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Lean Hypotheses and Effectual Commitments: An Integrative Framework Delineating the Methods of Science and Entrepreneurship

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Recently, there is increasing interest in building theories that offer actionable guidance to the practice of entrepreneurship. Here I present a general theoretical framework, called CAVE, for understanding, assessing, and enhancing existing tools that offer such guidance. The framework encompasses a two-dimensional space with prediction and control as its axes. The CAVE framework accommodates a wide variety of extant practical tools as well as relevant concepts from psychology and economics. Specifically, I compare and contrast effectuation with lean startup within this framework. Whereas lean startup centers around hypothesis testing, effectuation focuses on cocreative commitments from self-selecting stakeholders. In other words, the former takes markets as exogenous, while the latter explicates how they can be made endogenous and why that matters. More generally, I show how these differences connect with and delineate the scientific method from the entrepreneurial method.

Keywords: *lean startup; effectuation; scientific method; entrepreneurial method; non-predictive control; hypothesis testing; market shaping; experimentation; cocreation*

Introduction

Reality is always more textured and complicated than any theory, whether descriptive or normative. Yet, it is precisely because of this multifaceted messiness of reality that we need theories, especially theories that offer actionable guidance in the form of frameworks and

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heuristic principles. Effectuation (Sarasvathy, 2001), originating in a rigorous study of a representative sample of expert entrepreneurs (Read, Dew, Sarasvathy, Song, & Wiltbank, 2009; Sarasvathy, 2022 [2008]), then elaborated through dozens of studies in a variety of settings using a variety of empirical methods, offers such guidance. Lean startup (Ries, 2011), inspired by Blank's (2005) work on customer development originating in practical observations in one convenient, yet important, corner of venturing activity—namely Silicon Valley startups—and spread through best sellers and consulting activities, also offers useful guidance for navigating messy reality. In this essay, I seek to carefully spell out differences with a view to integrating these into a more generalizable theoretical framework that can fruitfully inform future research and entrepreneurship education. In doing so, I heed Geertz's (1973) wisdom about thick description, "What generality it contrives to achieve grows out of the delicacy of its distinctions, not the sweep of its abstractions." (320)

The general framework, called CAVE, is a modification of the Prediction Control (PC) Space theorized in Wiltbank, Dew, Read, and Sarasvathy (2006). The CAVE framework consists of the four quadrants – Causal, Adaptive, Visionary and Effectual. Not only is this a framework that can map several different theories of strategic management, but it also accommodates a wide variety of practical toolboxes currently in use in entrepreneurship education and training around the world. These toolboxes are related in interesting ways to key concepts from disciplines ranging from psychology and economics to history and philosophy. Most importantly, they offer spaces for delineating the scientific method and the entrepreneurial method without turning the two into a straw man dichotomy. Instead, the CAVE framework allows us to build a useful and meaningful tapestry worth examining at different layers of complexity.

In the ensuing essay, I first present and explicate the CAVE framework, showing how extant techniques and toolboxes from practice, including lean startup and effectuation, can be arranged within it. This mapping exercise organically leads to the delineation of science and entrepreneurship as adjacent yet interconnected methods within the PC space. The mapping also embraces the fact that the scientific method underlies both research and practice in entrepreneurship, just as entrepreneurial approaches have always been part of the development of science and technology through human history. After the section discussing this delineation and interconnection, I briefly outline the need for and usefulness of effectuation as a toolbox to navigate the non-predictive control quadrant within the PC space. I then connect back to lean startup describing overlaps and distinctions between effectuation and lean startup as actionable theories. Finally, I end with a brief yet crucial discussion of the dubious role of performance in the development of content for entrepreneurship education.

Brief Review of Effectuation

There is no need to belabor the details of effectuation that have been dealt with in great depth in dozens of peer reviewed articles and several books (see Alsos, Clausen, Mauer, Read, and Sarasvathy, 2019 for a recent special issue). However, for the sake of clarity and convenience. I would like to outline its basic skeletal structure here:

- As mentioned earlier, the five principles of effectuation were derived from a cognitive science-based study of expert entrepreneurs who participated in a think aloud protocol experiment involving 10 typical decisions that occur in all startups.

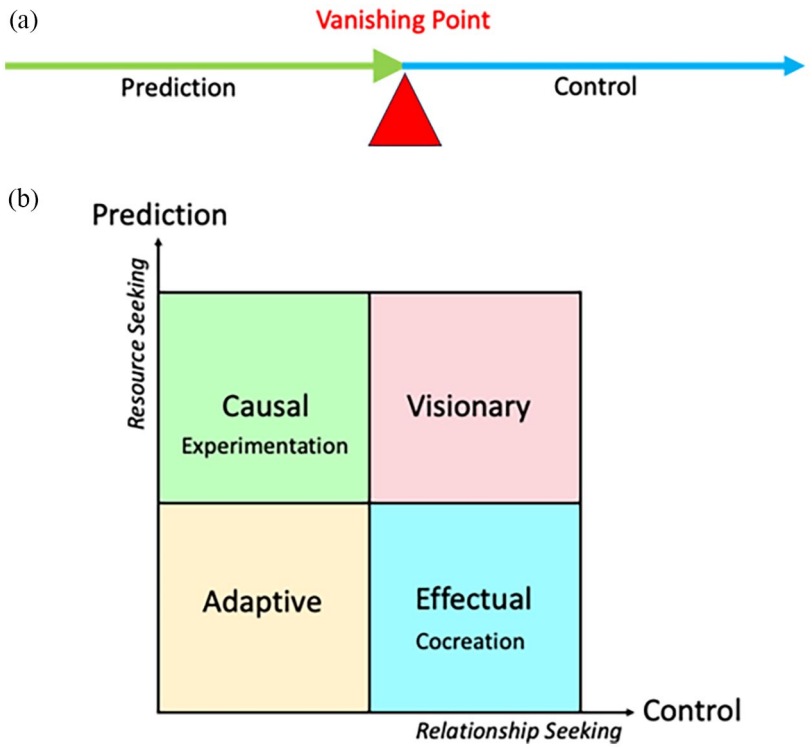
- Each of the five principles minimize or eliminate prediction:
  1. Bird-in-hand: Work with things already within your control, specifically who you are, what you know, and whom you know, to come up with ventures you can immediately start building. No need to wait for a brilliant new-to-the-world scalable idea. When it comes to ideas, doability trumps scalability. Note that the former is within one's control, the latter is not.
  2. Affordable loss: Invest no more than you can afford to lose, preferably as close to zero as possible. No need to worry about expected return. The important thing is to keep the downside within your control, as well as choose a project worth doing irrespective of its likelihood of success.
  3. Crazy quilt: Work with whoever wants to work with you and is willing to invest real skin in the game. In other words, allow stakeholders to self-select by making actual commitments. No need to worry about potential competitors when next steps are underwritten and made affordable loss by committed stakeholders.
  4. Lemonade: Leverage contingencies and transform even negative ones, including failures, into new opportunities. No need to avoid surprises. They are ingredients feeding into bird-in-hand and affordable loss. They also offer ways to strengthen the bond with self-selected stakeholders.
  5. Pilot in the plane: Since history does not run on auto-pilot, see and treat all committed stakeholders as partners and copilots. No need to predict and place bets on the future when you can shape and cocreate new futures with people you did not even know could be your stakeholders, but who walked in with real commitments.
- Effectuators work with things already within their control to cocreate new and as yet unpredictable futures and goals, whether embodied in products, ventures, institutions, or markets. In other words, in effectuation control is not merely an outcome. Control is strategy. Moreover, when control is strategy, prediction is unnecessary and irrelevant.
- In terms of performance implications, effectuation increases the probability of innovation when success occurs and decreases the costs of failure when failure happens. Thus it does not directly impact the probability of success or failure of any given venture. However, whenever entrepreneurs are willing to start more than one venture, an effectual approach does increase the probability of success of entrepreneurs, irrespective of the probability of success of any given venture they might start.

The Prediction Control Space

It is important to note two facts about effectuation. First, effectuation is a theory derived from a study of expert entrepreneurs (Read, Dew, Sarasvathy, Song, & Wiltbank, 2009; Sarasvathy, 2022 [2008]). Hence, it does not claim that all entrepreneurs are effectual; nor even that successful entrepreneurs are effectual; or worse still, that effectual action will lead to venture success. Second, the means-driven action named bird-in-hand principle is but one of five principles in effectuation, each of which is characterized by the reduction of prediction and embrace of control as strategy. In other words, an action is effectual to the extent that it reduces reliance on predictive information, and not primarily on whether it is means- or goal-driven.

Hence the most important insight from the original think-aloud protocol study of expert entrepreneurs is that prediction and control can be conceptualized as orthogonal to each other. As depicted in Figure 1a, received wisdom prior to the discovery of effectuation, whether from the sciences or economics, posited that there is nothing but a vanishing point between prediction and control. This wisdom can be traced back to the origins of the

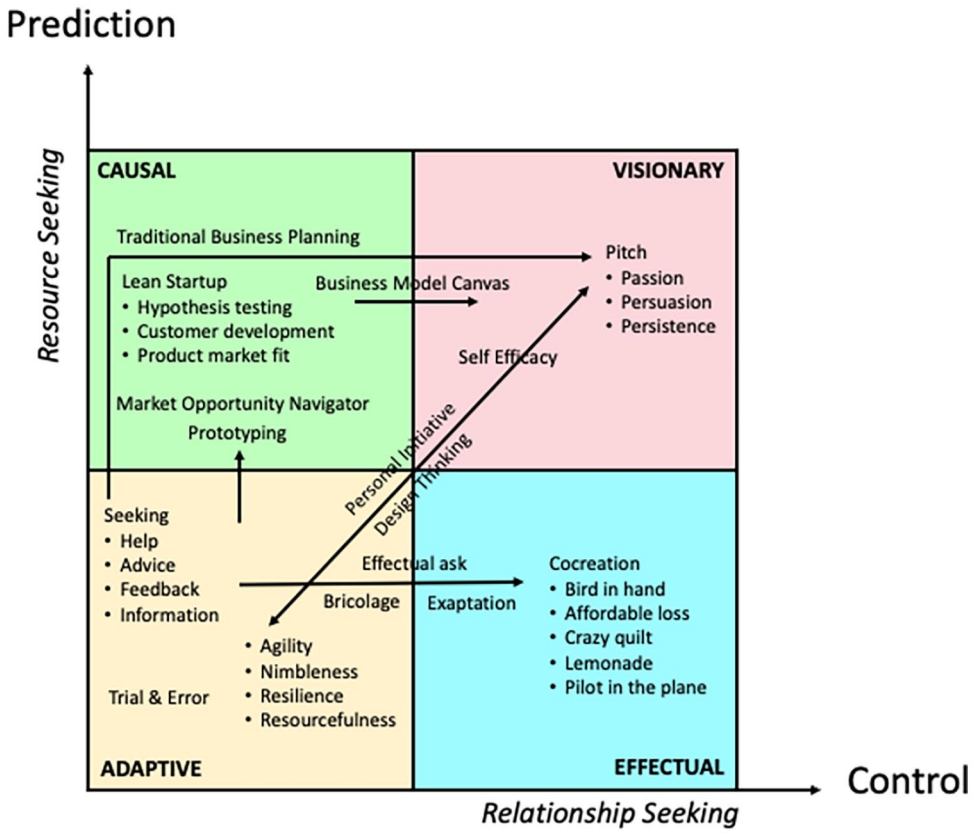
Figure 1
(a) What the Scientific Method Teaches and (b) What Entrepreneurs Learn: The Dimensionless Point Is a Space onsisting of the Four Quadrants of the CAVE Framework



scientific method (Merchant, 2015; Pearson, [1911] 1957; Salmon, 1999). Since prediction and control are tightly coupled in science, the more we can predict the relationship between two variables, the better we can control one in terms of the other. In contrast, the lessons expert entrepreneurs learn through years of lived experiences starting and running both successful and failed ventures lead them to see that the dimensionless point between prediction and control can be expanded into a two-dimensional space, as depicted in Figure 1b. Here, control is not only an outcome of prediction, but is also a strategy in itself, without having to be derived from prediction.

Wiltbank et al. (2006) explicated this insight through a detailed review of strategic management literature to show how various theories could be mapped on to the PC space. In deference to extant strategic management theories at the time, the causal quadrant was labeled "planning" strategies and the effectual was labeled "transformative" strategies. Since then, the PC space has been used to map theories from other areas, such as internationalization (Galkina & Chetty, 2015), uncertainty (Packard, Clark, & Klein, 2017), networking (Engel, Kaandorp, & Elfring, 2017), entrepreneurial psychology (Sarasvathy, 2021b), design (Berglund, Bousfiha, & Mansoori, 2020), and negotiation (Sarasvathy & Botha, 2022).

Figure 2
Techniques and Toolboxes in the CAVE Framework



In addition to theories from the social sciences, we can also map techniques and toolboxes from entrepreneurial and management practice onto the PC space, as I have done in Figure 2. Note that the collection of techniques is not meant to be complete. Nor is the location of each one a proof of its connection to others in its vicinity, since several of these have been developed independent of each other. Occasionally, some techniques have been grouped together in literature and hence I put these together, through bullet points, into a toolbox. Even in the case of toolboxes, however, each of the bullet points (techniques) can still be seen and studied as separate from each other.

For ease of comprehension, I have divided the discussion below into two parts along the diagonals. We will begin with the adaptive quadrant.

The Adaptive-Visionary Diagonal

The adaptive toolbox on the bottom left encompasses a wide variety of techniques related to the literature on help-seeking. In their review of this literature, Lim, Tai, Bamberger, and

Morrison (2020) identified four kinds of nonfinancial resources—advice, feedback, help, and information—all of which are part of entrepreneurship, whether within organizations or in the development of de novo ventures. This quadrant encompasses both early-stage resource-seeking in normal situations of venturing, as well as techniques that rely neither on prediction nor on control. Several of these may be conceptualized as psychological variables, such as agility (Stephan et al., 2023), nimbleness (Ancona, Backman, & Isaacs, 2019), resilience (Ayala & Manzano, 2014), and resourcefulness (Williams, Zhao, Sonenshein, Ucbasaran, & George, 2021) in responding to the unexpected. Therefore, this quadrant is primarily reactive to the environment, seeking to adapt both in the beginning and along the way when surprises hit.

In addition to working as mundane starting points to entrepreneurial action involving trial and error—and as useful reaction to the unexpected—techniques in this quadrant can be incorporated into creative approaches such as bricolage (Baker & Nelson, 2005) and design thinking (Sarooghi, Sunny, Hornsby, & Fernhaber, 2019), as well as evolutionary approaches such as exaptation (Andriani & Cattani, 2016). At the opposite end of the diagonal from the adaptive lie the tools and techniques of a visionary approach (Baum, Locke, & Kirkpatrick, 1998). While sometimes these are conceived as starting points for the entrepreneurial process, they can also be seen as endpoints ensuing from a step-by-step information-gathering movement from the adaptive, through the causal, into the visionary quadrant.

Additionally, psychological training in the development of personal initiative (Frese, Hass, & Friedrich, 2016) and the strengthening of self-efficacy (Gielnik, Bledow, & Stark, 2020) may move back and forth along the diagonal in tandem with creative approaches like design thinking and problem-based learning, rather than step by step across the three quadrants. As we will see in the next section, these types of training may help traverse and even span the boundary between science and entrepreneurship in productive ways.

Keeping the above movements in mind, let us consider the toolboxes and techniques located within the visionary quadrant. The most important technique here consists in a pitch (Ciuchta, Letwin, Stevenson, McMahon, & Huvaj, 2018). The visionary pitch contains within it a powerful compelling idea, preferably an innovative one that is shored up with passion, confidence, and persuasion in communicating it to targeted stakeholders that own the necessary resources to implement the vision (Clark, 2008; Clarke, Cornelissen, & Healey, 2019). The most studied and widely taught pitch in entrepreneurship education is the investor pitch (Balachandra, Briggs, Eddleston, & Brush, 2019; Chen, Yao, & Kotha, 2009). Equally important in practice, but not taught as much, is the sales pitch (Cespedes & Weinfurter, 2016; Matthews, Chalmers, & Fraser, 2018; Spiller, Kim, & Aitken, 2020).

The question then arises: How does a visionary construct his or her pitch? Sometimes, as in largely apocryphal legends about entrepreneurs such as Steve Jobs and Elon Musk, the answer lies in sheer force of personality, consisting in psychological traits such as self-efficacy, passion, persistence, and so forth (Cardon & Kirk, 2015). A compelling pitch can also be explained in terms of the power of the idea or the vision itself: "to be Earth's most customer-centric company" in the case of Amazon, or "a microcomputer on every desk and in every home running Microsoft software." It can also consist in sheer chutzpah as in the case of "Just do it" from Nike, or the daring of a reckless risk taker—Reid Hoffman's "jumping off a cliff and assembling the plane on your way down" being an iconic example of the latter.

For most teaching and training purposes, or even for actually building these very same ventures listed above, constructing and delivering a winning pitch takes more than mere

bromides. This is where the causal quadrant can contribute substantive content for a winning pitch. A convincing pitch or even a compelling story requires good information, data connecting elements of the business model, such as product features and customer needs, combined into strong value propositions. That, in turn, requires research, whether traditional market research or discovery processes such as those elaborated in lean startup and the business model canvas (Keane, Cormican, & Sheahan, 2018; Osterwalder & Pigneur, 2010).

The Causal-Effectual Diagonal

Before the publications on effectuation (Sarasvathy, 2001), customer development (Blank & Dorf, 2012), and lean startup (Ries, 2011), the dominant deliverable in entrepreneurship courses and training programs consisted of business plans. One could argue that that continues to be the dominant paradigm, even today. The continuing prevalence of business plan competitions provides evidence for that. The importance of business planning is also attested to in academic articles exhorting as well as critiquing the need for and importance of business plans. Delmar and Shane (2003), for example, found that business plans reduced the probability of disbanding and increased the speed of product development and organizing activities. Honig and Karlsson (2004) found that even without a strong relationship between plans and performance, entrepreneurs were coerced through institutional or mimetic pressures into investing time and effort in writing lengthy business plans.

In a meta-analysis of the business plan literature, Brinckmann, Dew, Read, Mayer-Haug, and Grichnik (2019) examined the antecedents to business planning. They found that while education and general work experience had a positive relationship to planning, entrepreneurial experience had a negative effect. This coheres well with Blank's (2019) arguments for moving beyond the target market roulette. The entrepreneurial experiences recounted by Eric Ries that led to his abandoning traditional business planning in favor of the lean startup model also offers a case in support of this finding. The overwhelmingly negative reactions to market research and business plans found in the study of expert entrepreneurs also support the finding that individuals with entrepreneurial experience were significantly less likely to invest in business planning.

However, the lessons drawn by Rees from his experience, incorporated in the lean startup model, are different in important ways from the lessons drawn by expert entrepreneurs in the study leading to effectuation. Specifically, Ries inferred from his experiences that breaking down the business plan into its components, formulating hypotheses about customer behavior, and testing them through careful experiments, was the needed antidote. The expert entrepreneurs I studied went a step further from this to conclude that in addition to validated predictions based on experimentation, one can also simply minimize or even completely eliminate prediction altogether (in a later section below, I outline how effectuation does this). Note that the core insight remains the same: business plans do not work. However, the remedies for that problem can vary from deeper understanding of customer development and more careful experimentation, to effectual cocreation with a wider variety of stakeholders than customers alone.

In order to illustrate how and why expert entrepreneurs may navigate the PC space to arrive at an effectual approach in the quadrant of non-predictive control, it might be useful here to consider the experiences of one such entrepreneur, in his own words.

Viaweb: An illustrative case along the causal-effectual diagonal. The following is an excerpt from Livingston's (2008) interview of Paul Graham, cofounder of Viaweb, who later went on to found the iconic accelerator YCombinator that has trained hundreds of founders of startups with a proven record of above average success rates. The interview provides rich details of an entrepreneur's experiences that can help make our explication of the CAVE framework come alive (2008: 205):

> Livingston: You had a different startup before Viaweb, didn't you? Can you tell me a little about that?
>
> Graham: Before Viaweb we had a startup called Artix. We were going to put art galleries online. The problem was, art galleries didn't want to be online. They still don't want to be online. We spent a long time trying to convince these people to use something they didn't want before we had the idea that maybe we should make something people actually did want.

This description of Artix fits with a visionary view of the PC Space, a vision that was rudely dispelled by the reality of no one willing to buy the vision. This rude awakening is similar to Ries' early experiences building IMVU that he recounts in his book as the inspiration for the lean startup model. Based on the CAVE framework, we could imagine Graham (or Ries) simply quitting (adaptive) or persisting without pivoting (visionary in response to the market's rejection of their vision). We could also posit Graham learning the lessons Ries learned; namely, that he needed to carry out more careful experimentation. In the entrepreneur's own words, let us see what happened next (2008: 205-6):

> Livingston: You scrapped Artix and switched to making software for websites for online stores?
>
> Graham: Yeah. Actually, it's pretty similar software. We realized that if we could write software that could generate sites for galleries, we were only a shopping cart away from generating online stores. Everyone seemed to want online stores, so why not just do that instead?
>
> At least, we thought everyone wanted online stores. There was a lot of talk in the press about e-commerce then, because Netscape was doing a big PR campaign for their IPO. They had to convince everyone that the Internet would be economically important, and they picked the most literal example they could think of.
>
> Actually most merchants didn't want to sell online, not yet. But when they started to want to, we were there.

We can easily pick up a faint flavor of effectuation as well as lean startup in Graham's realization that "similar" software (bird-in-hand) could be used for another market (pivot). Furthermore, there was predictive (causal) evidence for this new market from the media at the time. However, this evidence was not validated in accordance with the lean startup approach using careful experimentation and A/B testing. Even if Graham had considered carefully formulating his hypothesis based on the media predictions, the evidence still rejected it, "Actually most merchants didn't want to sell online, not yet." In other words, Graham did not pivot to a new market that wanted his product, but modified his product by exapting something that was already part of his bird-in-hand.

Yet, eventually, the market came around to wanting what Viaweb had to offer. Was this merely a matter of luck? Or visionary persistence? It definitely does not sound like lean startup or effectuation. To figure this out, we need to dive deeper into what happened between the early customers not wanting it and then the market coming around to it. In the interview,

Graham lists the following steps and turning points in the interim—there is no substitute for reading the original interview in full, but for our purposes here, a bulleted list can suffice:

- Wrote a prototype version of the software in 2 days
- Conceptual leap to make it software on the web rather than on the desktop
- Early funding of $10,000 from a friend, Julian
- Cofounder Morris loses faith in the pace of coding and is reluctant to work alone
- Convinced Morris's classmate Trevor to come on board
- Hired programmers to build and refine a working demo
- Working demo shown to formal investors
- But walked away from the deal since they asked for too much equity

What about customers? (2008: 208)

> Livingston: Once you had this demo, did you start thinking about signing up customers or were you focused on raising money?
> Graham: What we really thought we needed to do was write more software. We were software guys. Maybe someone who knew more about business would be thinking about going and getting customers, but frankly the idea of customers frightened us. We thought, "Before we go get any customers, why don't we just write a few more thousand lines of code?"

Graham then goes on to list a litany of errors in finding customers, but continuing to write and improve the software because that was what they knew how to do. Along the way angel investors who knew them continued to provide just enough funding to continue. Also, offers for acquisition came along that did not work out. Graham talks about giving away software and not even having the ability to process credit card transactions 2 years into the business. Yet, the business was humming along both on the supply and demand side. In Graham's own words (2008: 212),

> There were always two stories going on simultaneously with Viaweb. There was the software and the customer story, which just went smoothly and wonderfully the whole way along. We kept writing great software, we kept getting more and more customers, the customers loved us, the growth was this beautiful, smooth upward curve. Simultaneously, there was this story about the business, which was one disaster after another. So most of the actual turning points are not software or customer turning points, because everything went great there. All the turning points are business turning points.

These business turning points were almost all related to the soap opera of stakeholder interactions inside and outside the venture. For example, "The next one was probably when Robert went off that summer and took a summer job working for another company." This kickstarted the search for a CEO that brought its own twists and turns until (2008: 213),

> We lucked out. At practically the last moment, we found Fred Egan—or rather, he found us. Fred Egan saved us. That was a great turning point, when we got Fred. The lowest point, well, maybe tied for the lowest point in the company's history, was that summer when Robert was away and the investors were pressuring us to take some business guy as our boss. When we finally got Fred, that ended that summer of horror.

Although expressed in terms of luck, this is not an uncommon turning point in the early histories of enduring companies. By "this" I mean the entrance of a self-selected stakeholder that constitutes the crazy quilt principle in effectuation. The effectuation community has chronicled dozens of these in stories of ventures and entrepreneurs from around the world (Read, Sarasvathy, Dew, & Wiltbank, 2016). Famous examples include Howard Schulz walking into the Pike Place market store of Starbucks and Max Levchin meeting Peter Thiel at a talk at Stanford attended by only six people, leading to several conversations and meetings during one of which Thiel offered to become CEO of Paypal and Levchin agreed.

At the heart of the effectual quadrant is this focus on stakeholder interactions that are less about validating hypotheses or obtaining information and financial resources, and more about gathering commitments from self-selected stakeholders (Sarasvathy & Dew, 2005). This crazy quilt process enables the pilot-in-the-plane principle consisting in the iterative, reflexive, continual shaping, and cocreating of key elements of the venture, including its business model and even the structures, contents, and contexts of its market(s). Note that the term stakeholder in the effectual process goes beyond actual or potential customers and investors to others, especially suppliers and employees (as in the case of Viaweb).

In sum, lessons from entrepreneurial experience span the entire spectrum along all four quadrants of the PC space. Moreover, even as these lessons speak to the futility of pure prediction and planning, most of them go beyond experimentation to the cocreative dance of stakeholder interactions. In other words, they not only highlight the flaws in trying to predict the future, but also shine light on how human beings shape and fabricate new futures.

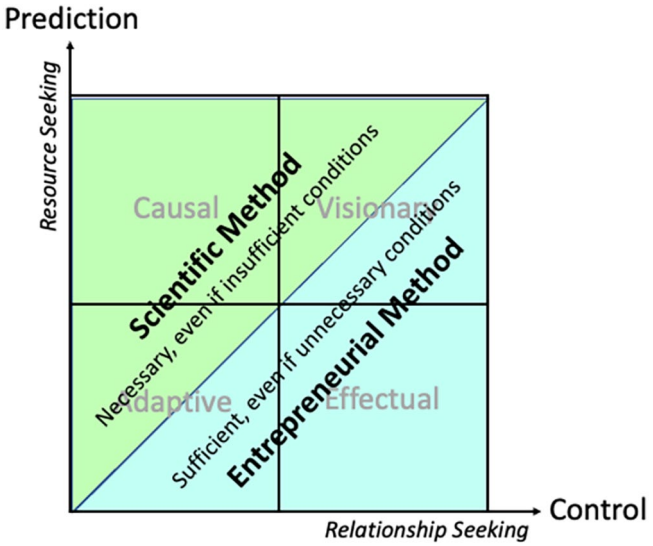
Separating out predictive from non-predictive control offers a powerful framework precisely because it makes room for human action as an agentic, cocreative force that works in tandem with, and is constrained by—yet often independently of and undetermined by—natural forces. This separation brings to view ways in which the space human beings act within is itself endogenous to human action. It is this endogeneity that differentiates the entrepreneurial from the scientific method. Let us investigate that next.

On Science and Entrepreneurship

Figure 3 delineates the PC space into science and entrepreneurship along the adaptive-visionary diagonal. This puts causal squarely within the scientific method and effectual within entrepreneurial. That is because predictive control is the cornerstone of science, leaving non-predictive control as pasture for entrepreneurship. However, it is not necessary to make the delineation overly sharp or mutually exclusive because, as a practical matter, science too is a human enterprise.

All the same, the philosophical and logical concretization of the scientific *method* (Bacon, 1878; Gower, 1997) is still a useful frame to clarify, teach, and practice science in highly productive and beneficial ways. Similarly, specifying a concrete theoretical boundary dichotomizing the scientific and entrepreneurial methods has its uses. The point of such logical and philosophical distinctions is to theoretically clarify, precisely so that they can in reality be mixed and matched in productive and beneficial ways. Keeping in mind both the theoretical

Figure 3
Scientific Method and Entrepreneurial Method



dichotomy and practical combinatorics, we can take a deeper dive into each—separately first, recombining afterward.

Differentiating the Entrepreneurial Method From the Scientific

There are several dimensions along which we can examine both contrasts and complementarities between the scientific and entrepreneurial methods (Sarasvathy & Venkataraman, 2011). Let us briefly examine and elaborate a few of these.

Purpose. The overarching purpose of science is to understand the universe. Some would argue it is the pure pursuit of truth (Quine, 1990). All the same, most would agree that the scientific method is useful to achieve human purposes, such as curing diseases and developing new sources of energy, and, in the case of the social sciences, building better institutions and solving societal problems such as poverty and illiteracy. Even when one sets out to build a world-destroying weapon such as the atomic bomb, the ostensible reason is defense against an unjust enemy and the cause of peace. If we take a more cynical view of the Manhattan project, such as world domination, that too is, at bottom, a human purpose, immoral or otherwise. Even post-truth social constructionists and ardent deconstructionists of science acknowledge its benefits and attest to it being a human endeavor (Kofman, 2018; Whooley, 2018).

Given that the scientific method is useful to achieve human purposes, it is interesting to note that the method explicitly eschews normative views about what those purposes ought to be (Feynman, 1956; Teller, 1998). At a more mundane level, science does not seek to set goals for humanity, even though it can help inform normative views about what they ought

to be. Mostly, science is used to achieve goals, irrespective of why or how those goals came to be, whether from moral philosophy, religion, socio-political processes, or the power dynamics of a flawed species. Science also points out physical constraints and universal limits on human action, often deterministic and immutable. The speed of light is a case in point (Penrose, 2006).

Entrepreneurship also is a useful method to achieve human purposes, but it need not—and, as a practical matter, does not—take a hands-off approach to shaping and demolishing what those purposes ought to be (Senge, Scharmer, Jaworski, & Flowers, 2008). Sometimes in tandem with and sometimes in rebellion to prevailing normative precepts, small groups of people act to reshape their environments, in the face of all predictive pointers to their failure. In practical terms, entrepreneurship offers ways not only to embody human desires, aspirations, and purposes into viable actionable goals, but it also explicitly offers a method to fabricate new goals worth achieving, without externally prescribing what they should be. Such unprescribed and unpredicted goals can then open up new purposes at higher levels (Simon, 1964). In other words, while the scientific method takes a top-down view of goals as subservient to existing purposes, the entrepreneurial method looks both ways up and down the hierarchy of goals and purposes, reshaping new ones as well as realizing and destroying extant ones.

Put succinctly, while science can constrain or enable human action, and inform understandings about human purposes, it does not provide a method to create new human purposes, or even to shape extant ones at higher levels. Shaping human purpose and imagining new ends worth achieving are, in contrast, all grist to the mill of entrepreneurship, especially effectual entrepreneurship.

COVID-19 offered a spectacular view of the distinction between the two. The scientific method was put to work in developing vaccines and succeeded—in a predictively controlled fashion. Getting those vaccines into human veins required a method of a different sort, entailing a wide variety of persuasive communication, coercive regulation, cocreated work arounds, and old-fashioned horse trading of financial and non-financial incentives—in other words, techniques of non-predictive control. Note also that the task at hand, at least in democracies, was not to cater to existing human preferences or markets, but to shape and cocreate them without the use of brute force. The entrepreneurial method is particularly suited for this task.

Content. The scientific method specifically seeks to discover general laws such as the second law of thermodynamics. The aim here is to precisely identify relationships that are universal and stable across time (Mirowski, 1991; Mitchell, 2000). Contrast that with effectual entrepreneurship where the emphasis is on locality and contingency (Sarasvathy, 2003). The scientific method, even when it cannot quite achieve the ideal of universality—that is, satisfy conditions of both necessity and sufficiency—seeks to at least enumerate necessary conditions. In the social sciences, for example, we seek to find stable explanatory variables that can reliably predict outcomes of interest, even if they are only necessary and not sufficient. Effectual entrepreneurship, as I have explained in depth elsewhere, consists in identifying and satisfying sufficient conditions, each of which may be unnecessary (Sarasvathy, 2021a).

As Powell (2002) explained, if we observe a house on fire, we can immediately conclude that there must have been flammable materials in or around the house that caused the fire. In

other words, flammable materials are necessary conditions for a fire to occur. However, there may be several possible such materials and even if we discovered the correct one, the mere existence of that is not sufficient to explain the fire. We will need at least one more causal link that set it alight, for example, an electrical short circuit.

There is an unstated assumption in current research that it is possible to find such necessary—even if insufficient—conditions that explain how and why certain ventures, strategies, organizational processes, and institutions succeed (Collis, 1994; Winter, 2003). However, empirical evidence for successes only indicates the fact that people managed to implement a set of conditions sufficiently stable for certain periods of time within certain domains. This is analogous to the provisional non-rejection of hypotheses in science rather than validation or reification of them, however strong and broad the consensus around that non-rejection.

For every Starbucks or Airbnb that shaped and cocreated a large new market or business model innovation, we can tell stories after the fact that suggest certain necessary conditions that led to their success. That sort of "just so story" ignores two complementary sets of facts. First, it is not easy to predict ex ante which one of the numerous so-called "disruptive" innovations are likely to succeed. In fact, the failure rate of venture capitalists whose job it is to make those predictions is 9 out of 10, about 90% worse than the failure rate of all firms in the economy which is closer to 5 out of 10 (Santarelli & Vivarelli, 2007). Second, the moment the success of one of these innovations is realized, there sprout up hundreds of smaller ventures that incrementally innovate on those "disruptive" models (Einav & Levin, 2010). A larger proportion of these (definitely larger than the 10% VC rate) survive and even endure over long periods of time (Jacobson, 1992; Posen, Ross, Wu, Benigni, & Cao, 2023). Both of these phenomena attest to the importance of sufficient conditions making necessary conditions untenable at best.

It is clearer to see now that while there may be some basis for dichotomizing them, there is also a yin and yang type relationship between the scientific and entrepreneurial methods, an overarching philosophical complementarity in terms of necessity and sufficiency. This complementarity is as important as the delicate differences (to hark back to Geertz quoted earlier), to understand and leverage both methods in navigating the PC space.

Focus. The explicitly stated focus of the scientific method is on the objective (Cohen, 2011). Not only can it be fruitfully applied only to clearly observable, precisely measurable, and reliably replicable data, being scientific also entails carefully parsing out findings from interpretations of those findings. Even when consensus is built through peer review processes, the emphasis is on not relying on psychological or intersubjective persuasion, but letting objectively collected data speak—hence, the exaltation of double-blind reviews and strictly controlled experiments as the gold standard of the scientific method (Hepburn & Andersen, 2015). The key argument here is to privilege exogenous validation from objective reality (even when that reality consists of peer reviews) and conscious attempts to exclude subjective motivations and social cliques. It is in this sense that competition becomes a discovery procedure leading to innovation, as Hayek and others have argued (Hayek, 2002). Collective collusions are more likely to lead to delusions. Rival views evaluated through objective evidence and fair competition is the only hope for progress in science—and in the marketplace.

Yet, whether in the natural or the social sciences, we simply cannot eschew what Adam Smith called "the principle to perswade" so rife in human nature (Smith, 1978 [1766]). This

is especially true in the forging of new ends. Even Hayek agreed on this when arguing for the creative power of free civilizations (Hayek, 1977). On the one hand, we are free to pursue our own individual ends in a free society; but, if we are to arrive at ends worth pursuing at a larger level of company, community, country, or the climate, cocreating them is the most productive way to progress. Almost every new end worth pursuing that has ever been fashioned, has required the building of intersubjective agreements, initially within very small groups, but growing progressively outward to larger circles as they get embedded in norms and/or regulations. Take for example, the suffragettes or gay marriage, or even the very invention of the term "human rights" itself, all of which are rather recent achievements in human history, unpredictable and even unconceivable in the millennia before (Hunt, 2007).

The non-predictive and cocreative process of the entrepreneurial method can currently be observed at various levels, group sizes, and institutional formats in ongoing ventures of tackling climate change. The ends-in-the-making here evoke Darwin's encounter with the finches on Galapagos islands, all in different interim stages of evolution, none quite speciated yet, and therefore unpredictable, yet being shaped by evolutionary forces. In the case of climate change, both causal prediction and effectual control can be seen driving actions and interactions. Both scientific and entrepreneurial methods are busy at work. Again, there is contrast as well as complementarity in evidence here. Science predicts the problem and even points to possible solutions, but non-predictive human action enmeshed in stakeholder interactions is the key to translating these into specific goals worth implementing.

Logic. The dominant logic of the scientific method is prediction (Friedman, 1953). Even though the philosophy of science may argue for science as the pursuit of truth in an objective sense, riding on the high horse of testable hypotheses and double-blind review processes, the history of science offers glimpses of human nature navigating the PC space just as entrepreneurs do. That means we should be able to find evidence for the use of techniques from all four quadrants of the CAVE framework by scientists as well as entrepreneurs.

A couple of recent publications have tried to show how and why teaching tools from science to potential entrepreneurs ought to be an important ingredient of entrepreneurship education (Camuffo, Cordova, Gambardella, & Spina, 2020; Zellweger & Zenger, 2022). History shows that both scientists and entrepreneurs navigate the PC Space. Yet, the method of science is focused on prediction, while the method of entrepreneurship emphasizes non-predictive control. Given that the story of science is a story of spectacular successes in human history, and the outputs of science have helped reshape the world we live in, it might be worth investigating why we may need the entrepreneurial method at all. This question is especially pertinent to the topic at hand because the underlying logic of lean startup is the logic of hypothesis testing, albeit its emphasis on validation rather than on falsification.

The successes of science attest to the fact that prediction does lead to control. In fact, prediction and control are inseparable in science—but is the rationale for the *method* of science what leads to good predictions? The method consists in unbiased observations and data collection, construction of testable hypotheses, tests of these through careful experimentation, and independent replication. However, practical implementation of these steps does not always lead to good predictions, let alone to good hypotheses worth testing. At best, the scientific method can only reject hypotheses and rule out bad predictions.

The history of science does not lack evidence of unproductive goose chases. Consider, for example, 200 years of chasing the hypothesis that heat is a substance until the formulation of the kinetic theory of heat (Goldstein & Goldstein, 1984); or centuries of miasma before coming up with the germ theory of disease (Kannadan, 2018); or moving beyond Newtonian mechanics (Dugas, 2012); or, in just the last century, the elusive pursuit of quantum gravity, string theory and other hypotheses to reconcile the incompatibility between quantum mechanics and general relativity (Maudlin, 2019).

The scientific method does not lead to disruptive new theories worth testing, just as it cannot lead to disruptive innovations in business or entrepreneurship. In other words, there are no sure-fire ways to create disruptive innovations. That does not mean that the scientific method is not powerful. The accomplishments of science as a method are not trivial, precisely because they work in the small on a daily basis even when big successes are rare. In fact, the incremental developments embodied in scientific tools and techniques are key to the big successes. Given an idea or insight or testable hypotheses, wherever those might come from, the scientific method can help test them and, in most cases, rule out the ones that actually do not work. That is not a trivial accomplishment. It is also not a predictable path to success—in science or elsewhere (Dasgupta, Schulz, & Gershman, 2017; Schulz, 2011).

When we historically examine how insightful hypotheses in science come to be, we are inescapably led to infer that "the trail of the human serpent is over everything" as James (1907) points out. In other words, even in science, we find the need for the entrepreneurial method in action. Again, a specific case may help enliven our inquiry.

In the 1600s, the austere astronomer Johannes Kepler was forced to hang around and ingratiate himself with the profligate Tycho Brahe, who had the leisure and wealth to collect enormous quantities of the data that could verify his hypotheses about the circular orbits of planets nested within Platonic solids. In other words, cocreative partnership between stakeholders was needed. Sadly, in Kepler's case this did not happen. Instead, he had to wait and steal the data after Brahe died, leaving the data to his heirs. Tycho's heirs were anxious to make as much money as possible out of the estate, and the impoverished Kepler realized that if he did not act immediately, he would never get to use most of Tycho's data. As he wrote in a letter in 1605, "I confess that when Tycho died, I quickly took advantage of the absence, or lack of circumspection, of the heirs, by taking the observations under my care, or perhaps usurping them" (Koestler, 2017[1959]: 280).

It took almost a decade of work analyzing the purloined data. The data almost entirely validated Kepler's theory of circular orbits—but not quite. There was a tiny, unexpected kink in the orbit of Mars; tiny, but consistent. Yet, Kepler was loath to throw away his theory that had taken up decades of painstaking work and start again from scratch, so he invested considerable time and effort pondering and investigating the possibilities of observational errors. Eventually, Kepler did restart from scratch and reluctantly hypothesized elliptical orbits. After finding they fit the data, he still mourned the loss of his beautiful theory of circular orbits and expressed his disappointment with the ugly ellipse calling it "a cart-full of dung."

Based on decades of studying the history of science, Herbert Simon would point out that coming up with hypotheses worth testing was clearly unexplained within the scientific toolbox. One of his favorite examples that can also be found in Lieberson (1985) is that rigorous statistical tests of variance can fully explain falling objects without ever invoking gravity. Galileo, therefore, was doing something more than following the standard model of the

scientific method. Another of Simon's favorites was the so-called serendipitous discovery of penicillin (Roberts, 1989). Simon's argument here was that years of development of expertise was necessary for this "serendipity" to occur. Someone without the expert eye—just as in the case of Kepler—might easily have thrown away the data, in this case, the petri dish with the unexpected mold growing in it. In other words, recognizing the unexpected and unwanted as unexpectedly valuable requires a stance of doing something with the "unpredicted" based on one's bird-in-hand. This usually consists in life experiences (Galileo and gravity), knowledge (Fleming and penicillin), and networks (Kepler, Brahe, and elliptical orbits).

It is clear that the scientific method, as well as the entrepreneurial method, can and should be part of entrepreneurial education. In fact, both should be part of education per se. As depicted in Figure 3, the scientific method occupies half of the PC space, and hence is vital to the development and use of predictive control. It does not, however, encompass the tools required to navigate the other half of the space. Nor do all of its own tools come from within, as we saw above in the case of coming up with hypotheses worth testing.

However, to the extent that science does lead to unrejected hypotheses, it embodies a causal logic, that is, a logic of predictive control. Similarly, to the extent that entrepreneurship cocreates new ends worth achieving and reshapes the environment it operates in—including new markets and new institutions—it embodies an effectual logic, that is, a logic of non-predictive control.

Effectuation Matters: Why and How

An effectual approach is vital to navigate the PC space because it is currently the only one that explicitly tackles the bottom right quadrant of non-predictive control.

How Do Expert Entrepreneurs Become Effectual?

For this we return to the Viaweb case derived from Paul Graham's interview with Jessica Livingston (Livingston, 2008). As Graham walks us through his experiences building the venture, every step he describes traverses different quadrants of the CAVE framework. For example, whereas Artix came from the visionary quadrant, in the beginning Graham is less aware of where he is treading. Every time something does not work out (art galleries do not want to go online; nor do retailers), he pivots (maybe catalog companies? Antique stores? Technical bookstores? and so on). His actions are more reactive, happening through adaptive trial and error. Eventually, the pivot to online stores is envisioned through media predictions and exapted from software he had already written for another market. Overall, his aims were not necessarily toward the reduction of prediction, except in writing code which is within his and Viaweb's control: "We gave them the software for free for as long as they wanted. We built their sites ourselves. If they needed to have images in them, we would scan the images. We were basically web consultants." (2008: 209)

As he manages to outlive small failures and cumulate small successes, he has his first moment of true awareness of the PC space—while product and customers begin fitting together well, "business" problems, that is, stakeholder issues, begin to dominate his days (investors ask for too much equity, acquisition deal falls through due to "clash of cultures," cofounder takes a job elsewhere, CEO search seems endless). Even as his sphere of control

increases and he is able to make it predictable, the only way to increase it further is to tackle the unpredictable through things within his control—and whenever that works, everything moves forward. Trying to predict the unpredictable stalls and stymies progress. Not trying to predict, but pushing the boundaries of what is already doable within his control, is faster, cheaper and, to his surprise, more enjoyable.

This was reinforced though another insight, this time about the difference between predicted versus actual commitments:

> That was my first introduction to something that turns out to be a very important lesson for startups: it's never a deal till the money's in the bank. So many things can go wrong with deals, and they all do. Before we ultimately got bought by Yahoo, we probably had nine or ten different acquirers that we were talking to, and things always went wrong for one reason or another. (2008: 212)

And later, a surprising lesson about control, without prediction, "You know, in retrospect I think the big problem with our investors was that we weren't forceful enough with them. I think investors like to be bossed around, like horses. It reassures them when you're in control." (2008: 214)

Although this is but one case from a single interview, this progression can be evidenced in the lived experiences of entrepreneurs across the globe, over different periods of time in history, within a variety of different kinds of markets and sociopolitical environments. The progression typically moves from (1) initial trial and error through the PC space, driven sometimes by visionary, sometimes predictive or even sheer reactive desperation at other times, to (2) particular insights at particular moments when things start working and becoming more predictable on the one hand, yet concurrent with uncertain unpleasant surprises that hit the venture. Both invoke a sensitization toward the pervasiveness of unpredictability and the value of committed stakeholders. Eventually (3) these insights coalesce into a deep appreciation for control itself as strategy. Thereon, expert entrepreneurs begin to sort almost everything—resources, events, relationships, contingencies—in terms of what is within their control and what is not, actively seeking to minimize reliance on prediction, except perhaps occasionally as a communication device.

A note of caution is warranted here. Any moment along this random walk across the PC space, an entrepreneur might quit before getting to an appreciation of non-predictive control or even a clarity about the contours of the space. It costs time and perseverance to learn from experience alone as a teacher. It takes even more time and effort to reap the benefits of such learning. That is exactly why a rigorous understanding of entrepreneurial expertise is crucial. Based on it, we can help construct a path of deliberate practice and fabricate training tools that shorten the random walk for novices, as well as shore up against premature quitting and futile churning (Ericsson, 2018). Once again, let us remember that expertise is not about the success or failure of any given venture, but the success of entrepreneurs, irrespective of any given venture they build (Dew, Ramesh, Read, & Sarasvathy, 2018).

Lean Startup and Effectuation: Overlaps and Distinctions

Having examined the larger landscape, namely the PC space, which different toolboxes and techniques of entrepreneurial practice help navigate, and also having investigated

how and why the scientific and entrepreneurial methods are needed and used through history, we can now spell out practical overlaps and distinctions between lean startup and effectuation.

Both lean startup and effectuation (a) argue against business planning; (b) emphasize customer development; (c) seek to reduce time to market; and (d) can be used for innovation in startups as well as larger organizations. However, as summarized in Table 1, the two also differ in a number of important ways, each of which harks back to their distinct non-overlapping locations within the PC space. Let us delve into distinctions after discussing overlaps.

Overlaps Between Lean Startup and Effectuation

Business Planning. Both lean startup and effectuation point to flaws in traditional business planning. In his working guide for writing a winning business plan, Schilit (1987) advised an executive summary plus 10 sections spanning marketing, financial forecasts, team development, and risk analyses. Each of these requires data gathering through methods such as surveys and focus groups, combined with financial forecasting leading to detailed budgets, milestones, and timelines. Until very recently, this type of business plan was the only standard deliverable. University courses in entrepreneurship were almost entirely organized around teaching students to write them.

Every one of the expert entrepreneurs I studied had something nasty to say about this kind of planning based on market research and financial forecasts. All considered the business plan a necessary evil for obtaining formal funding. As one of them exclaimed, "Of course you gotta do it, I have written hundreds of these, but God forbid you believe it's a *plan*!" (Sarasvathy, 2022[2008]: 73-4). This exasperation with business planning also led to the lean startup model. As Ries (2011: 31) explains, "Unfortunately, too many startup business plans look more like they are planning to launch a rocket ship than drive a car." How experienced and/or expert entrepreneurs arrive at their disdain for business plans might vary as much as the ways in which they express that disdain. Both lean startup and effectuation heed that disdain and seek to offer alternatives to traditional business planning.

Customer development. Both lean startup and effectuation offer techniques for customer development. Interestingly, while effectuators go deeper in their skepticism of all predictive information, lean startup offers a deeper dive into prediction: "Validated learning is the process of demonstrating empirically that a team has discovered valuable truths about a startup's present and future business prospects. It is more concrete, more accurate, and faster than market forecasting or classical business planning" (Ries, 2011: 48). This concept of validated learning can be traced back to the customer development model in Blank (2005, 2013).

The idea behind validated learning and customer development consists in going beyond traditional market research (through surveys and focus groups for example) to systematically test customer preferences and behavior through experiments such as those used in science. As Ries (2011: 66) puts it, "we need a method for systematically breaking down a business plan into its component parts and testing each part empirically." Testing usually takes the form of A/B testing, that is. dividing customers into random groups and offering them two options that are similar on everything except for one feature that is being tested or validated. In practice, as Shepherd and Gruber (2021) point out, startup entrepreneurs tend to be more

Table 1
Distinctions Between Lean Startup and Effectuation

Startup Features	Lean Startup	Effectuation
Initial Idea	Not specified where ideas come from or how to choose between them. Recently, however, the Market Opportunity Navigator was added as the fourth tool.	Although it is not necessary to start with an idea, the bird-in-hand principle does provide guidance.
Hypotheses	Although the criteria for good hypotheses are well-specified, the generation of such hypotheses is not a well specified technique, even in scientific research, let alone in lean startup.	This is a non-problem since there is no hypothesis generation or testing required in effectuation.
Customer Development	Focus on searching for, finding, and developing customers. However, the problem of unpredicted customers (who are therefore not talked to or developed) is ignored.	Focus on talking to anyone and everyone willing to talk to the entrepreneur. Furthermore, not only customers, but any and all stakeholders can self-select and move the effectual process forward.
Pivots	When customers reject hypotheses, need to pivot arises. No specification on how many pivots might be needed nor how to halt the process.	Process moves forward only through commitments that make the next step affordable loss. While effectuators may not want to commit to something a self-selecting stakeholder offers, to the extent effectuators are willing to change their goals, it takes only a few substantial commitments for the process to converge.
Product Market Fit	Assumes markets exist exogenously and can be "found."	Seeks to shape and cocreate markets endogenously as well as find them where they already exist.
To Pivot or Not to: Psychological Issues	Psychological issues related to giving up one's vision/passion in order to pivot are not resolved.	Psychological issues related to goal change can be hurdles. However, the crazy quilt and pilot-in-the-plane principles offer the possibility of returning to one's vision/passion later after these become affordable loss.
Failure	Promises higher probability of success without specifics on failures along the way.	The lemonade principle specifically tackles failures as part of the process. Also, success/failure of venture does not equal success/failure of entrepreneur.
Uncertainty	Useful when prediction is possible.	Useful under uncertainty, especially Knightian uncertainty.

focused on confirming rather than falsifying their hypotheses. This is not always a bad thing. In some cases, even a belief-model of hypothesis testing could be beneficial (Shepherd, Haynie, & McMullen, 2012).

In effectuation customer development is part of the crazy quilt principle where the aim is to pre-sell the product, even before a prototype may be ready; and if not pre-sell, at least to get pre-commitments from customers. As one expert entrepreneur put it, "the best form of market research is actual sales" Gianforte (2005: 21). Even though the techniques differ, with lean startup leaning into better prediction and effectuation focused on pre-selling and partnering, both lean and effectuation do highlight the importance of customer development early on.

Reduction in time to market. Simply doing the two things above, (a) not having people research and write elaborate business plans and (b) engaging in customer development

sooner rather than later, enables both lean startup and effectuation to reduce time to market. In the case of lean startup, customers rejecting hypotheses might result in pivots and more tests that could add to the time to get to product market fit. However, it is still likely to be quicker to get to market than writing elaborate business plans and later finding out no one actually buys the product or service.

In effectuation, the issue is not whether customers reject any given hypothesis or product feature. Instead, the idea is to build whatever actual customers actually pay for. Here, too, it may take time to find a customer who pre-commits. However, since effectual entrepreneurs are explicitly open to changing their goals, they can assent to a wider variety of products and services sooner, thereby staying engaged in building only products customers actually want.

Therefore, both lean startup and effectuation provide techniques to reduce time to market, compared to traditional business planning.

Innovation beyond startups. Lean startup methods are used in larger organizations for product development and the commercialization of new technologies. Effectuation, too, can be found in corporate venturing, new product development, and in research and development (R&D) departments in established companies (Brettel, Mauer, Engelen, & Küpper, 2012). Furthermore, effectuation has been shown to be in use in domains beyond business. Olive-Tomas and Harmeling (2020) present the use of effectuation by Picasso and Braque in building the Cubism movement in art; Murphy, Danis, and Mack (2020) show how the Toquaht nation engages in community effectuation; and several studies evidence the use of effectuation in social enterprises (Corner & Ho, 2010; Johannisson, 2018) and tackling large societal problems requiring collective action and polycentric governance (Sarasvathy & Ramesh, 2019).

Distinctions Between Lean Startup and Effectuation

Initial idea. There are several studies examining idea generation and opportunity recognition in entrepreneurship. In fact, the latter can be traced back to the widely accepted definition of the field as a whole (Venkataraman, 1997). In recent research, models explaining the discovery of opportunities are beginning to be related to methods such as design thinking and lean startup. That has led to identifying gaps in these models as well as examining their usefulness. For example, noting a deficiency in lean startup as to where ideas come from, Gruber and Tal (2017) developed the Market Opportunity Navigator (MON) as an important learning layer within lean startup. MON offers a wide lens perspective for entrepreneurs to come up with a portfolio of market ideas, and then helps them to choose the one with highest potential as the starting point for applying lean startup.

Effectuation, in contrast, suggests that entrepreneurs begin with their bird-in-hand—namely, who they are (identity), what they know (knowledge), and whom they know (network)—and then come up with things they can immediately do/make within their affordable loss. The point here is not to overthink or spend too much time in idea generation or opportunity identification mode. Instead, the focus is on doing the doable based on things already within one's control. The rationale for this is the belief that (a) it is futile to predict which ideas are more or less likely to succeed, and (b) ideas are almost immediately going to change as effectuators engage in opening the door to commitments from stakeholders.

In a Youtube video, serial entrepreneur and cofounder of Netflix, Marc Randolph, attests to the futility of trying to predict which ideas will work and which will not, as follows:

> Nobody knows anything, true in Hollywood and I believe true almost any place people are trying new ideas. I mentioned before that Netflix is just one of seven startups of mine but if you'd asked me on Day 1 for each of these which was going to be the big hit and which was going to be the complete failure, I promise that I could never have told you. Nor could anybody else. (https://www.youtube.com/watch?v=ObJx_mY4I8k)

In short, while lean startup provides little guidance on coming up with the venture idea, and MON emphasizes the need to identify which idea one ought to work on, effectuation proposes moving into action and interaction immediately, doing whatever is doable for affordable loss. If the effectuator comes up with more than one idea, they can choose one based on their subjective preferences or else try to enroll stakeholders for all of them. Depending on which idea gathers enough commitments to make their next steps affordable loss, the effectual process itself leads to the most doable venture without the entrepreneur first having to predict which one is likely the best.

Hypotheses. Another major issue that lean startup does not provide good guidance on is the formulation of hypotheses. Shepherd and Gruber (2021: 973) highlight this as follows:

> More specifically, the design of a business model presents a "leap of faith" as it requires an entrepreneur to create a set of assumptions regarding whether a (potential) customer problem can be solved by a product or service that delivers value to customers and whether value-generating new business can be established. (Osterwalder & Pigneur, 2010)

In this connection they allude to the fact that even the MON model focuses on where to play and not on how to play. Hark back to the fact that the history of science also attests to this difficulty. As we saw earlier, the scientific method, too, does not provide clear guidance on where good hypotheses worth testing come from or how to generate them from scratch.

This problem simply does not exist in effectuation since prediction is unnecessary and irrelevant to the process. Therefore, not having to come up with hypotheses to test, especially under high uncertainty, is a useful feature of non-predictive control. It raises the question, however: If not hypothesis testing, what does the effectual entrepreneur do?

While effectuators use any idea they come up with as an opener in conversations with people, their task is to quickly move to match their bird-in-hand to anything and everything a self-selecting stakeholder is willing to commit to. It might turn out that there is not a big market for any given product a customer might want, but so long as they are willing to pay enough for it, or a supplier is willing to make a close-to-free batch of it, or investors are willing to keep providing just enough funding for it, effectual entrepreneurs can continue building them, as in the case of Viaweb that we examined earlier. Even prototypes and MVPs are underwritten by stakeholders in effectuation and hence are not a priori conditions for talking to customers, except when entrepreneurs can easily make them within their affordable loss, and want to do so.

Customer Development

Furthermore, while hypothesis testing is primarily a matter of customer development in lean startup, the key stakeholder in effectuation need not even be a customer. There is an implicit assumption in lean startup that we can predict in advance the set of all possible customers.

Since effectuation emphasizes that we cannot know who may not turn out to be a customer, we need to talk to anyone and everyone who will talk to us. In fact, any and all stakeholders, not only customers, can kickstart the effectual venture and keep it going through market cocreation. Consider the case of Virgin Atlantic. Richard Branson called Boeing to ask to lease airplanes and their assenting made it affordable loss for him to start the venture.

Another issue in lean startup concerns the customer that the startup may not know or even imagine exists. In other words, predictions of who the customer(s) might be are often wrong. In the case of the CD-ROM, for example, the market for music was imagined almost a decade after its invention and use as data storage. Even the internet was not seen as technology for commerce for about 15 years (Sarasvathy & Dew, 2005). Uncertainty exists not only within extant markets, but often takes the form of markets that simply do not yet exist. The only way to cocreate markets no one has even imagined yet is to interact with any and all people willing to come together to build things for affordable loss, without clear predictions of who the customers might be.

Pivots. Lean startup seeks to gather high quality predictive information about customers and related aspects of the business model. It provides detailed guidance for breaking down the business plan or imagined business model into constituent parts and testing assumptions and hypotheses related to these. Whenever these assumptions and hypotheses are rejected by the tests, the lean startup entrepreneur has to pivot and come up with new ideas and features of the business model and start testing these. In other words, information gathered through A/B and other types of tests (e.g., surveys, interviews) constitute the engine of the lean startup.

As already mentioned, commitments from self-selected stakeholders drive the effectual process. The effectual entrepreneur talks to anyone and everyone with the aim of every conversation being to get to a deal, a real commitment that makes the next step affordable loss. Note that commitments (Sarasvathy & Dew, 2005) are a kind of information too, yet they are more than that. They are sufficient conditions to get the next step in effectual cocreation done. In other words, commitments are not predictive of future deals. They constitute the actual deal in the present that allows startups to make the next feature of a new future.

One could argue that both lean startup and effectuation may lead to churn, or endless pivoting, or, put another way, that they present a "halting problem" in the startup process (Fischer & Reuber, 2011). Without taking a position on whether that is a problem in lean startup, I contend that it is not a problem in effectuation. The effectual process moves forward almost exclusively through commitments from self-selecting stakeholders (Van Mumford & Zettinig, 2022). Note that the entrepreneur is one of those stakeholders. Hence, the effectual entrepreneur can unilaterally commit up to the maximum level of his or her subjectively determined affordable loss. In other words, the effectual process halts either when entrepreneurs run out of their affordable loss, and/or no one else commits anything to the venture (Sarasvathy & Dew, 2005).

Because pivoting in effectuation can happen only through sufficiently large commitments, the number of pivots is necessarily few. In over 200 case studies from all around the world, we have found evidence for only a handful of changes from the original venture idea. As the venture grows, a few more pivots might happen. These later pivots take the form of product line extensions as well as the cocreation of new markets. Another way to say this is that effectual ventures evolve. They do not necessarily pivot.

Product market fit. The main objective in lean startup and related approaches is to find product-market fit. This assumes markets exist exogenous to entrepreneurial action. Hence what is needed is a validated search process, carefully designed and executed using A/B and other testing of assumptions and hypotheses.

As conceptualized in depth in Sarasvathy and Dew (2005) and Karami and Read (2021), and evidenced empirically (Kaartemo, Kowalkowski, & Edvardsson, 2018; Ko, Roberts, Perks, & Candi, 2022; Read, Dew, Sarasvathy, Song, & Wiltbank, 2009), the effectual process seeks to shape and cocreate new markets, not only penetrate and occupy existing ones. Cocreation not only includes ways to fit products to markets, but also ways to *make* markets that fit entrepreneurs' own as well as their self-selected stakeholders' birds-in-hand.

To pivot or not to pivot. As Shepherd and Gruber (2021) discuss, an interesting variation on the theme of pivoting has to do with psychological issues that make it hard to do. On the one hand, entrepreneurs tend to be passionate about their ventures. They are also exhorted to inculcate in themselves traits like perseverance, grit, and resilience. These are not qualities that comply easily with pivoting. Add to that certain traits from the dark side, such as vanity or narcissism, and pivoting or interpreting disconfirming tests can become a substantial hurdle.

This is also one of the problems in training entrepreneurs to effectuate. Novice entrepreneurs quickly fall in love with their own visions of building the venture and find it difficult to listen to, let alone actually open up to allow stakeholders to self-select, even when they are willing to make substantial commitments. One way we tackle this problem in effectuation is to get entrepreneurs to see that they get more than one shot at the pot, so to speak. By cocreating with current stakeholders whatever they are committing to cocreate, effectual entrepreneurs need not necessarily abandon their own ideas and vision. They can work concurrently on their original idea, or return to building it after they have accumulated enough resources through the effectuated venture to make it affordable loss. All the same, effectual entrepreneurs need to learn to let the crazy quilt principle drive the process before engaging the affordable loss gear on their pet passions—sometimes much later.

Here is a story from one of the expert entrepreneurs:

> I just wanted my own lab. But I did not have the money to build it. Nor could I raise the money through grants. In desperation I turned to private investors. The ones I talked to would get excited about my unique technical background but wanted me to build other products rather than fund my lab. Eventually I agreed and built a three billion dollar company based on their ideas. But could not get back to building my own lab until I found a CEO to replace me. That took years since there are not many people with technical expertise in my area and I had to train my successor from scratch.

Discussion and Implications for Future Work

In this section I provide brief outlines of implications from the above exposition to entrepreneurship education as well as future research. Let us begin with considering the role of performance in informing education content.

Implications for the Role of Performance in Entrepreneurship Education

As it says in its title, lean startup claims to increase the probability of success of new product development both in startups and larger organizations (Ries, 2011). These claims are yet to

be empirically tested. However, academic research in entrepreneurship is rife with studies claiming to explain venture survival and success as well as other aspects, more narrowly and precisely defined as impacting performance variables of interest to entrepreneurship such as idea generation, opportunity identification, gestation activities, and obtaining funding. There is also a rising focus on relating variables that are correlated with the starting and survival of ventures to entrepreneurship education (Eesley & Roberts, 2012; Elert, Andersson, & Wennberg, 2015).

Recently, some studies argue for specific elements that ought to be part of entrepreneurship education based on experimental evidence, claiming to correlate them to success. As mentioned earlier, one emphasizes the importance of teaching scientific hypothesis testing (Camuffo et al., 2020). Another set of studies relate psychological variables, such as personal initiative, to performance (Frese et al., 2016; Unger, Keith, Hilling, Gielnik, & Frese, 2009). Studies have also claimed positive relationships between aspects of effectuation and entrepreneurial performance (Deligianni, Voudouris, & Lioukas, 2017; Laskovaia, Shirokova, & Morris, 2017; Read, Song, & Smit, 2009; Shirokova, Osiyevskyy, Laskovaia, & MahdaviMazdeh, 2020). I have argued, too, for the higher probability of innovation and lower costs of failure as important performance implications from the use of an effectual approach.

All the same, given the larger historical discussion of the scientific method and its relationship to the entrepreneurial method in the PC space, it might be worthwhile reconsidering the role of such studies in providing the main content of entrepreneurship education. Holding up evidence of positive relationships between any of the toolboxes and measures, such as the rate of starting ventures and success in building them as a rationale to including them in entrepreneurship education, is akin to developing science curricula based on how many students become scientists and build breakthrough inventions.

I am not arguing for giving up studies of entrepreneurial performance. I am questioning their value as the main rationale for choice of content in entrepreneurship education.

What is the alternative, you might ask? The history of science offers good alternatives. For each element of content, we need to make a theoretical case with internally consistent logic. Every element in the scientific method embodies such logic. The "care" in careful data collection has to do with independent replicability by others. Replication is needed to ensure objectivity, to avoid contamination through subjective biases. Likewise, testing hypotheses allows for objective reality to be prioritized over subjective aspirations. Hence the need for falsifiability as the key criterion for good theorizing. Techniques of controlled experimentation embody the best of these internally logical criteria and elements. Hence the randomized controlled experiment is the gold standard and the vehicle through which the scientific method is taught—not because it leads to success, but because it is consistent with the fundamental logic of science as a method.

Most importantly, the scientific method is taught to *everyone*, not only to potential scientists. As argued above and elsewhere, I would like a similar ideal for our efforts in building rigorous and relevant entrepreneurship education.

Implications for Future Research

In addition to expanding interest in education and performance, entrepreneurship as a field has taken an important and interesting turn toward a deeper understanding of practical tools and how these may connect with and inform research and policy (Berglund et al.,

2020; Campos et al., 2017; Camuffo et al., 2020). The current special issue is a case in point, and the launching of the *Journal of Business Venturing Design* is yet another step in this direction.

As Gigerenzer (1991) showed, this move away from borrowing from other disciplines and toward developing practical tools from the field into new theories finds healthy parallels in the history of science. There are at least two new pastures for exploration that open with such a move in entrepreneurship. First, we may want to pay closer attention to methods of interactions—not only between entrepreneurs and customers, but between entrepreneurs and all their stakeholders. Recent conceptualizations for examining phenomena such as stakeholder enrollment (Mitchell, Israelsen, Mitchell, & Lim, 2021; Suddaby, Israelsen, Robert Mitchell, & Lim, 2023) offer doorways to new empirical work. Second, access to content analyses tools based on artificial intelligence allows us to begin examining vast quantities of as yet unanalyzed data on conversations, conflicts, complaints, and every form of communication between entrepreneurs and their stakeholders, potential and actual.

Most importantly, the fertile interest in methods we are currently embracing offers the field an opportunity to extract specific tools of dyadic and dynamic interactions between entrepreneurs and their stakeholders, ventures and their environments, as well as economic and non-economic benefits and values. The tools we have currently identified are but the tip of the iceberg of possible tools. Each of these new tools that we will extract from entrepreneurial practice will likely contain insights for dealing with a variety of different kinds of uncertainties. By elucidating these in careful tiered progression, we should be able to weave them together into frameworks and theories that can coevolve with ideas from all the social sciences. Such careful tiered progression has to be the way forward to building entrepreneurship as a method.

Conclusion

The scientific method is necessary but not sufficient, even for doing science. The history of science readily attests to the use of the entrepreneurial method and tools from all four quadrants of the CAVE framework. On the flip side, the scientific method is also useful but definitely not sufficient for doing entrepreneurship. In a world in which uncertainty is increasing along multiple dimensions, prediction is often neither feasible nor desirable. In such a world, techniques of non-predictive control, locally (in particular contexts), and contingently (for certain periods of time), are invaluable for the fashioning of valuable new ends no one has yet imagined. Thankfully, these can still be cocreated with what we already have within our control.

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