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ENDOGENOUS APPROPRIABILITY

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ABSTRACT

The appropriability of innovation depends not only on the instruments available to an innovator to protect private returns, but how those instruments interact with each other as part of the firm's entrepreneurial strategy. We consider the interplay between two appropriability mechanisms available to start-up innovators: control, whereby the innovator earns rents from their establishment of formal intellectual property rights, versus execution, whereby innovators earn returns through a first-mover advantage that yields dynamic benefits allowing the firm to "get ahead, stay ahead." While most prior work has taken these instruments to be independent, we establish that these two alternative appropriability instruments are substitutes on the margin. For example, if the learning advantage from execution is sufficiently high, an entrepreneur might choose not to invest in a patent, even if intellectual property protection is costless. Moreover, the endogenous choice between control and execution is interdependent with other strategic choices of start-up innovators, such as the choice to pursue a narrow or broad customer segment, or whether to commercialize a "minimal viable product" version of their innovation versus delay commercialization until a product is available with a higher level of technical functionality and reliability.

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Since Nelson (1959) and Arrow (1962), economists have understood that the private value of an innovation may be significantly lower than its social value, and that this gap may result in significant underinvestment in innovation. This insight has prompted significant study by economists and researchers in related fields such as strategy focusing on how innovators can appropriate the value of their innovations, and how this varies across different economic, institutional and strategic environments (Teece, 1986; Cohen, Nelson, and Walsh, 2000).

Attention has been focused on the appropriability of innovations arising in new firms (i.e., entrepreneurial start-ups) that are unable to leverage existing capital or product market assets such as manufacturing capabilities or brand reputation (Aghion and Howitt, 1992; Gans and Stern, 2003). At least two appropriability approaches have been identified for start-up innovators: reliance on formal intellectual property protection such as patents and copyrights (which we will refer to as a "control" approach) and first-mover competitive advantage (which we will refer to as an "execution" approach). Most theoretical and empirical research in economics and strategy have taken the appropriability regime governing a given start-up innovation to be exogenous, resulting from the economic and strategic environment in which the start-up operates. For example, start-up innovators in the biotechnology industry such as Genentech are presumed to appropriate returns through their ability to leverage the interplay between strong formal intellectual property rights and regulatory entry barriers (Pisano, 1997), while Internet software entrepreneurs such as Netflix or Amazon are presumed to appropriate through rapid time-to-market and their ability to learn from customers to "get ahead, stay ahead" (Teece, Pisano and Shuen, 1997; Sutton, 2012).

This paper develops a simple model highlighting the interplay between control and execution as alternative routes to appropriability. A core element of this model is that, whereas a control strategy allows an innovator to forestall imitation once control is established, control itself takes time to establish, and so can delay market entry; in contrast, an execution strategy is premised on taking advantage of the benefits arising from rapid market entry such as learning from customers, early reputational advantages or coordination on a standard. In effect, the sharpest distinction is between choices that are predicated on the startup being shielded from future competition by entry barriers (as might be afforded by formal intellectual property protection, control of key assets or some network effects) versus that competition being met by superior quality or cost capabilities that are built and developed early. In other words, investing in control is akin to investing to compete for the market whereas investing in execution is competing in the market through the establishment of dynamic capabilities.[1]

We derive two main results. First, we find that, as an endogenous choice of the start-up, control and execution are strategic substitutes. Rather than simply reflecting exogenous and independent environmental conditions governing the fraction of value captured by the innovator, the choice of an appropriability strategy by the start-up shapes the appropriability regime that ultimately governs the innovation. For example, when the ability to learn from early customer feedback in the marketplace is sufficiently high, an entrepreneur might choose not to invest in intellectual property protection for their innovation, even if intellectual property protection is costless. Second, the choice between control and execution is interdependent with other key strategic choices for start-up entrepreneurs, such as their choice to pursue a narrow or broad customer segment, or their choice of whether to commercialize a "minimal viable product" version of their innovation or only commercialize products with high levels of technical functionality and reliability. Consistent with the framework and evidence developed in Ching, Gans and Stern (2017), our core results suggest that the appropriability of innovation depends not only on the instruments available to an innovator, but on how those instruments interact with each other as part of the firm's (endogenous) entrepreneurial strategy.

I. The Model

We consider an entrepreneur who has already developed an idea. The maximal value from the idea in any given period is equal to 1 (e.g., there is a uniform unit mass of consumers each with willingness to pay of 1). To introduce an innovation, the innovator incurs a one-time sunk cost C, and each firm operating in the market incurs a per-period fixed operating cost of c (< 1); the potential net present value of the market is, therefore, $\frac{1-c}{1-\delta} - C$, where δ is the discount rate.

There are two potential ways that the innovator can lose their ability to capture value from the idea: imitation and competitive follow-on innovation. Imitation occurs in period t+1 (with certainty, and resulting in subsequent profits of 0) if the idea is introduced into the market in t

[1] While our model highlights the starkest choice between control-oriented and execution-oriented commercialization, the distinction in practice is of course more subtle. For example, aggressive entry into a market with network effects may allow a firm to establish effective entry barrriers; while the end objective of such a strategy is control, some of the initial investments in building out scale may be difficult to distinguish from an execution-oriented approach.

without any intellectual property protection and the start-up does not undertake activities during t to obtain a period t+1 advantage over potential rivals.

A separate risk facing the innovator is the potential for follow-on innovation commercialized by a rival. A potential follow-on innovation arises each period with probability λ that can be introduced into the market at an incremental sunk cost of C. For simplicity, we assume that, though the follow-on innovation when commercialized supersedes the earlier product generation (i.e., the original start-up will end up earning 0 in subsequent periods if the follow-on innovation is introduced by a competitor), the value of the market remains the same across periods (i.e., at a unit mass of 1 with WTP of 1).[2]

If the entrepreneur simply releases the product to the market without intellectual property protection and without developing capabilities that yield a future marginal cost advantage, the innovator will enjoy a single-period of monopoly followed by the complete loss of appropriability (we will refer to this possibility as *opportunistic entry*). As such, the entrepreneur will evaluate alternative mechanisms for enhancing their appropriability through their ability to forestall imitation and competitive follow-on innovation.

We consider two strategies: control and execution. Under control, the start-up delays product launch until their ability to control their innovation has been established, such as through formal intellectual property protection such as patents or copyrights, contract-based control mechanisms such as non-disclosure agreements or non-compete agreements with employees, or product design approaches such as through the establishment of proprietary architectures.[3] The key assumption is that, even when control is effective, control takes time to establish (or, equivalently, results in a delay in the ability to bring the product to market quickly). For simplicity and focus, we consider a case where, though control involves an opportunity cost of delay, the financial costs of intellectual property are equal to zero and intellectual property rights, once established, are effective in shielding the strat-up from immediate and future competition. Specifically, Control yields two distinct benefits: it precludes imitative competition (with probability one) and, for any

[2] As in quality ladder models (O'Donoghue, Scotchmer, and Thisse, 1998), and models of step-by-step innovation (Aghion, et al, 2001), this assumption allows us to focus sharply on the strategic tradeoffs between control versus execution rather than conflating these effects with the impact of market expansion resulting from follow-on innovation.

[3] While we focus here on the direct benefits from control as the start-up brings the product to market, formal intellectual property rights will also be complementary with cooperation (as opposed to competition) with established product market players, as formal intellectual property rights allows start-ups and established firms to overcome the disclosure problem inherent to negotiating an agreement (Arrow, 1962; Gans and Stern, 2000; Gans, Hsu, and Stern, 2002).

new follow-on innovation opportunity, allows the start-up to have priority over that subsequent innovation with probability α.[4]

Alternatively, under execution, the entrepreneur introduces the product to the market immediately, and incurs a per-period incremental cost e ($< 1 - c$), yielding two distinct benefits through the development of product market experience capabilities. First, these capabilities allow the start-up to establish a marginal cost advantage over potential rivals in the subsequent period (though these capabilities decay after one period and so require reinvestment each period). Second, execution allows the start-up to sense and take advantage of follow-on innovation opportunities that match these capabilities (Teece, Pisano, and Shuen, 1997; Gans, 2016). Thus, we assume that with probability β (a measure of the impact of product market learning on their ability to "get ahead, stay ahead"), the entrepreneur can exploit a follow-on innovation faster than any rivals and capture the market for that product generation. Therefore, under both control and execution, an entrepreneur has the possibility to secure rents from follow-on innovations.

II. Control Versus Execution

We now turn to analysis of the appropriability strategy that will be undertaken by the start-up. There are four options for investment in the face of a new innovation: opportunistic entry, control, execution, or control+execution. To do so, we start by describing the stationary net present value from each strategy, taking advantage of the fact that, given the model set-up, the optimal strategy chosen in response to a given innovation opportunity will be independent of whether that was the initial innovation opportunity or a subsequent follow-on innovation opportunity (and so the strategy is time- and state-independent).

Opportunistic Entry: The entrepreneur commercializes the product immediately at a cost C and has the market to themselves for one period. However, imitative entry in the next period (and all periods thereafter) results in a total loss of subsequent appropriability. Under opportunistic entry, the entrepreneur earns:

(1) $v_{OE} - C = 1 - c - C \Rightarrow v_{OE} = 1 - c$

[4] α can be interpreted as a measure of the breadth of control over the innovation, as in O'Donoghue, Scotchmer and Thisse, 1998 or in terms of control over follow-on innovation (as in Aghion and Howitt, 1993).

Control: The entrepreneur establishes control after a one-period delay but loses control each period (including during the time before they initially come to market) with probability $\lambda(1\text{-}\alpha)$. The net present value, v_{CON}, is therefore:

(2) $v_{CON} - C = \big(1 - \lambda(1-\alpha)\big)\delta(1 - c + v_{CON}) - \lambda\alpha\delta C - C$

$\Rightarrow v_{CON} = \delta\frac{(1-\lambda(1-\alpha))(1-c)-\lambda\alpha C}{1-(1-\lambda(1-\alpha))\delta}$

Execution: The entrepreneur enters immediately but incurs an incremental per-period cost to develop capabilities that foreclose imitative entry and gain an advantage on access to follow-on innovation. The net present value of this strategy is therefore:

(3) $v_{EXE} - C = -C + 1 - c - e + \big(1 - \lambda(1-\beta)\big)\delta v_{EXE} - \lambda\beta\delta C$

$\Rightarrow v_{EXE} = \frac{1-c-e-\lambda\beta\delta C}{1-(1-\lambda(1-\beta))\delta}$

Control + Execution: This involves the entrepreneur pursuing both strategies, which allows them to exploit both directions in sustaining leadership, but also they must incur both costs. Their product introduction is delayed for one period yet they must incur the execution cost *e* in all periods. The expected payoff is therefore:

(4) $v_{BOTH} - C = -C - e - \big(1 - \lambda(1-\alpha)(1-\beta)\big)\delta(1 - c + v_{BOTH}) - \lambda(\alpha + \beta - \alpha\beta)\delta C$

$\Rightarrow v_{BOTH} = \frac{-e+(1-\lambda(1-\alpha)(1-\beta))\delta(1-c)-\lambda(\alpha+\beta-\alpha\beta)\delta C}{1-(1-\lambda(1-\alpha)(1-\beta))\delta}$

Our first result is that execution and control are substitute strategies from the perspective of the entrepreneur. This means that the marginal return to either one is reduced if the other is being undertaken. This is summarised in the following proposition.

Proposition 1. *Control and execution are substitute strategies.*

The two strategies are substitutes if $v_{BOTH} - v_{EXE} \leq v_{CON} - v_{OE}$. This condition holds because while both strategies have distinct costs (execution involves an ongoing cost *e* while control involves an opportunity cost of delay), both strategies yield a similar benefit – the deterrence of short-term entry and the potential to forestall follow-on innovation competition. While the costs of each strategy are independent, the marginal benefit of each is reduced when the other strategy is also implemented. Consequently, the two strategies are substitutes on the margin. For start-up innovators, where both human and financial resources are highly constrained, it is likely that there will be a meaningful trade-off between an investment in the types of activities that would allow the firm to forestall imitation or gain a legal right to block follow-on innovation versus those activities that would focus the young firm on learning about customers and developing the capabilities required to "get ahead, stay ahead." The choice between control and execution depends of course on the idiosyncratic costs and benefit of each strategy for a start-up. As we emphasize in Ching, Gans, and Stern (2017), a particularly interesting case to consider is when, because of uncertainty about how each strategy will be realized in the market, the start-up is unable to rank these alternatives in terms of their ability to forestall follow-on innovative entry by competitors i.e., $\alpha = \beta$).[5] In this scenario, execution will be preferred to control if $1 - \delta\big(1 - \lambda(1 - \beta)\big) > \frac{e}{1-c}$. Execution is chosen when the rate of generation of product innovations is high, or the ability to leverage current incumbency into future leadership is low. As well, for a sufficiently low discount factor (ie., when the start-up is impatient to earn revenue), execution will again be preferred. More generally, this result highlights that a start-up innovator may choose to forego intellectual property as part of their optimal strategy even when formal intellectual property protection is costless and allows for strict appropriability once established. Given that execution is chosen when the product innovation rate is rapid (λ is high), this means that the observed rate of patented innovation may be low even when the true rate of patentable innovation is high.

III. Entrepreneurial Strategy Complementarities

We now turn to consider how the choice between control and execution depends on the other strategic choices and conditions governing the overall entrepreneurial strategy of the start-up innovator.

A. Customer

For a given innovation, a start-up often faces a choice not only of whether to commercialize through control versus execution but also whether to focus initially on a niche customer base or attempt to appeal to the mass market (Christensen, 1996; Zott and Amit, 2008; Gans, Stern, and Wu, 2016). Targeting a smaller customer segment comes at the expense of demand but offers the potential for a lower cost of learning about customers (allowing the firm to maintain a dynamic advantage over imitative rivals). How does the choice of market segment size relate to the choice

[5] Specifically, Ching, Gans and Stern (2017) highlight how Rosenberg uncertainty – the inability to forecast the precise details of the market demand and cost for a technologically successful innovation – implies that it will be difficult for start-up innovators to meaningfully rank the potential of alternative commercialization paths in terms of their relative long-term profit potential.

between control and execution? Consider a start-up who is considering a market segment size choice, $\sigma < 1$, where the net returns each period are $\sigma - c(\sigma)$ where *c* is an increasing and convex function of σ. σ both determines the size of the (served) market each period, and impacts the per-period cost of market operation (since serving a larger market is more expensive at an increasing rate). As well, suppose that the choice of σ impacts the cost of implementing an execution-oriented approach: *e* is also an increasing function of *σ*; in other words, with a broader market segment, the start-up faces a higher cost of effort to maintain dynamic capabilities that forestall imitative entry and allow for a higher chance of taking advantage of follow-on innovation opportunities (β). Now contrast that with how the cost structure associated with implementing a control-oriented strategy is influenced by market size. The costs of control – such as the costs of obtaining effective formal intellectual property protection or the costs of designing a product in such a way as to make imitative competition and follow-on innovation more difficult (e.g., by establishing proprietary technical interfaces) – are largely independent of the size of the market being served. At the same time, the ability to use control over a design and customer base in the current generation as a means for deterring follow-on innovation competition in subsequent generations is likely enhanced (at least on the margin) when the start-up serves more customers initially. In other words, *α* is a function is *σ* with $\alpha'(\sigma) \geq 0$; that is, the larger the share of customers you acquire, the easier it is to defend your market leadership as the next generation technology arises.

The resulting optimization problem for the start-up establishes complementarity between market size and the choice of appropriability regime.

Proposition 2. *Suppose that* $e'(\sigma) > 0$ *and* $\alpha'(\sigma) \geq 0$. *Let* $\sigma^*(s)$ *be the optimal customer share of the entrepreneur under* $s \in \{EXE, CON\}$, *respectively. Then* $\sigma^*(EXE) < \sigma^*(CON)$.

PROOF: To see this, note that in a period where control is chosen the optimal share is determined by:

$$max_\sigma\{-C + (1 - \lambda(1 - \alpha(\sigma))\delta(\sigma - c(\sigma) + v_{CON}) - \lambda\alpha(\sigma)\delta C\}$$

This gives a first order condition:

$$\lambda\alpha'(\sigma)\delta(\sigma - c(\sigma) + v_{CON} - C) + (1 - \lambda(1 - \alpha(\sigma))\delta\big(1 - c'(\sigma)\big) = 0$$

Note that, as the first term is positive, this implies that $1 \leq c'(\sigma^*(CON))$ (holding with equality if $\alpha'(\sigma) = 0$).

For a period where execution is chosen, the optimal share is determined by:

$$max_\sigma\{-C + \sigma - c(\sigma) - e(\sigma) + (1 - \lambda(1 - \beta)\delta v_{EXE} - \lambda\beta\delta C\}$$

This gives a first order condition: $1 - c'(\sigma) = e'(\sigma)$ which implies that $1 > c'(\sigma^*(EXE))$. Recalling that *c* is convex completes the proof. □

Intuitively, the efficacy of control is enhanced if the venture secures a larger customer base whereas the reverse is true for execution. Thus, we expect to see an execution strategy associated with a smaller initial customer base upon launch than a control strategy; recalling that in the latter case, product launch comes later.[6]

B. Technology

A second domain for strategic choice on the part of a start-up innovator is whether to bring an early-stage version of their product to market in order to receive customer feedback before undertaking subsequent R&D investment or whether to ensure that the first product in the marketplace achieves a high level of functionality and reliability. For example, proponents of the "lean start-up" methodology emphasize the importance of bringing a "minimum viable product" (MVP) to market to gain customer feedback and avoid costly investments and delayed product introductions (Ries, 2010).

To see how this choice of whether to release a "beta" version of a product interacts with the choice between control versus execution, consider an alternative to our baseline model where the entrepreneur can forego paying the fixed product development cost *C*, and instead immediately come to market with an "MVP" that involves a lower value for each consumer, $u_{MVP} < 1$, and a higher per-period cost of serving the market, $c_{MVP} > c$. To ensure that an investment in execution remains a viable strategy, assume that $(u_{MVP} - c_{MVP}) > e$. Finally, assume that the start-up cannot rank the long-term profitability of alternative commercialization paths (i.e., $\alpha = \beta$). The start-up innovator, therefore, faces the simultaneous choice between control and execution and a choice between an MVP or traditional product development approach:

Proposition 3. *Suppose that $\alpha = \beta$. Choosing an MVP is a complement to execution and a substitute to control.*

PROOF: Note that the return to execution versus control (under MVP) is:

$$\frac{(u_{MVP} - c_{MVP}) - e}{1 - (1 - \lambda(1 - \beta))\delta} - \delta \frac{(1 - \lambda(1 - \alpha))(u_{\mathrm{MVP}} - c_{MVP})}{1 - (1 - \lambda(1 - \alpha))\delta}$$

While under 'right' the relative return to execution is:

[6] It is important to note that this result is deliberately simplified. It may well be that the set of customers targeted has broader impacts than just on *e* and *α* as assumed here. However, these two effects are likely to be more general and hence, be a driver of the choice and worth highlighting.

$$\delta\frac{(1-\lambda(1-\beta))(1-c-e)-\lambda\beta C}{1-(1-\lambda(1-\beta))\delta}-\delta\frac{(1-\lambda(1-\alpha))(1-c)-\lambda\alpha C}{1-(1-\lambda(1-\alpha))\delta}$$

An MVP will be a complement with execution if the relative return to execution rises when an MVP is chosen. This happens if:

$$u_{MVP}-c_{MVP}-e-\delta(1-\lambda(1-\beta))(1-c-e)+\lambda\beta C$$
$$>(1-\lambda(1-\alpha))\delta(u_{MVP}-c_{MVP}-(1-c))+\lambda\alpha C$$
$$\Rightarrow (u_{MVP}-c_{MVP})>e$$

which is assumed to be true. The substitution result is the symmetric dual of this result. □

Put simply, both an execution-oriented appropriability strategy and an MVP-oriented product development strategy prioritize early introduction to the marketplace at the expense of the establishment of long-term competitive advantage. Control involves a higher degree of patience because of the delays associated with its implementation, and this is complementary to a product development approach that focuses on "getting the product right."

C. *Identity*

A final area to consider is how the appropriability strategy of the start-up depends on the personal characteristics – the identity – of the founding team. In our simple model, a number of parameters, such as the opportunity cost of time borne by the start-up to actually engage in execution, the costs of being able to navigate complex business activities that might be associated with control, or even the innovator's discount rate, are likely to depend not simply on characteristics of the technology and market, but on the identity of the innovators themselves. For example, each of these costs are likely different for a young recently graduated engineering student (who might face a low cost of their own time but not be familiar with complex business processes due to a lack of experience), versus a more seasoned innovator such as a serial entrepreneur or established faculty member. Under these conditions, for a given innovation, execution will have higher returns for younger and less experienced founders while control will have relatively high returns for more senior and experienced innovators. In Ching, Gans and Stern (2017), we draw out the logic of this comparative static by focusing on a sample of innovations that result from academic publications jointly authored by faculty and students that result in a start-up firm, and establish that while faculty-led start-ups are more heavily oriented towards formal intellectual protection, student-led start-ups are more timely in terms of their speed from initial publication to firm founding, first funding, and first product introduction.

V. Conclusion

Our objective has been simply to raise the prospect that the realized appropriability regime governing an innovation depends not only on the instruments available to an innovator to protect private returns, but how those instruments interact with each other as part of the firm's entrepreneurial strategy. This approach stands in contrast to most research in economics and strategy (starting with Teece, 1986, but including our own) that has taken the appropriability regime governing an innovation to be an exogenous feature of the technological and market environment. Control and execution are not simply two mechanisms for appropriability, but can be strategic substitutes, and so start-up innovators will choose between them as they consider how to commercialize their innovations. Of course, appropriability may only be possible for certain innovations if one invests in both control and execution; this would result in a complementarity between the two instruments (Ching, Gans and Stern (2017) find evidence for substitutability among academic entrepreneurs). In the case where start-ups do face the choice between control and execution, this choice interacts in natural and potentially testable ways with other elements of the firm's entrepreneurial strategy (Gans, Stern, and Wu; 2016; Ching, Gans, and Stern, 2017). Exploring how these complementarities and interdependencies play out in practice, and how start-up innovators choose (or not) among alternative routes for the commercialization of innovation seems likely a promising avenue for further research.