licensing in the hope that additional (positive) information will be revealed to the market. However, delaying is not costless from the point of view of efficiency since the buyer's development costs are lower than those of the seller. Our model suggests a different reason for selling late: More buyers implies that delaying the sale can be efficient due to better matching in the late market. Allain et al. (2016) also do not consider the possibility of flexibility and the associated implications for the efficiency of the startup market and entrepreneurial strategy.

We are aware of two papers that look at startups exit timing but do not assume gradual revelation of information about the value of a startup over time. Cong (2019) develops a continuous-time model of auctions of real options where the startup's technology can be considered a real option. Over time, the value of the technology changes and the buyer has to decide when to commercialize it; i.e., when to exercise the option. Buyers differ in their commercialization costs, and the startup tends to delay the auction inefficiently in order to attract more buyers and to reduce the winner's rents. In our model, the commitment case provides similar insights and intuition, although it has a different micro-foundation. However, in Cong's model, an early sale is always efficient while startups benefit privately from delay. By contrast, in our model, a late sale can be efficient because of the possibility of a better match. Also, as Cong does not analyze the flexible case, there is no comparison across exit environments.

Nörback and Persson (2009) build a model where a startup is either acquired early by an incumbent or receives venture capitalist support and is sold late. Similar to Allain et al. (2016), they analyze competition among downstream firms, wherein the acquirer has higher profits while other incumbents suffer a profit loss. The venture capitalist has too strong an incentive to develop the innovation because the price of the startup in the late market reflects both the profit increment for the acquiring firm and the reduction in the non-acquirers' profits. On the other hand, incumbents have an incentive to acquire the innovation early to preempt the over-investment in development. Nörback and Persson (2009) show that startups are sold late only if venture capitalists have cost advantages relative to incumbent firms, or the development of the startup idea suffers from a double moral hazard problem. While their objective –

understanding how venture capital backing changes the incentives to innovate – is different, their conclusions about how it delays the startup sale are similar to our case with commitment to exit timing.

Our paper is also related to the literature on the market for technology. In our model, a startup has only one technology, and there is no difference between acquiring the startup or getting an exclusive license. There are two papers which consider technology licensing timing. Gans et al. (2008) show that there is an increase in the probability of licensing around the patent-grant date. Hegde and Luo (2018) argue that mechanisms that publicize information about the technology reduce the time-to-license of the patented technology. They develop a model showing that if firms are forced to publish their patent applications, licensing is more likely. Together, these two papers show that if patent rights are better defined and there is more information available about the technology, technology transactions occur at an earlier stage. These papers complement our model, which emphasizes the tradeoff between value creation and value capture, rather than the transaction costs involved in licensing technology.

Finally, Gans et al. (2019) offer a conceptual argument about the importance of commitment as a counter to the growing popularity of frameworks which prescribe experimentation and flexibility to entrepreneurs. We examine both commitment and flexibility and find that the efficiency properties of the market outcomes change drastically. Further, and consistent with Gans et al. (2019), we show that there are cases where a startup would be better off committing to an exit timing rather than being flexible. In addition to limited time and attention, flexibility is also costly because it affects buyer behavior. When faced with a flexible seller, early buyers only bid if their valuations are above a threshold. This endogenous reduction in the number of early offers is especially costly for startups that are unlikely to make it to the late market.

To sum up, our model includes some important differences compared to extant modeling efforts to study startups' exit timing. First, with the exception of Daley and Green (2012), who consider fully flexible startups, existing work assumes that startups commit to an exit timing. We propose a parsimonious model where the startup's exit strategy emerges endogenously. Second, we show that the exit strategy affects the efficiency of market outcomes. Differently from existing studies, we show that a startup sale can occur inefficiently early. This is because we propose a novel tradeoff for startups: the possibility of a better match in the late market versus a greater likelihood of failing to reach a later stage. We depart from the extant literature by assuming that the value a startup brings to a potential acquirer varies across acquirers.[8]

[8] For instance, pharmaceutical firms that have had a failed drug will value an acquisition more. Similarly, a startup that is a closer substitute for an existing product may be valued more (for its rent-destroying potential) by the incumbent. A recent paper by Cunningham et al. (2018) provides supporting evidence. Further, startups may add crucial complements to an incumbent's portfolio, again leading to different match quality.

This assumption also distinguishes a startup from a purely financial asset, which is less likely to have a buyer-specific valuation.

## 3. Baseline model

### 3.1. Model description

We assume that a startup sale can occur at two points in time: *early*, at the invention stage (for instance, a startup has only a patent or a prototype), and *late*, at the innovation stage (for instance, a startup has a functioning technology or a viable product).[9] While a discrete time model is a simplification, it captures the notion that there are inflection points in the lifecycle of a startup. Moving from early (invention) to late (innovation) requires scale-up or execution capabilities, which differ across startups. The early market has two key features: a) only a subset of buyers participate; b) early acquisitions imply a higher likelihood of transitioning from invention to innovation since incumbents are assumed to be better than startups at scaling-up. We next describe each side of the market and the decisions companies can make.

#### 3.1.1. The startup

*Execution capability*

We consider a representative startup that can either sell in the early market to those buyers with absorptive capacity or "wait" for a late deal. If the startup waits, all buyers compete for the startup in the late market. The startup has a probability $\theta$ of successfully transitioning from the early to the late market if it is not acquired in the early market. Therefore, $\theta$ captures a startup's execution capabilities for instance in fundraising, recruiting, manufacturing, sales, and marketing. We assume that a startup acquired by an incumbent buyer is always successful, so that $1-\theta$ is a measure of the startup's execution disadvantage relative to an incumbent. The success probability $\theta$ is drawn from the distribution function $Q(.)$, and the draws are public knowledge (we discuss asymmetric information about $\theta$ in section 5). For tractability, we assume that $\theta$ is uniformly distributed on $[b, 1]$, where $0 \leq b < 1$. To reduce the number of cases, $b = 0$ is assumed in most parts of the analysis.

*Exit strategy*

[9] The distinction between early (invention) and late (innovation) is likely to be industry specific. For instance, in the pharmaceutical industry, an early sale could correspond to a biotech startup that has identified a target linked to a disease, developed a lead compound and eventually pushed it into preclinical trials. A late sale could be the same biotech startup acquired after phase II or phase III of the clinical trials.

We envision startups as resource constrained organizations. The total amount of resources available is *R*, which can be allocated between: a) trying the early market, and b) developing the invention into an innovation (i.e., transitioning to the late market).[10] Concretely, we assume that trying the early market requires *c* units of resources, with $c \leq R$. Thus, the startup can dedicate $R\text{-}c \geq 0$ units of resources to develop the invention. We introduce a function $\phi(.)$ that captures the degree to which the potential value in the late market is realized as a function of the resources devoted to developing the invention, $\phi'(.) > 0$. We assume that $\phi(R) = 1$ and $\phi(0) = 0$. That is, if the startup dedicates all available resources to developing the invention, the full potential of the technology is realized. On the other hand, there is no technology to sell in the late market if no resources are dedicated to develop the invention. If the startup invests resources both in pursuing an early sale and in developing the invention, $0 \leq \phi(R\text{-}c) \leq 1$. If trying the early market is costless (i.e., $c = 0$), then $\phi = 1$. If trying the early market is very expensive (i.e. $c = R$), then $\phi = 0$.[11] If two exit strategies have the same expected monetary payoff, we assume that the startup prefers the least time consuming strategy.

The history of the telephone industry illustrates this tradeoff. After inventing and patenting the first practical telephone, Alexander Graham Bell offered its patents to Western Union, which declined the offer. In the language of our model, Bell tried to sell early. This incursion into the early market was not costless as it came “at the expense of his ability to compete quickly and adeptly with Western Union from 1877 through 1879” (Ching et al., 2018, p. 8), a cost captured in our model by a low $\phi$. In other cases, this cost might be very small. For instance, a startup might be more visible to early buyers because it is located in a tech cluster and thus receives unsolicited offers that require little resource investment.

*Discussion*

The micro-foundation of startup exit strategies described above relies on two main assumptions: 1) trying the early market and developing the invention are undertaken simultaneously before receiving early offers; and 2) the startup is resource constrained. These assumptions go together as it makes sense to think about constraints on time and attention when the demands on these resources arise simultaneously. To relax these assumptions, one could build a model where *c* and *q* are the costs of the two activities (in this case, the interpretation of resources as capital is more sensible). However, if the startup tries the early

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[10] Our preferred interpretation of resources is time (attention), which is notoriously constrained in the early phase of a startup’s lifecycle. Entrepreneurs have many demands on their time; looking for potential acquirers during the early phase can distract from other tasks and the startup may fail to move forward.
[11] A different interpretation is to assume that startups are capital constrained, so *R* is the total amount of capital to invest in both activities. In this case, *c* and *R* will appear in the profit equations as monetary costs (this would also capture the case in which the opportunity cost of one unit of time is equal to 1). While the algebra gets messier, qualitative results are similar and are available from the authors.

market, it would develop the invention only if it rejects early deals. In this case, time-compression diseconomies would imply that trying the early market but selling late requires a greater investment than just going directly to the late market.[12] This model produces qualitatively similar results and it is available from the authors upon request.

### 3.1.2. Buyers

*Early and late buyers*

We assume that there is an exogenous number, $n$, of incumbent firms (buyers) that compete upstream for the startup but not downstream in the product market.[13] All $n$ buyers are active in the late market. However, to participate in the early market, buyers need "absorptive capacity"; i.e., the ability to understand, develop and integrate nascent technology (Cohen and Levinthal, 1989). Buyers that have invested in absorptive capacity can thus acquire startups in both the early and the late markets. We use $m$ to denote the number of buyers active in the early market. Absorptive capacity is the outcome of investments in basic research and scientific capabilities (Rosenberg, 1990). If these investments are substantial we will have $m < n$ which is a key assumption of our model. Anecdotal evidence corroborates this. For instance, both Cisco and IBM have acquired large numbers of companies over the years. While IBM has always invested heavily in internal research, Cisco has a limited research budget. Cisco's acquisitions typically involve more mature targets with "a minimum of 40% market share" (John Chambers, CEO, Cisco).[14] Instead, IBM has acquired companies in different stages of their lifecycle from small, newly founded startups to more established corporations such as RedHat. IBM's annual reports document how the company uses its research labs to inform its merger and acquisition strategy. Microsoft is another company with huge investment in basic science and a long history of acquiring early and late stage startups. Thus, while late acquisitions are available to most industry incumbents, early acquisitions are restricted to a set of companies that have the ability to evaluate early ventures and the organizational skills to absorb them.[15]

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[12] Note there could be some economies of scope as well. Some of the investments made in order to prepare an early sale might also be helpful for moving forward towards the late market. For example, a business plan that specifies the value proposition and the competitive landscape can be helpful in developing the invention for the late market.

[13] Downstream competition among buyers does not change our qualitative results, see Anonymized Authors (2018).

[14] https://www.businessinsider.com/cisco-john-chambers-acquisition-strategy-2014-7?IR=T

[15] A startup might scale up its invention in directions that are less compatible with some buyers (Graebner et al. 2010; Karim and Mitchell, 2004) whereas an early acquisition is more malleable and easier to integrate. This possibility could be modeled by introducing an integration benefit that scales up the expected value of an early startup for all buyers. This would make the early market more attractive but

From the point of view of the startup, the number of buyers in the early market is exogenous and we treat it as such. However, in section 4.4, we model the incumbents' choice of investing in absorptive capacity and discuss the additional insights that this provides.

*The value of a startup*

In the late market, a startup's value to buyer $i$ is $w+v_i$ where $w$ is a common component (common to all acquirers) and $v_i$ is an idiosyncratic component. In the early market, buyers bid anticipating the value of the startup's innovation once fully developed. Since we ignore discounting, the value to buyer $i$ in the early market is also $w+v_i$ (recall that if acquired, the startup will advance to the late stage with probability 1). Abusing the notation, we drop the subindex $i$ from here on. The common component, $w$, represents the part of the value of the innovation on which all buyers agree.[16] The idiosyncratic component is buyer-specific, and is independent and identically distributed across buyers. It represents heterogeneity in the value of the innovation, and a specific fit with the buyer's existing products and capabilities. For instance, buyers might differ in terms of geographic markets, distribution channels, potential for cannibalization of existing products, or breadth of application of the innovation. All buyers draw the idiosyncratic component from a distribution function $H(.)$ on [-1, 1]. For tractability, we assume that $v$ is uniformly distributed so that $v$ is mean 0. To ensure that all potential buyers assign positive value to a startup, we assume further that $w > 1$.

#### 3.1.3. Other details

*Early and late market*

We model the functioning of the technology market as a sealed-bid second price (or Vickrey) auction where buyers submit bids without knowing the other bids. The buyer submitting the highest bid ultimately acquires the startup by paying the second-highest bid. Auctions provide a convenient micro-foundation for modeling price formation in startup sales (see for instance Ransbotham and Mitra, 2010; Nörback and Persson, 2009; Allain et al., 2016). However, most of our results do not rely on this specific modeling choice. They would hold in any situation in which the startup is assigned to the buyer with the

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would not change any of the results. However, if some late buyers drop out of the pool because the startup's innovation becomes incompatible, then our assumption that $m < n$ would not necessarily hold. We thank an anonymous reviewer for pointing out this counterargument.

[16] If, instead, buyers receive different and imperfect signals about the common value component (see e.g. Ransbotham and Mitra, 2010), the problem of the "winner's curse" arises. If uncertainty about the common component dissipates with time, then a startup is more likely to wait for a late acquisition, other things being equal.

highest valuation (in the given market) and the seller's share of the surplus is increasing in the number of buyers.[17]

*Timing*

We assume that actions and decisions follow a three-stage game (see table 1). In stage I, startup type, $\theta$ is publicly revealed, and the startup decides whether to allocate resources to try the early market or not, and whether to allocate resources to develop the invention or not.[18]. If the startup allocates resources to both activities it becomes flexible. Otherwise, it is de facto committing to either an early or a late sale. In stage II, a startup that has tried the early market receives bids from those *m* buyers that have invested in absorptive capacity. Profits are realized if a bid is accepted by the startup. In stage III, the startup that allocated resources in developing the invention for the late market and survived (including if it tried the early market but rejected all early offers), receives bids from all *n* buyers.

*Value creation and efficiency*

Value creation is defined by total expected profits of the startup and all potential buyers. An allocation is considered efficient when value creation is maximized.

[Table 1 about here]

### 3.2. Solving the model

It is useful here to introduce some additional notation and incorporate some results from the theory of order statistics. Let $x(k, z)$ represent the $k^{th}$ highest out of *z iid* random draws of the variable *v* from the distribution function $H(.)$. Then, $x(1, z)$ represents the highest idiosyncratic component, and $x(2, z)$ the second highest. Denote by $X(k, z)$ the expectation of $x(k, z)$.

**Lemma 1**. *The cumulative distribution functions and density functions of the idiosyncratic component of the highest and the second highest valuations with z buyers are respectively:*

[17] In fact, since the valuations of a startup are independently and identically distributed and all buyers are risk neutral, it follows from the Revenue Equivalence Theorem (Myerson, 1981; Riley and Samuelson, 1981) that all auction formats where the buyer with the highest valuation acquires the startup yield the same expected payoff to the buyers and the seller. Importantly, this implies that assuming a first-price instead of a second-price auction would lead to identical results.

[18] If the startup makes the decision about the allocation of resources before knowing its execution capability, it has stronger incentives to both try the early market and develop the invention because by being flexible it can better adjust to the realized execution capability. This issue is analyzed in more detail in online Appendix A6.

(i) $F(x,z) = H(x)^z$ *and* $f(x,z) = zH(x)^{z-1}h(x)$,

(ii) $G(x,z) = zH(x)^{z-1} - (z-1)H(x)^z$ *and* $g(x,z) = z(z-1)H(x)^{z-2}\big(1-H(x)\big)h(x)$.

Proof: See Krishna (2010), Appendix C.

**Lemma 2**. $\frac{1}{z}[X(1,z) - X(2,z)] = [X(1,z) - X(1,z-1)]$.

Proof: See Krishna (2010), Appendix C.

**Lemma 3**. *If* $H(v) \sim U(-1,1)$ *then*, $X(1,z) = \frac{z-1}{z+1}$, $X(2,z) = \frac{z-3}{z+1}$, $\frac{1}{z}[X(1,z) - X(2,z)] = \frac{2}{z(z+1)}$.

Proof: By direct substitution.

### 3.3. Commitment

If the startup commits to either the early or the late market, it is straightforward to compute the expected profits of all players. In a sealed-bid second price auction, the (weakly) dominant strategy for a buyer is to bid up to the true valuation see e.g., Krishna (2010). Hence, the expected price is equal to the expected value of the second-highest valuation, $w + X(2,z)$ in a market with *z* potential buyers. Because there are no transaction costs, this corresponds also to the seller's expected profit. A buyer wins the auction if it draws the highest idiosyncratic component which happens with probability *1/z*. It pays a price equal to the second highest bid yielding an expected profit of $X(1,z) - X(2,z)$. Notice that the common part of the value *w* is competed away and is fully captured by the startup. Thus, using the above notation, a buyer's and the seller's expected profits are:

$$\begin{aligned} \pi_B^E(m) &= \frac{1}{m}[X(1,m) - X(2,m)] \quad & \pi_S^E(m) &= w + X(2,m) \\ \pi_B^L(n) &= \frac{1}{n}[X(1,n) - X(2,n)] \quad & \pi_S^L(n) &= w + X(2,n) \end{aligned} \tag{1}$$

where superscript E denotes the early market, L the late market, subscript S the seller (startup) and B the buyer (incumbent).

Thus, a startup that only tries the early market and does not dedicate resources to developing the invention earns expected profit $\Pi^E = w + X(2,m)$. A startup with execution capability $\theta$ that commits to the late market (i.e. it does not try the early market) earns expected profit $\Pi^L = \theta[w + X(2,n)]$. In Figure 1, expected profits from committing early and committing late are represented by the double line and the dotted line, respectively. Here, $\tilde{\theta}$ denotes the unique value of θ for which $\Pi^{\mathrm{E}} = \Pi^{\mathrm{L}}$.

### 3.4. Flexibility

The startup obtains flexibility by both trying the early market and developing the invention. In this case, it is crucial to understand when the startup is willing to accept a given bid in the early market rather than wait for the late market, and how the bidding strategies of buyers change in response.

We assume that buyers active in both the late and the early market draw each time from the same distribution of idiosyncratic valuations, which therefore are independent across markets. This assumption is plausible if, for instance, deals occur spaced in time. During which time the buyer's product pipeline and needs may have changed, and thus it makes sense that the buyer's idiosyncratic valuations change as well. In the online Appendix (see online Appendix A4), we solve the case where valuations are the same across the two markets. Intuitively, because buyers' valuations are constant for the buyers active in the early market, both early buyers and the startup use this information and the bids from the early auction to update their beliefs about the outcome of the auction in the late market. As a result, the optimal strategies of the buyers and the startup are more complex but reassuringly the qualitative findings regarding efficiency of market outcomes do not change.

After observing $\theta$, the startup has an expected profit in the late market of $\phi\theta\big(w + X(2, n)\big)$, and thus will accept any offer that is greater than that. We capture this by assuming that there is a reserve price $R^*(\phi\theta) = \phi\theta\big(w + X(2, n)\big)$ in the second-price auction. This implies that the winning buyer pays $Max\{w + x(2, m), R^*(\phi\theta)\}$, where $x(2, m)$ is the *realized* second highest valuation among all the early buyers. Buyers in the early market also take into account that they can buy in the late market if the startup is not sold in the early market, and this possibility modifies their bidding strategies. Lemma 4 characterizes the equilibrium bidding strategy of an early buyer.

**Lemma 4**. *Define* $\underline{v}^*(\phi\theta) = Max\{\phi\theta\Big(\pi_B^L(n) + w + X(2, n)\Big) - w, -1\}$. *Then, there exists a symmetric equilibrium in the early market where the bidding strategy of a buyer with idiosyncratic valuation v is given by:*

*i)* *Bid its true valuation* $(w + v)$ *if* $v \geq \underline{v}^*(\phi\theta)$;

*ii)* *Do not bid if* $v < \underline{v}^*(\phi\theta)$.

Here, we provide the intuition for the case where $\underline{v}^*(\phi\theta) = \phi\theta\Big(\pi_B^L(n) + w + X(2, n)\Big) - w$ (the formal proof is included in online Appendix A1). A buyer with a valuation of $w + \underline{v}^*(\phi\theta)$ is indifferent between bidding and not bidding. The buyer can only make strictly positive profits if all other buyers have lower valuations and do not bid in the early market. In this case, bidding $w + \underline{v}^*(\phi\theta)$ and paying the reserve price yields an expected profit equal to $\phi\theta\pi_B^L(n)$. This is also the expected profit that the focal buyer would make by not bidding in the early market and competing for the same startup in the late market. Consider now a buyer with a valuation greater than $w + \underline{v}^*(\phi\theta)$. If there are competing buyers, it is optimal to bid the true valuation in a second-price auction. If there are no competing buyers, it is also optimal to bid the true valuation and pay the reserve price, the lowest price at which the startup can be acquired. Finally, a buyer with a valuation lower than $w + \underline{v}^*(\phi\theta)$ strictly prefers not to bid in the early market since it would prefer to compete for the startup in the late market than to acquire it at the reserve price.

The startup's expected profit in case it simultaneously tries the early market and develops the invention is given by:

$$\Pi^F = \int_{\underline{v}^*(\phi\theta)}^{1} (w + x)g(x, m)dx + G\big(\underline{v}^*(\phi\theta), m\big)\phi\theta\big(w + X(2, n)\big). \qquad (2)$$

The integral in the above expression corresponds to the startup's expected profit when the second highest valuation of early buyers (recall that *G(.)* is the distribution of the second highest valuation) is equal to or greater than $w + \underline{v}^*(\phi\theta)$. In this case, there is always a deal in the early market. Instead, if the second highest valuation of early buyers is lower than $w + \underline{v}^*(\phi\theta)$, the startup either receives the reserve price in the early market (if the highest valuation is greater than $w + \underline{v}^*(\phi\theta)$) or makes the expected profit in the late market. Both outcomes result in the expected profit $\phi\theta\big(w + X(2, n)\big)$, and are captured by the second term of equation (2).

We focus below on the case of *c* small enough (i.e. $\phi$ large enough) such that flexibility is preferred to early commitment for at least some (large) values of $\theta$.

**Lemma 5**. *Let c be small enough and n finite. Suppose that the startup allocates resources to both trying the early market and developing the invention into an innovation. Then, if* $\theta \leq \frac{w-1}{\phi[w+X(2,n)+\pi_B^L(n)]}$, *the startup's profit from flexibility is independent of* $\theta$ *and is equal to* $\Pi^E = w + X(2, m)$. *If* $\theta > \frac{w-1}{\phi[w+X(2,n)+\pi_B^L(n)]}$, *the startup's profit from flexibility first declines and then increases with* $\theta$.

A formal proof is provided in the online Appendix (see A2). Intuitively, notice that if $\theta$ is very low, such that $\phi\theta\left(\pi_B^L(n) + w + X(2, n)\right) - w < -1$, then $\underline{v}^*(\phi\theta) = -1$ and the startup accepts all possible deals in the early market. In this range of $\theta$, flexibility has no value because the potential for higher offers in the late market does not compensate for the risk of losing everything including *w*. For higher values of $\theta$, flexibility has an advantage and a cost, both of which depend on $\theta$. Flexibility has the advantage that when entering the early market the startup can always guarantee itself at least the expected profit in the late market, either by accepting a sufficiently high early offer or by continuing to the late market. The attractiveness of waiting is increasing in $\theta$ and so is the benefit of flexibility in the early market. But, flexibility also has a cost which is less obvious, and which is due to the change in the bidding behavior that it causes. When the second highest valuation of early buyers is greater than $\phi\theta(w + X(2,n))$ but lower than $w + \underline{v}^*(\phi\theta)$, the second highest valuation bidder does not bid. This implies that the seller receives its reserve price, which is lower than the second highest valuation of the early buyers.

Our analysis shows that the cost increases with $\theta$ but at a lower rate than does the benefit from flexibility. Startups with high execution capability always benefit from flexibility when they enter the early market. However, an important implication of Lemma 5 is that for some low levels of execution capabilities, flexibility is worse than having no choice but to sell in the early market, even for $c = 0$ (i.e., $\phi = 1$). In this case, the startup prefers to commit to the early market even if flexibility does not compromise the development of the business. Not allocating resources to develop the invention can be thus a credible commitment to avoid unfavorable bidding behavior by early buyers. This might explain statements such as "we always had a strategy to be out by Phase II" (Geoff Davis, founder and Chief Scientific Officer of Abgenix; quoted in Dolan, 2001, p. 8), which help make public the commitment to early exit by the startup. This is consistent also with recent work by Gans et al. (2019) which proposes a conceptual argument about the importance of commitment and strategic choices in entrepreneurship.

Proposition 1 characterizes the optimal choice of the startup's exit strategies under different resource requirements for trying the early market.

**Proposition 1**. *There exist $\underline{c}$ and $\overline{c}$, $0 < \underline{c} < \overline{c} < R$, such that the startup's exit strategies are as follows:*

- *(i)* *If $c \leq \underline{c}$, the startup always tries the early market. There exists a threshold $\theta_L \in \left(\frac{w-1}{\phi(w+X(1,n))}, \tilde{\theta}\right)$ such that it also invests in developing the invention, thereby choosing flexibility, if and only if $\theta > \theta_L$.*
- *(ii)* *If $\underline{c} < c < \overline{c}$, there exists a threshold $\theta_H \in (\tilde{\theta}, 1)$ such that a startup with $\theta \geq \theta_H$ commits to the late market. A startup with $\theta < \theta_H$ always tries the early market; it also invests in developing the invention if $\theta_H > \theta > \theta_L$, thereby choosing flexibility.*
- *(iii)* *If $c \geq \overline{c}$, a startup with low $\theta\,(\theta \leq \tilde{\theta})$ tries the early market, but does not invest in developing the invention, thereby committing to the early market. A startup with high $\theta\,(\theta > \tilde{\theta})$ commits to the late market by devoting all resources to developing the invention.*

<u>Proof</u>. See online Appendix A2.

Part (iii) of Proposition 1 represents the situation where the cost of trying the early market is so high that the startup will be unable to develop the invention if it actively seeks early deals. Thus, the startup has to commit to either the early market or the late market. Instead, if the cost of trying the early market is very low (part i), the profit from flexibility is always greater than the profit from committing to the late market. However, as discussed above, for low values of $\theta$ (even with $c=0$) the startup prefers to commit to the early market and thus it does not invest in developing the invention.

Part (ii) features the more interesting case in which the cost of trying the early market is intermediate ($\underline{c} < c < \overline{c}$). Figure 1 shows the startup's optimal exit strategy as a function of $\theta$. The key finding from Proposition 1 has a clear economic intuition. If the startup is almost sure to survive to the late market, it will attribute a low value to flexibility because even if it were active in the early market it would reject all early deals with high probability (because the reserve price is an increasing function of $\theta$). Likewise, if the startup is almost certain it will not make it to the late market, flexibility is again of little value since it would accept virtually any early offer. Moreover, as shown in Lemma 4, there is a range of values of $\theta \leq \theta_L$ for which commitment to the early market generates strictly greater profits than flexibility. Flexibility is thus more valuable for intermediate values of $\theta$. That is, when the resource requirement for trying the early market is substantial, but not so prohibitive as to preclude the late market, a low execution capability startup focuses on the early market, a high execution capability startup focuses on the late market, and an intermediate execution capability startup chooses to be flexible.

Theoretically, this finding is reminiscent of the logic driving the value of information. Information is valuable only insofar as the decision maker changes its actions as a consequence of the information (Arrow 1962). Thus, information is more valuable if the agent is more uncertain about its decision, and less valuable if the a priori probability of an outcome is either very high or very low (Arora and Fosfuri, 2005). In our setting, flexibility is most valuable if the startup's expected profits from the early and late markets are similar. If one of the two options greatly dominates the other, flexibility is less valuable because the startup is unlikely to change its "preferred" course of action even if it has flexibility.

Recall that $\theta$ measures execution capabilities. One observable feature that correlates positively with $\theta$ is the founding team's experience and strength (for instance, number of previous companies founded). In this case, our model predicts that there is a non-monotonic relationship between the founding team quality and the probability to observe a flexible startup, which could be tested empirically. While teams with intermediate quality both seek early offers and simultaneously make significant effort to build the business, more capable and less capable teams focus, although on different activities.

### 3.5. Innovation, market characteristics and the choice of the exit strategy

The next proposition explores how the thresholds $\theta_L$ and $\theta_H$ depend on the exogenous parameters of the model *w*, *n*, *m* and *c*.

**Proposition 2 (comparative statics):** *Let $\underline{c} < c < \overline{c}$ and m < n. Then, the following holds:*

*i)* $\frac{\partial\theta_L}{\partial w} > 0$.

*ii)* $\frac{\partial\theta_L}{\partial n} < 0$ *and* $\frac{\partial\theta_H}{\partial n}$*<0.*

*iii)* $\frac{\partial\theta_L}{\partial m} > 0$ *for n → ∞, and* $\frac{\partial\theta_H}{\partial m} > 0$.

*iv)* $\frac{\partial\theta_L}{\partial c} > 0$ *and* $\frac{\partial\theta_H}{\partial c} < 0$.

Proof. See online Appendix A3.

The first result implies that a low execution capability startup is more likely to give up flexibility and commit to the early market for inventions that are more valuable to all buyers. The second result implies that, when the late market becomes more attractive due to more late buyers, a low capability startup is more likely to give up its commitment to the early market and choose flexibility but a high capability startup is more likely to give up flexibility and commit to the late market. The third result implies that a high capability startup is more likely to forgo its commitment to the late market and instead choose flexibility in response to an increase in the number of early buyers. If the late market has many buyers, then a low capability startup is more likely to commit to the early market and forgo flexibility in response to more early buyers. The fourth result implies that when trying the early market absorbs more resources both a low capability startup and a high capability startup are more likely to give up flexibility, and commit to the early market and the late market respectively.

The ex-ante probabilities of observing a flexible startup, of one that commits to the early market, and of one that commits to the late market are respectively: $S_{Flex} = \frac{\theta_H - \theta_L}{1-b}$, $S_{Early} = \frac{\theta_L - b}{1-b}$ and $S_{Late} = \frac{1-\theta_H}{1-b}$. Thus, the overall probability that the startup tries the early market is $S_{Early} + S_{Flex} = \frac{\theta_H - b}{1-b}$. Therefore, with fewer late buyers, more early buyers and with lower resource requirement to try the early market, the startup is more likely to participate in the early market.

In a recent paper, Arora et al. (2018) show that US corporations are moving away from science. If this is correlated with fewer potential buyers in the early market, an implication of their finding is that fewer technology startups will try the early market. In turn, this implies that startups have greater incentives to develop execution capability and be prepared to raise more capital to develop their inventions for the late market.

Finally, consider the effect of venture capital (VC). Greater availability of VC leads to a reduction in execution failure (Gompers and Lerner, 2001; Hsu, 2006), or equivalently, to an increase in the probability of reaching the late stage. For instance, Baum and Silverman (2004) argue that venture capitalists select companies that have strong technology and relationships and provide them with management inputs that enhance their long-term survival. Chemmanur et al. (2011) show that VC backing increases startups' efficiency through monitoring which in turn, increases the probability of successful exit through acquisition. Therefore, we can model the availability of VC by an increase in *b* (see, for instance, Nörback and Persson, 2009) which is equivalent to a first order stochastic dominance shift in the distribution of $\theta$. First, notice that $\theta_H$ and $\theta_L$ do not depend on *b*. From $S_{Flex}$ and $S_{Late}$, it follows that a higher *b* implies that it is less likely that a startup is available for sale in the early market, and it is more likely that it will both try the early market and develop the invention. Whether this is efficient or not will be explored in the next section.

## 4. Efficiency

In this section we explore the efficiency properties of the equilibrium between the startup and the buyers. We ask the question: Is the startup sold too early or too late from the point of view of efficiency? Recall that the efficient timing of startup sale is the one that maximizes total value creation (i.e. the sum of the expected profits of the startup and the buyers). It turns out that the answer depends crucially on how costly is to try the early market. To sharpen the exposition, we focus below on two polar cases: 1) the cost of trying the early market is so high that the startup either seeks early offers or develops the invention; 2) the cost of trying the early market is so low that the startup never chooses to commit to late exit. These two cases correspond to parts (iii) and (i) of Proposition 1, respectively, and we will refer to them as "commitment" and "flexibility" in this section.

### 4.1. Commitment

When *c* is sufficiently high, the startup is de facto committing to an exit timing. Proposition 1 part (iii) characterizes the equilibrium. In stage I, the startup commits to sell early if $\theta \leq \tilde{\theta}$ and late if $\theta > \tilde{\theta}$. Assuming that *v* is uniformly distributed, the indifferent type $\tilde{\theta}$is:

$$\tilde{\theta} = \frac{w+\frac{m-3}{m+1}}{w+\frac{n-3}{n+1}}, \tag{3}$$

where $\tilde{\theta} < 1$ since *m* < *n*.

#### 4.1.1. Efficiency under commitment

The expected value creation in the early and late markets is *w + X(1,m)* and *w + X(1,n)*, respectively. It is straightforward to show that value creation is highest if a startup with $\theta \leq \hat{\theta}$ go early, and a startup with $\theta > \hat{\theta}$ go late where:

$$\hat{\theta} = \frac{w+X(1,m)}{w+X(1,n)}, \tag{4}$$

where $\hat{\theta} < 1$ since $m < n$. The startup cares about value capture, rather than value creation. The following lemma is useful when comparing the exit choice from the perspectives of value creation and capture.

**Lemma 6**. *Let $H(v) \sim U(-1,+1)$. The ratio between expected value creation and value capture shrinks with the number of buyers,* $\frac{\partial \frac{w+X(1,z)}{w+X(2,z)}}{\partial z} < 0$.[19]

Lemma 6 implies that in thicker markets not only is value creation greater because of better matching but also the startup captures a larger share of the value created due to increased competition. We can now derive the following proposition.

Proposition 3: *When trying the early market and developing the invention are mutually exclusive, the startup sells inefficiently late: the efficient threshold for trying the early market* $\boldsymbol{\hat{\theta}}$ *is greater than* $\boldsymbol{\tilde{\theta}}$*, the threshold used by the startup in equilibrium.*

Proof: Notice that $\boldsymbol{\hat{\theta}} > \boldsymbol{\tilde{\theta}} \Leftrightarrow \frac{\boldsymbol{w+X(1,m)}}{\boldsymbol{w+X(1,n)}} > \frac{\boldsymbol{w+X(2,m)}}{\boldsymbol{w+X(2,n)}} \Leftrightarrow \frac{\boldsymbol{w+X(2,n)}}{\boldsymbol{w+X(1,n)}} > \frac{\boldsymbol{w+X(2,m)}}{\boldsymbol{w+X(1,m)}}$. Using lemma 6, this holds because *n* > *m*. □

A startup compares value capture in the early and the late markets. If value capture were a constant fraction of value creation, the startup's decision would always be efficient. However, by Lemma 6, in the early market the startup captures a smaller fraction of the total value creation than in the late market because there are fewer early buyers. A direct implication is that, for a range of execution capabilities, the startup develops the invention for the late market while it would be efficient to focus exclusively on trying the early market. This finding is similar to the result in Cong (2019) and other studies that assume asymmetric information which diminishes over time (see, for instance, Daley and Green, 2012; Allain et al., 2016).

### 4.2. Flexibility

If the cost of looking for an early buyer is very low, the startup always tries the early market. However, as shown in Proposition 1 part (i) for $\theta \leq \theta_L$ the startup does not allocate resources to develop the invention thereby committing to the early market.

#### 4.2.1. Efficiency under flexibility

[19] This result holds also for the generalized extreme value and the exponential distributions.

**Proposition 4**. *When the cost of trying the early market is low, the startup is more likely to be sold early compared to the efficient timing.*

Proof: From the efficiency standpoint, a startup that is flexible should be traded in the early market if and only if the highest realized valuation $w + x(1, m)$ is greater than or equal to the expected value if the startup continued to the late market, $\phi\theta(w + X(1, n))$. This also implies that for $\theta \geq \frac{w-1}{\phi(w+X(1,n))}$ it is efficient that the startup allocate resources to develop the invention. However, Proposition 1(i) shows that the startup invests in developing the invention only if $\theta > \theta_L > \frac{w-1}{\phi(w+X(1,n))}$, which implies that for a range of $\theta$ the startup commits early although it is efficient to also develop the invention. Put differently, some low execution capability startups, which should have developed the invention, inefficiently choose to commit to the early market. Finally, Lemma 4 implies that, when the startup is flexible, the transaction takes place in the early market if and only if $w + x(1, m)$ is greater than $w + \underline{v}^*(\phi\theta)$. Since $\phi\theta(w + X(1, n)) > w + \underline{v}^*(\phi\theta)$, it follows that too many offers are accepted in the early market for a given number of early buyers (compared to what it is efficient) when the startup is flexible. In sum, the startup both commits early more than the efficient threshold and, when flexible, accepts inefficiently too often the offers. □

In the early market, the trading parties are able to ensure for themselves at least the same expected payoff they would earn by withdrawing and waiting for a potential late sale. The seller secures this payoff by setting a credible reserve price, whereas the buyer secures this by refraining from bidding if the value is not sufficiently above the reserve price. Although early deals are individually rational, Proposition 4 shows that there are cases where the startup is sold early but it would have created more value had it waited for the late market. Intuitively, there is too much early trade because the trading parties consider only their own payoffs when evaluating an early deal. Therefore, they ignore the expected profits that would accrue to buyers not present in the early market if the startup were to continue to the late market, and this externality results in too much early trade in equilibrium.

### 4.3. Exit environment and efficiency

Taken together, Propositions 3 and 4 show that the exit environment is pivotal to understanding the efficiency properties of the market for startups: If the startup has to commit to an exit strategy, the early market features too few deals relative to the efficient benchmark, as several scholars show in models with asymmetric information (Daley and Green, 2012; Allain et al., 2016). In contrast, if trying the early market is costless and the startup can be flexible, the early market features too many deals from the efficiency viewpoint. The intuition behind this finding is twofold. In the case of commitment, the startup determines the exit timing, and tends to sell inefficiently late because the late market offers better value capture. In the case of flexibility, the early market operates in the shadow of the late market. In equilibrium, the startup and the corresponding highest value buyer trade when an early deal offers more value capture to them than the expected value capture in the late market. Since they ignore the expected value capture of other late buyers, there is too much early trade from the point of view of efficiency. To our knowledge, this is a novel result and has some important implications for policy, exemplified by the effects of VC, which we illustrate below.

### 4.4. Absorptive capacity (*m* endogenous)

Absorptive capacity is the outcome of investments in basic research and scientific capabilities (Rosenberg, 1990) which so far we have assumed to be exogenous. Extant research shows that absorptive capacity is the result of sustained investments over time (Cohen and Levinthal, 1989). Thus, it is plausible that there are historical reasons why some firms have absorptive capacity and others do not, and we can reasonably assume this variation across buyers to be exogenous.

Here, we discuss the case in which buyers must invest in absorptive capacity to make deals in the early market. Assume that buyers need to pay a fixed amount, $T$ to accumulate absorptive capacity, which is thus their entry cost in the early market. Buyers make this decision before the startup decides its exit timing. The order of moves captures the idea that absorptive capacity takes time to accumulate, and that the startup takes the number of early and late buyers as given. Buyers enter the early market as long as their expected profits cover $T$. Thus, a free entry condition determines the endogenous number of early buyers, $m^*$. The incentive to invest in absorptive capacity will depend on the probability of the startup to sample the early market.

In the *commitment* case, the equilibrium number of incumbents $m^*$ investing in absorptive capacity and participating in the early market is given by: $Q(\tilde{\theta})\pi_B^E(m^*) = T$. Using our distributional assumptions, the number of early buyers $m^*$ as a function of $\tilde{\theta}$ is:

$$m^*(\tilde{\theta}) = \frac{1}{2}\left(\sqrt{1 + \frac{8(\tilde{\theta} - \mathrm{b})}{T(1-b)}} - 1\right). \tag{5}$$

Using equation (3), the indifferent type $\tilde{\theta}$ as a function of $m^*$ is given by:

$$\tilde{\theta} = \frac{w + \frac{m^*-3}{m^*+1}}{w + \frac{n-3}{n+1}}. \tag{6}$$

Together, equations (5) and (6) determine the equilibrium of the model that we derive in more detail in the online Appendix (see A5). We impose restrictions on the parameter values such that $n > m^*(\tilde{\theta}) \geq 2$, and focus on the stable equilibrium.[20]

It follows directly from Lemma 2 that $\boldsymbol{\pi_B^E(m) = X(1, m) - X(1, m-1)}$. Hence, the value that a buyer captures corresponds exactly to the additional value created by its presence in the early market. This implies immediately that $m^*$ is efficient given $\tilde{\theta}$. However, because $\boldsymbol{\hat{\theta} > \tilde{\theta}}$ there is also insufficient entry by buyers in the early market (or in other words, the number of buyers investing in absorptive capacity is inefficiently low). Most importantly, it can be shown that the ratio between $\boldsymbol{\hat{\theta}}$ and $\boldsymbol{\tilde{\theta}}$ which we call the *efficiency gap* is decreasing in $m^*$. Any factor that decreases investment in absorptive capacity in the early market has the consequence of enlarging the efficiency gap.

In the *flexibility* case, the endogenous number of early buyers, $m^*$, can be obtained following a similar logic. However, the algebra is more complex and we report the formal expressions and their derivations in online Appendix A5. The excessive incentive of the startup to accept early offers implies that $m^*$ is larger than the efficient number of early buyers i.e. there is excessive investment in absorptive capacity by incumbent firms. We can conclude that the finding in Proposition 4 is reinforced if we allow the number of early buyers to be endogenous.

#### 4.4.1. VC with endogenous *m*

We focus here on a factor that has received some attention in the innovation literature: the availability of VC. As explained in the previous section, we can model the availability of VC by an increase in *b* (see, for instance, Nörback and Persson, 2009). When the cost of trying the early market, *c*, is high and firms commit to an exit timing, VC exacerbates the inefficiency of market outcomes through its effect on entry into the early market by buyers. Greater availability of VC has the direct effect of making the startup less likely to try the early market. In response, fewer prospective buyers invest in absorptive capacity i.e. $m^*$ falls, further reducing the probability of an early sale. Thus, we can conclude that if exit timing requires commitment, greater availability of VC increases the efficiency gap i.e. the startup goes inefficiently late, and especially when VC is abundant.

However, when *c* is low, and startups may be flexible in the choice of exit timing, the effect of VC is more nuanced. Although greater availability of VC shifts some deals to the late market, the efficiency of the market equilibrium does not necessarily improve. Recall that in this case, there are inefficient early

[20] An equilibrium with no early market always exists. If a buyer expects other buyers not to invest in absorptive capacity, it has no incentive to invest itself because two or more competing buyers are needed to convince the startup to try the early market.

deals because the startup and the buyer ignore the gains to other potential late buyers. The inefficiency is greatest if the deal involves a startup with high execution capability that would have been likely to survive to the late market. Thus, a more capable startup is also more likely to enter into an inefficient early deal. Moreover, an increase in VC increases the share of startups that are more likely to survive to the later market. Thus, it is possible that VC can increase inefficiency. While analytical results are elusive, numerical simulations show that a shift to the right in the distribution of execution capabilities associated with an inflow of VC may exacerbate the market inefficiency, here by reinforcing the tendency towards too many early deals.

We acknowledge that the way we model VC funding is quite stylized. In addition to the direct effect of decreasing execution risk, the availability of VC might have other positive effects on startups such as access to a larger pool of potential buyers or reduced costs of trying the early market. Thus, the negative effect of VC when exit timing is a mutually exclusive choice between early and late needs to be compared to all of these other effects in order to reach a thorough conclusion. Still, this negative feature has been overlooked in the current literature, and thus constitutes a novel insight of our model.

Finally, independently of the startup exit environment, our findings show that greater availability of VC reduces the number of prospective buyers investing in absorptive capacity. If one assumes that the investment in science by large corporation is motivated by the desire to accumulate absorptive capacity (Rosenberg, 1990), then the finding reported in Arora et al (2018) that large US corporations are moving away from science might be explained by the explosion of the VC industry in the last two decades.

## 5. Other extensions

### 5.1. Founder preferences

So far, we have assumed that the decision about startup exit timing is driven only by economic considerations. However, startups' choices might be affected also by preferences. For instance, entrepreneurs enjoy being in the driving seat of development of their idea (Graebner and Eisenhardt, 2004; Cong, 2019), so they might prefer to retain control of the company for longer even if this decision is not profit maximizing. A simple way to account for this possibility in our model is to assume that the startup's expected benefit from selling in the late market is $\Delta\theta\big(w + X(2,n)\big)$ in case the startup commits to the late market and $\Delta\phi\theta\big(w + X(2,n)\big)$ in case the startup is flexible, where $\Delta > 1$. In this formulation, one dollar of profit in the late market is associated with additional private benefits of monetary value $\Delta - 1$. Simple algebra shows that, unsurprisingly, higher private benefits (i.e. larger $\Delta$) reduce the probability that the startup tries the early market and that an early offer is accepted. A startup where the entrepreneur enjoys higher private benefits is more likely to be sold late but also is more likely to fail than a startup with lower or no private benefits. Conditional on an early deal, the expected price is increasing in the value of the entrepreneur's private benefits from being in control.

### 5.2. IP protection

The market for technology startups, especially at early stages, resembles the market for ideas, which is notoriously plagued by frictions that make it difficult for inventors to sell their inventions (Gans and Stern, 2010). We have disregarded this aspect so far. Here, we follow Luo (2014) by assuming that inventions that are sold in the early market suffers from greater frictions than innovations that are sold in the late market. We capture this through the parameter $\lambda < 1$ that multiplies all expected profits if the startup tries the early market. Thus, $1 - \lambda$ is the cost of such frictions in the market for inventions. In other words, once the startup tries the early market it is subject to a greater risk of idea expropriation which affects both the early and the late market profits. Stronger IP protection has been shown to reduce frictions in the market for technology (e.g. Gans et al., 2008). We can therefore assume that stronger IP protection increases $\lambda$. Simple algebra shows that, stronger IP protection increases the probability that the startup tries the early market, that is $\frac{\partial \theta_H}{\partial \lambda} > 0$. Notice also that $\frac{\partial \theta_L}{\partial \lambda} = 0$ because $\lambda$ multiplies both the profit from early commitment and the profit from flexibility, which are equal at $\theta_L$, thereby implying that stronger IP protection does not change the probability that the startup commits to the early market. Together, these findings imply that it is more likely that the startup becomes flexible when IP protection is stronger.

Moving a step further, one could endogenize $\lambda$ by allowing the startup to invest in IP protection. While the marginal returns of investment in increasing $\lambda$ is zero for a startup that commits to the late market, it is positive for a startup that enters the early market. The value of IP protection to a startup is increasing in the expected profit, and it is therefore highest for a startup that both tries the early market and invests in developing the invention. Together with the findings of Proposition 2, this implies that startups with more capable founding teams are those with the weakest incentives to seek patent protection. Instead, startups with founding teams of intermediate capabilities are both more likely to be flexible and to invest in patent protection.

### 5.3. Asymmetric information

Throughout the paper, we have assumed away asymmetric information both because its consideration would make the model unfocused (given our goal to study the choice of startups' exit strategies) and because it has been analyzed extensively in the extant literature, leaving little room for new insights. Nevertheless, there might be aspects of our story that can be studied in a model of asymmetric information. For instance, buyers might not know the opportunity cost of the startup to wait. In terms of our model, one could assume that buyers do not know the exact level of execution capability of a given startup, which is thus private information. In the commitment case ($c$ high), this information asymmetry would not matter because the startup self-selects into the early and late markets and buyers bid their true valuation. In the flexible case ($c$ low), things become more complicated.

In particular, there is no separating equilibrium with flexible startups where startups truthfully reveal their type. If a startup is flexible, both its reserve price and the bidding strategy of the buyers depend on $\theta$. The startup has incentives to both overstate and understate its true type. Overstating increases the startup's payoff if there is only one buyer with a valuation above the reserve price, while understating increases the probability of receiving bids. It is possible to show that the incentive to understate dominates for startups with very low execution capability (a formal proof is available from the authors). This precludes the existence of a separating "cheap talk" equilibrium where the startup truthfully reveals its type, e.g., through an oral report to the early buyers. The equilibrium when buyers have to bid for a startup knowing less about prospects in the late market than the startup is an interesting question for future research, as is whether there are equilibria (with costly signals) that would allow the startup to credibly reveal its type to buyers in the early market.

## 6. Conclusion

Many technology startups devise strategies for being acquired by large incumbents (Gans et al., 2002). In some cases, the acquisition is meant to take place at the idea stage, when the technology is nascent. In others, startups target a late acquisition by developing their innovation. Sometimes, startups are flexible, soliciting early offers but eventually going for a late deal. The timing of startup sale is influenced by the interactions between sellers and buyers in both the early and the late markets for startups, and depends on different environmental factors. These interactions and factors drive not just the value captured by each side but also the value created in the form of the fit between startup and acquirer.

A key determinant of the efficiency of the market for startups in terms of the timing of the acquisition is whether startups have to commit to an exit timing, or they can both seek early offers and develop the business. Soliciting early offers can take time and attention, as does developing the technology and the startup. When time and attention of the founder becomes a binding constraint, the startup has to commit. Instead, if the startup can reach potential early buyers with little effort, it has the flexibility to test the early market while still preparing for a late acquisition. When startups are flexible, the early market sees too much activity relative to the efficient level: Too many startups accept early deals, and eventually, too many incumbents invest to participate in the early market. On the other hand, if startups have to commit to an exit timing, too many will choose to go late. Consistent with this, too few incumbents will invest in absorptive capacity. In this case, VC, by increasing the survival chances of the startups, contributes to increasing the inefficiency of the market outcome.

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**TABLES AND FIGURES**

**Table 1**: *Timing of the game*

| **Stage I** | **Stage II** | **Stage III** |
|---|---|---|
| Startups observe θ and decide about trying the early market or committing to go late | Startups trying the early market and accepting the offers obtain payoffs | All surviving startups are sold in the late market |

**Figure 1:** *Endogenous choice of exit strategy (0 < c < R)*