ENTREPRENEURIAL ACTION AND ENTREPRENEURIAL RENTS

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ABSTRACT

This dissertation is comprised of three independently standing research papers (chapters 2, 3 and 4) that come together in the common theme of investigating the relationship between entrepreneurial action and performance. The introduction chapter argues that this theme is the main agenda of an entrepreneurial approach to strategy, and provides some background and context for the core chapters. The entrepreneurial approach to strategy falls in line with an array of action-based theories of strategy that trace their economic foundations to the Austrian school of economics. Chapters 2 and 3 take a game theoretical modeling and computer simulation approach and represent one of the first attempts at formal analysis of the Austrian economic foundations of action-based strategy theory. These chapters attempt to demonstrate ways in which formal analysis can begin to approach compatibility with the central tenets of Austrian economics (i.e., subjectivism, dynamism, and methodological individualism). The simulation results shed light on our understanding of the relationship between opportunity creation and discovery, and economic rents in the process of moving towards and away from equilibrium. Chapter 4 operationalizes creation and discovery as exploration and exploitation in an empirical study using data from the Kauffman Firm Survey and highlights the trade-offs faced by start-ups in linking action to different dimensions of performance (i.e., survival, profitability, and getting acquired). Using multinomial logistic regression for competing risks analysis and random effects panel data regression, we find that high technology start-ups face a trade-off between acquisition likelihood and profitability-given-survival while low and medium technology start-ups face a trade-off between survival and profitability-given-survival. Chapter 5 concludes the dissertation by highlighting some of the overall contributions and suggesting avenues for future research.

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CHAPTER 1: INTRODUCTION

What does an entrepreneurial approach bring to the theory of strategy? We argue that it brings to the fore three important determinants of competitive advantage previously ignored or under-emphasized in strategic management: a) the ability to discover and identify opportunities, b) the initiative to take action in exploiting those opportunities, and c) the ability to imagine and create new opportunities. Together, these notions shift the focus of the independent variable in strategy to 'entrepreneurial action.' This dissertation is comprised of three independently standing research papers (chapters 2, 3 and 4) that come together in the common theme of investigating the relationship between entrepreneurial action and performance. In this introduction we argue that this theme is the main agenda of an entrepreneurial approach to strategy[1].

After outlining the entrepreneurial approach to strategy and reviewing its economic foundations, we discuss the much used and confused notion of 'rent' and whether or not entrepreneurial rent can be distinguished from prevailing notions of rent underlying equilibrium-based strategy theories. These two sections serve as a foundation for the final two sections of this introduction, which in turn provide some background for chapters 2-4. The background for chapters 2 and 3 elaborates on the formal analytical approach of those chapters, while the background for chapter 4 emphasizes the way in which entrepreneurial action and rents are translated into empirically measurable constructs in the real world.

THE ENTREPRENEURIAL APPROACH TO STRATEGY

Consider two of the main theories that have dominated the mainstream of strategic management research in the past three decades (Conner, 1991): one is based on the structure-conduct-performance paradigm in Industrial Organization (IO), famously championed by Michael Porter (1979, 1980) building on the work of Caves (1984) and Bain (Bain, 1968), and the other is the resource-based view (RBV) based on the Chicago-UCLA school of economics and the work of

[1] Since we are heavily concerned with the economic foundations of an entrepreneurial approach to strategy, and performance is commonly associated with the notion of economic rents when linking strategy theory to its economic foundations, we use the terms rent, competitive advantage and performance interchangeably to refer to the dependent variable of interest in strategy theory. And for reasons that will be explained below, we also use the terms profit, rent, and return interchangeably.

Demsetz (1973, 1982), famously championed by Jay Barney[2] (1986, 1991) after the seminal papers by Wernerfelt (1984) and Rumelt (1984). Both of these theories take as a point of departure the first fundamental theorem of welfare economics, which states that if markets are perfectly competitive they will reach an equilibrium in which all profits are dissipated (i.e., competed away). These two theories then proceed to locate 'competitive advantage' or 'supernormal profit' or 'rent' by examining the existence of structural market imperfections that create deviations from the first fundamental theorem of welfare economics, and thus allow non-zero profits to be made (Barney, 1986; Foss, 2003; Mahoney, 2001; Yao, 1988).

Based on this logic, the IO-based theories emphasize external market forces such as customer and supplier bargaining power, threat of new entrants and substitutes, and intensity of rivalry among competitors (Porter, 1980). The weakness of any of these forces would indicate a market imperfection that could give the focal firm competitive advantage over competitors in the resulting imperfectly competitive equilibrium. Shifting the pendulum from the outside to the inside of the firm (Hoskisson, Hitt, Wan, & Yiu, 1999), the RBV emphasizes ownership and control of valuable, rare, inimitable and non-substitutable resources (Barney, 1991). Control of such resources would be indicative of factor market imperfections that could give the focal firm competitive advantage over others in the resulting imperfectly competitive equilibrium.

To see if an entrepreneurial lens can add anything new to these theories, let us conduct a thought experiment: suppose two rival firms have practically identical market positions in terms of bargaining power, threat of entrants and substitutes, and rivalry. Suppose also that they have practically identical resources and technologies. Furthermore, suppose that they both operate in all regions of country A but not in the attractive and untapped market of country B. In such a case, both IO theory and the RBV will have little to say on which firm has an advantage over the other, or whether and how such an advantage may be created. These theories have little to recommend

[2] The RBV encompasses a broad literature. Here we are not considering the more process-oriented and evolutionary-based branches of RBV based on Penrose, Nelson & Winter, etc. that are less loyal to the equilibrium-based neoclassical framework. See Foss (2000b) for this distinction of RBV branches. We consider the process-oriented branch of RBV closer to the dynamic capabilities approach and part of the action and disequilibrium-based group of strategy theories.

firms starting off with no advantage or even with a disadvantage (Brush, Greene, Hart, & Haller, 2001; Madhok & Keyhani, 2012; Miller, 2003).

An entrepreneurial approach to strategy on the other hand, would have something to say. It would suggest that one firm may gain advantage over the other by being first to discover and identify the opportunity to enter the market of country B. If both firms discover this opportunity at the same time, the entrepreneurial approach would say that one firm may still gain advantage over the other by having the initiative to actually act on this opportunity. If they both act on the opportunity, the entrepreneurial approach would say that one firm may still gain advantage over the other by inventing a new cost-effective technology not available to the other, or by finding a new way to render a previously unattractive market in a third market (say country C) profitable and entering that market. The entrepreneurial approach would also say that there is no guarantee that any of these efforts will be successful, but that there are ways of increasing the chances of success.

While the above statements may seem relatively trivial to the practicing strategist, they are largely excluded from the logic of the mainstream strategy theories based on market imperfections in imperfectly competitive equilibrium. A closer look at the intellectual history and assumptions of the underlying formal framework in neoclassical economics reveals the reasons for this omission. In this framework, the information or knowledge that economic agents have is taken as constant, and is taken to be perfectly reflected in prices (Eckhardt & Shane, 2003), leaving no room for a change in this knowledge through discovery, creation or imagination. Advantage is calculated based on what the market structure is now, not what it can or may become in the future. Furthermore, action is taken to be automatic in this framework, merely a corollary of individual rationality. Everyone is assumed to act swiftly to adjust their production or consumption in order to maximize their utility: given the structure of the market, agents will automatically act in a predictable way that ultimately brings about equilibrium. The initiative and capability to act is overshadowed by structural conditions as the main independent variable. For example, Barney (2001, p. 53) has conceded that the classical formulation of the RBV assumes that, given possession of advantageous resources, ‘implementation follows, almost automatically’ as though ‘the actions the firm should take to exploit these resources will be self-evident’.

Research to date has provided ample grounds to demonstrate the inadequacy of these assumptions (Bromiley & Papenhausen, 2003). We know that decision makers are boundedly—and far from perfectly—rational (Simon, 1982), and systematically so (Ariely, 2008; Tversky & Kahneman, 2004). Even if they were perfectly rational, they are not perfectly omniscient: no one can perfectly predict the future. Uncertainty prevails (Knight, 1921) and the best course of action is not always known, or even knowable (Loasby, 2007; Shackle, 1979a). Failure is rampant among organizations (Christensen, 1997), and success is often a matter of luck and serendipity (Denrell, Fang, & Winter, 2003). Even if a given course of action is reasonably known to be the best alternative for now, it could easily be changed. The decision maker may learn new things and unlearn old things, and meta-learn new ways of learning and unlearning (Argyris, 1976); thus, revising her knowledge, very possibly mistakenly (Levinthal & March, 1993). She may be forced to revise her plans and expectations because of external shocks, surprises, and the actions of others (Lachmann, 1986; Shackle, 1953). Even assuming that the best course of action is thought to be approximately well known and this knowledge is reasonably expected to remain unchanged, it is not a trivial matter for a firm to overcome transaction costs (Coase, 1937; Foss, 2003; Williamson, 1979), inertia (Hannan & Freeman, 1984) and institutional constraints (Dimaggio & Powell, 1983) to actually take the necessary steps, especially if the action requires significant change (Quinn, 1985).

But while these realities may paint a dismal picture of a severely flawed and ignorant actor lost in an uncertain and ambiguous world, an entrepreneurial approach to strategy points to the other side of the coin: all the uncertainty and unpredictability means that a future, possibly full of new opportunities is always around the corner. Human idiosyncrasies, imperfections and flaws mean that not everyone will see the same opportunities, and not all profits will be competed away (Gavetti, 2012). And perhaps most important of all: humans can imagine and be creative; imagining alternative courses of action and their consequences, is an act of creation everyone engages in constantly (Shackle, 1979a). Coupled with their agency, individuals' ability to imagine allows them and their organizations to create new opportunities and expand the horizons. Being limited to a strictly given set of alternatives to choose from, is the exception rather than the rule. Coupled with the capability to act and influence the world directly, imagination gives the decision-maker the ability to *make* new alternatives and *shape* the future, rather than merely choose among given futures (Sarasvathy, 2001).

The dynamics of competitive advantage

In line with the entrepreneurial approach, a host of more recent theories of strategy have attempted to move beyond an equilibrium framework. In order to emphasize a focus on dynamics, all of these theories explicitly refer to the role of action as a centerpiece. The competitive dynamics literature studies competitive moves and countermoves by taking the 'action/response dyad' as the central unit of analysis, and examining characteristics of these actions including their aggressiveness, frequency, speed and scope (Chen, 1996; Chen & Miller, 2012). The resource management literature emphasizes the role of 'managerial action' in structuring, bundling and leveraging resources, in addition to—and distinct from—the characteristics of the resources themselves (Sirmon, Gove, & Hitt, 2008; Sirmon, Hitt, & Ireland, 2007). This is closely related to the dynamic capabilities and asset orchestration literature that emphasizes actions of search/selection and configuration/deployment (Helfat, 2007; Sirmon, Hitt, Ireland, & Gilbert, 2011), sometimes with explicit reference to opportunity creation, discovery, and exploitation as the fundamental actions of concern (Teece, 2007). We refer to these theories throughout the dissertation as action-based theories of strategy.

Importantly, an emphasis on action over structure removes the theory's reliance on existing advantage in the market imperfection sense of the word. This is no inconsequential matter, since almost all individuals and firms start off or find themselves at some point in a position of no advantage or even disadvantage compared to seniors, competitors and incumbents. In the entrepreneurial approach to strategy, the disadvantaged are far from hopeless: they too can find path-dependent routes to eventual advantage through discovery, creation and exploitation of opportunities (Miller, 2003). Not only that, but also disadvantage in many ways can form the basis of future advantage that would have been impossible to achieve without the initial disadvantage. For example, while knowledge is often considered a strategically valuable (if not *the most* valuable) resource in the RBV (Grant, 1996b; Kogut & Zander, 1992), the nature of knowledge is paradoxical. Having expert knowledge in a domain at once enables and limits the ability of the knower to identify and envision future opportunities. While previous knowledge enables us to understand new information and identify new opportunities by developing absorptive capacity (Cohen & Levinthal, 1990; Lane, Koka, & Pathak, 2006), it can also prevent us from thinking outside the box and identifying cognitively distant opportunities (Gavetti, 2012). The history of science is full of stories of discoveries made by those who were too ignorant to know what 'could not be done'. To emphasize the distinctive nature of the entrepreneurial approach in relaxing the reliance on existing advantage, Stevenson and Jarillo (1990) define entrepreneurship as the pursuit of opportunity *without regard* to the resources currently under control. We would add that entrepreneurs pursue opportunity not just *despite* a lack of current advantage, but even sometimes *enabled* by what seems to be disadvantage.

On the flip side, if disadvantage can turn into advantage then advantage can also turn into disadvantage. The dynamism that brings hope of gaining advantage also brings fear of losing it. Thus, while the equilibrium-based theories such as the IO approach and the RBV heralded the prospect of 'sustained' competitive advantage as the holy grail of strategy, the entrepreneurial approach appears to offer nothing more than temporary advantage. All of the above-mentioned action-based theories of advantage emphasize its temporary nature (D'Aveni, Dagnino, & Smith, 2010). Sirmon *et al.* (2007, p. 274) state that in the face of uncertainty, 'sustaining a competitive advantage over time is unlikely, with the result that a firm instead will seek to develop a series of temporary competitive advantages', while Chen, Lin, and Michel (2010, p. 142) point out that 'competitive advantage is time dependent and ephemeral, and any advantage gained by a firm through its actions will be negated sooner or later by competitors' responses.' Eisenhardt and Martin (2000, p. 1117) emphasize that dynamic environments prompt businesses to 'compete by creating a series of temporary advantages'. Klein *et al.* (forthcoming, p. 9) observe that the burgeoning field of strategic entrepreneurship 'appears to have dropped strategic management's search for the conditions of sustainability of (any single) competitive advantage, and instead focused on the entrepreneurial pursuit of a string of temporary advantages.'

In other words, the hope for advantage sustainability is not dead; it is only harder to achieve than equilibrium-based theories would admit. The light is in the notion of multiple consecutive acts of advantage creation. In this light, observed periods of *sustained* competitive advantage may be viewed as the concatenation of a series of temporary advantages (D'Aveni et al., 2010; Wiggins & Ruefli, 2005). While in the previous paradigm a structural advantage could itself provide the grounds for sustainability, in the entrepreneurial paradigm it is not enough to have one such advantage. Rather, it is necessary to continuously create such advantages by incessantly discovering and creating new opportunities and acting to exploit them.

Even without this light however, the threats of temporariness may have been exaggerated. The distinction between sustainable and temporary advantage is not as clear-cut as it may seem. The literature on sustainable advantage has already established that some advantages are more sustainable than others, for example due to differing strengths of isolating mechanisms (Oliver, 1997; Rumelt, 1984) and barriers to competition (Peteraf, 1993). But, by definition, to recognize differing degrees of sustainability is to recognize differing degrees of temporariness. They are one and the same, merely two different ways of naming the same continuum. To suppose that advantage in the entrepreneurial approach is fully ephemeral is to the same extent mistaken, as to suppose that advantage in the equilibrium-based approach is perfectly sustainable. But encouragingly, understanding why some advantages are more sustainable than others also tells us something about why some advantages are more temporary. Thus an entrepreneurial approach to strategy cannot disregard the role of structural advantage caused by market imperfections and sustained by isolating mechanisms, and thus does not necessarily invalidate previous theories. Rather, it builds on those theories to gain a more comprehensive understanding of advantage by adding to the scope of analysis the roles of discovery, imagination and action as the drivers of change. It follows that what is distinctive about the entrepreneurial approach to strategy is not an emphasis on the temporariness of advantage *per se*, but rather on the *dynamics* of advantage over time (Farjoun, 2007). Not just that advantage is temporary, but why and how so? When and why do advantages become obsolete? How can seemingly disadvantaged new entrants trump resource-rich and industry-leading incumbents? What are the mechanisms that render a competitive advantage stronger or weaker over time? How do companies replace old advantages with new ones in order to remain competitive?

Consider the type of markets that exhibit rich-get-richer and winner-take-all phenomena (Shapiro & Varian, 1999). In these markets once a small advantage is created, a positive feedback loop such as those created by network externalities (Katz & Shapiro, 1985, 1986), can result in a snowballing effect that renders the advantage over competitors greater and greater over time. Therefore, just 'acting' quicker than competitors can by itself create first mover advantage (Kerin, Varadarajan, & Peterson, 1992) and this advantage can be to some extent sustainable due to such factors as increasing returns mechanisms (Arthur, 1988), path dependencies (Teece, Pisano, & Shuen, 1997) and time compression diseconomies (Dierickx & Cool, 1989). At the same time, in such markets there is no guarantee that the first mover will be the one with the eventually dominant design

(Anderson & Tushman, 1990), and a superior design (perhaps from a firm with better resource-based advantage) may soon trump the first mover. Yet still, it is well known that the design that eventually becomes dominant will not necessarily be the technically superior design, because a weaker design may achieve the critical mass of user adoption sooner (Arthur, 1988).

Furthermore, research on disruptive innovations has demonstrated that the dynamics of change in demand and technology create conditions in which what is perceived as a technically superior design changes over time. Products produced by start-ups with limiting resource-constraints and competitive disadvantages compared to incumbents, eventually move on to take over the market and defeat the goliaths (Christensen, 1997) despite initially seeming weaker than those of competitors. Such revolutions occur even when the falling incumbent was entirely capable of producing the same product, and had better resources to do so. The previous success of incumbents is often the biggest contributor to later failure (Leonard-Barton, 1992), and the dominant logics that develop in an organization as a result of experienced success (Prahalad & Bettis, 1986) can operate as institutional isolating mechanisms (Oliver, 1997) that prevent the incumbents from competing away rents from otherwise disadvantaged newcomers. These patterns suggest clearly that actions and isolating mechanisms jointly determine the temporariness and sustainability of advantage, and that the action-based (i.e., entrepreneurial) dynamics of advantage need to be studied in conjunction with resource-based and structure-based advantage.

THE ECONOMIC FOUNDATIONS OF THE ENTREPRENEURIAL APPROACH

We began by pointing out that previous mainstream paradigms in strategy theory were rooted in static equilibrium-based economics. While this economics framework has its weaknesses, it provides the strategy theories with a foundation in which their logic is clarified (Adner, Pólos, Ryall, & Sorenson, 2009). The logic of the entrepreneurial approach can be sought in the dynamic disequilibrium-based school of thought known as Austrian economics (Böhm-Bawerk, 1891; Hayek, 1948; Lachmann, 1986; Menger, 1981; von Mises, 1949). Austrian economics has been suggested as an alternative foundation for strategy theory (Jacobson, 1992), and indeed all of the action-based theories of strategy alluded to earlier (competitive dynamics, resource orchestration, dynamic capabilities, etc.) specifically refer to it as a foundation. Austrian economists have long criticized the neoclassical model for its static approach, which they particularly recognize as the culprit behind the lack of place for the entrepreneur in neoclassical theory (Foss, 2000a). The distinctive features of the Austrian approach are an emphasis on subjectivism, methodological individualism, and the dynamics of time (Lachmann, 1978), all of which are heavily interrelated. We discuss methodological individualism—the idea that macro patterns should have micro foundations—later in the depiction of our methodological approach. Here we summarize the role of subjectivism and a dynamic view of time in shaping the economic foundations of the entrepreneurial approach to strategy.

Subjectivism

Lachmann (1982, p. 39) has pointed out 'subjectivism has come to mean different things to thinkers of successive generations...the term has gradually acquired a wider and wider meaning'. Today, subjectivism is taken for granted as a staple of strategy theory (Foss, Klein, Kor, & Mahoney, 2008; Roberts & Eisenhardt, 2003; Yu, 2003) and is defined as taking account of 'the facts that individuals hold different preferences, knowledge, and expectations' (Foss et al., 2008, p. 74), but we have come a long way and traversed many steps to define it as such (Littlechild, 1983). Hayek (1952, p. 31) has famously remarked that 'it is probably no exaggeration to say that every important advance in economic theory during the last hundred years was a further step in the consistent application of subjectivism.' First we arrived at the subjectivist theory of value: the idea that value is in the eye of the beholder and that different people have different preferences. From Hayek, we have inherited the idea that different people have different knowledge, and from Shackle (1949, 1958, 1961, 1970, 1979a) and Lachmann (1986) who introduced Shackle's ideas to Austrian economists, subjectivism has been extended to imagination and expectations.

This latter line of thought is sometimes referred to as 'radical subjectivism'. Nobel Laureate James Buchanan has commented that 'no economist other than Shackle works exclusively within the domain of subjective economic theory... Any methodological advance must build on the work of Shackle.' (Buchanan, 1982, p. 18). The unique contribution of Shackle to subjectivism is the idea that minds don't only differ in preferences, knowledge and expectations, but that they actively create this difference. Through imagination, every person is a creator of something out of nothing (Shackle, 1979a). Lachmann (1982) referring to Shackle as 'the master subjectivist' noted that 'we may describe the evolution of subjectivism from Menger through Mises to Shackle as an evolution from a subjectivism of given wants through one of given ends to that of active minds' (Lachmann, 1982, p. 39). The activeness of the mind advanced by Shackle is a strong intellectual foundation for the agency of the entrepreneurial actor and her ability to create opportunity.

The equilibrium-based approach to strategy often alludes to the notion of information asymmetry as a source of market imperfection (Akerlof, 1970). This is one of the foci of the more recent RBV paradigm, and its economic inheritance from the Chicago school that distinguishes it from earlier IO-based theories (Barney, 1986; Foss, 1999). The information asymmetry concept assumes that opportunities exist objectively but different market participants have varying information about them. Building on the distinction between information and knowledge (Alavi & Leidner, 2001) a subjectivist perspective extends the asymmetry further to knowledge asymmetry, emphasizing that it is not only the access to information that differs, but also the understanding and processing of that information in the individual's mind. Given the same information, individuals may harvest different knowledge. Furthermore, humans are not just the takers and processors of information, they are also creators. They create new information through their choices and actions, because they have the capability to imagine, asymmetrically so. Therefore even with the same information, individuals will have different visions of possible futures, and thus different plans and expectations. Knowledge asymmetry and imagination asymmetry lead to expectation asymmetry; thus, subjectivism paints a picture of a much more imperfect market, with many new barriers to arriving at an equilibrium. In fact, an emphasis of the Austrian approach is that the market is never in equilibrium.

Dynamics of time

Perhaps the most distinctive characteristic of Austrian economics is a shift from analyzing the market in static states to a view of the market as a process (Jacobson, 1992). This emphasis follows naturally from a subjectivist view of time. In the Arrow-Debreu world (Debreu, 1959) at the center of neoclassical theory, time is spatialized (Shackle, 1958). It is treated as a mathematical dimension along which alternatives exist, and all agents have perfect knowledge of those alternatives all through the time dimension. But 'time as we seem to experience it has a character profoundly and radically different from that of a mere algebraic abstraction capable of being adequately represented by the symbol of a scalar quantity' (Shackle, 1958, p. 23). Time as experienced by us in reality, is a moment at a time, together producing a sense of flow through memory of the past and expectation of the future. Shackle (1976) refers to the experience of time as the perception of a ‘stream of transformations’. The passage of time by itself brings change. ‘Change, rather than mere uncertainty, is the *true* effect of time’ (O'Driscoll & Rizzo, 1985, p. 57). It is only in the Newtonian sense of time as a mathematical dimension that ‘time can elapse without anything happening’ (O'Driscoll & Rizzo, 1985, p. 54).

According to Rizzo (1996, p. xv), subjectivism in time ‘requires that consciousness of the present moment manifest within itself a dynamic tendency … In the static conception of time the present is a virtual stop—the very negation of passage or flow.’ The experience of time as a flow arises through ‘the contrast between the remembered past and the expected future. Without the novelty of the future (seen as “novel” only in contrast to the remembered past) there could be no sense of temporal passage. Thus, subjectivism in time or time consciousness entails novelty and its correlative, ignorance.’

Hence the economic actor is perpetually ignorant, and her knowledge is perpetually changing through time. The idea of perpetual change in knowledge (and with it information, imagination, expectations, plans of action, profits, etc.) renders the study of equilibrium properties less interesting than the study of change processes. In this way a subjectivist view of time leads to the notion of the market as a dynamic process of continuous change, and shifts the focus away from the structure of the market in a given state toward the processes and drivers of change. If economic activity takes time, and time brings change, then the market is itself a dynamic process playing out through time (von Mises, 1949). The market is viewed as continuously in disequilibrium, perhaps moving towards or away from equilibrium, but never actually in it. What is the driver of this movement? Here, Austrian Economics gives center stage to *entrepreneurial action* as the main driver of change in stark contrast with neoclassical economics and the neoclassical theory of the firm which has largely ignored entrepreneurship as a subject of study (Kilby, 1971; Mathews, 2006b). Baumol (1968, p. 66) famously remarked that ‘The theoretical firm is entrepreneurless—the Prince of Denmark has been expunged from the discussion of *Hamlet*.’

Entrepreneurial action

If economic actors are in constant ignorance (O'Driscoll & Rizzo, 1985), and perfect knowledge of the future is unknown and unknowable (Shackle, 1970, 1979a) it follows that the future can never be perfectly reflected in current prices in the market (Eckhardt & Shane, 2003). This means that potential opportunities for profit can never be assumed away. Entrepreneurial action can be defined as acting to create perceived opportunity or to exploit opportunity perceived to have been discovered. Both of these are judgmental activities because there is no objective guarantee that they will in fact lead to the envisioned profit. There is no demonstrably correct procedure to verify these judgments objectively *ex ante* (Loasby, 2007). Perceived opportunity, sometimes referred to as the ‘business idea’ (Shane, 2012) can only exist subjectively as (possibly mistaken) judgments about the future (Casson, 1982; Knight, 1921).

Opportunities do not have to be limited to monetary profits. They can be defined more broadly as the chance to move to a preferred state of being (von Mises, 1949). To achieve a preferred state of being is the main motivation of all choice and action (Shackle, 1979a). In this sense all human action can be seen as entrepreneurial (von Mises, 1949). The boundaries of what we refer to as entrepreneurial action are limited only by the boundaries of the type of opportunities we choose to focus on. It follows that entrepreneurial action is not only limited to start-ups and new ventures, but that the logic can be applied to strategy in general, defined as broadly as needed.

The distinction between creation of new opportunities and discovery of existing opportunities is derived from the various ways in which different schools of thought within Austrian Economics have conceptualized the role of entrepreneurial action in the market process (Alvarez & Barney, 2007). Entrepreneurial action has been recognized as the agentive force that both disrupts equilibrium (Schumpeter, 1934), and moves the economy towards equilibrium (Kirzner, 1997). Both of these are envisioned as disequilibrium processes of movement towards or away from equilibrium. Chapter 3 provides more detail on the differences among various schools of thought in describing these dynamics.

CONCEPTUALIZING DISEQUILIBRIUM RENTS

The tradition of basing strategy theory on economic foundations comes with the tradition of linking the notion of economic rent to competitive advantage or performance as the main dependent variable of interest. Thus, the agenda of the equilibrium-based approach to strategy theory has been to explain the relationship between market structure or competitive imperfections and economic rents. By analogy then, the agenda of an entrepreneurial approach to strategy theory would be to explain the relationship between entrepreneurial action and economic rents (hence the title of this dissertation). But it is not clear that economic rents in the equilibrium-based framework have the same meaning in a disequilibrium-based framework. For this reason many authors have used terms such as disequilibrium rents, Austrian rents or entrepreneurial rents to distinguish the latter. A theory of entrepreneurial rents can be defined as a description of the economic mechanisms by which entrepreneurial action as the main independent variable is linked to performance as the main dependent variable.

Since the concepts of rent and entrepreneurial rent have been the source of much confusion and disagreement in the literature, in this section we explore in more depth the origins and meaning of the rent concept, and whether or not there is any distinctive character to the notion of entrepreneurial rents compared to equilibrium rents. Amit, Glosten, and Muller, (1993, p. 826) have noted many unanswered question about entrepreneurial rents: 'Are there abnormal returns to entrepreneurs? Are the rewards of the successful entrepreneur distinct from what we commonly refer to as 'monopoly rents'? Why and how are such rents created? While there are a range of prevailing economic rent concepts, there is no clear agreement about what constitutes entrepreneurial rents and how to measure them.' Our aim is to explore these questions, keeping in mind that entrepreneurial rents accrue to entrepreneurial action in general and thus 'entrepreneurs' in a very broad sense of the word, akin to the use of this word by (von Mises, 1949), and not just new business founders.

The concept of rent

For economists, the waste minimizing and allocative efficiency properties of perfectly competitive equilibrium make it a highly desirable outcome for society. Thus when firms actively pursue the manipulation of the market to create imperfections to their advantage, this phenomenon is often referred to as 'rent-seeking' in which the word 'rent' has a negative connotation (Krueger, 1974; Tullock, 1967). The notion of rent in this context has its historical origins in David Ricardo's (1817) discussion of lobbying efforts by landlords to push the British government to enforce restrictions on the importation of corn so as to increase the price of local land. The concept of rent-seeking has to a large extent retained its negative connotation in modern usage. For example, Baumol (1990) refers to rent-seeking as 'destructive' entrepreneurship.

Because equilibrium-based strategy theories have turned the logic of welfare maximization upside down, for the most part in the modern strategy and entrepreneurship literature the concept of rent has gained a widespread usage with a positive rather than negative connotation. Rent generation and appropriation is considered the main objective of economic agents (Alvarez & Barney, 2004).

Within strategic management, rents usually refer to above-normal returns in imperfectly competitive equilibrium, where ‘normal’ refers either to the zero profits of perfectly competitive equilibrium, or the positive but lower profits of competing firms in the imperfectly competitive equilibrium that are benefiting less from the market’s imperfections. Thus, strategic management theories commonly study imperfect competition, but retain the equilibrium assumption (Bromiley & Papenhausen, 2003; D'Aveni et al., 2010). Since equilibrium is considered a stable state (Samuels, 1997), rents in equilibrium are considered more desirable than any profits that may be made in disequilibrium. Because they are more sustainable compared to disequilibrium profits that are considered to be temporary (Peteraf & Barney, 2003). Hence we have the emphasis on the sustainability of competitive advantage in theories of strategy.

As noted earlier, the two main theories that take this approach are the IO-based positioning theory and the RBV. The IO-based theory focuses on imperfections in the product market, while the RBV is focused on imperfections in the factor market (Amit & Schoemaker, 1993; Barney, 1986; Mathews, 2006b). IO-based theory is normally associated with the concept of *monopoly rents*, which refers to supernormal profits due to the structure of industry and the firm’s particular position in it, such as the firm’s market power and barriers to entry for competitors (Porter, 1980). These forces enable the firm to set higher than normal prices. Resource-based theory is founded on the notion of *Ricardian rents*, which looks inside the firm for specific factors that are scarce and inelastic in supply (Barney & Clark, 2007). These factors are considered to give the firm an efficiency advantage, allowing it to produce at below normal costs or at higher quality for the same cost. Since valuable resources are usually not ‘perfectly’ scarce, inimitable and non-substitutable, strategy theorists often refer to Alfred Marshall’s concept of *quasi-rents* (Marshall, 1961). Marshall acknowledged that resources other than land may also accrue supernormal returns, but since they are usually not as perfectly inelastic in supply as land, the rent is likely to dissipate eventually over time, thus it is quasi-rent and not true rent (Dooley, 1991). The convention in modern strategy research is to use the terms rent and quasi-rent interchangeably.

Entrepreneurial rent

One possible view of entrepreneurial rent is to consider it a form of monopoly rents, because they arise from innovations. Since innovations are by definition new, the innovator holds a monopoly over them (Rumelt, 1987). If the innovator has sufficient property rights protection and/or the innovation is inimitable and non-substitutable enough (i.e., isolating mechanisms are strong enough), these monopoly rents or quasi-rents will be relatively sustainable (Makowski & Ostroy, 2001). Others have attempted to look at entrepreneurship as a unique resource or factor to which Ricardian rents accrue (Alvarez & Busenitz, 2001), although the attempt to fit entrepreneurship into the neoclassical model as a factor of production has not been well received (Mathews, 2006b). The point here is that if one espouses these viewpoints, then it is indeed possible—even imperative—to think of entrepreneurial rent as nothing distinct from monopoly or Ricardian rent.

But if the underlying economic framework is taken to be Austrian Economics, then the study of returns to entrepreneurial action moves beyond the assumptions of imperfectly competitive equilibrium, and brings disequilibrium to the forefront. In this approach entrepreneurial rents would be conceptualized as a third type of rents different from Ricardian rents and monopoly rents. Ricardian and monopoly rents are mathematically calculated by analyzing the structure of the single state of equilibrium in an imperfectly competitive market. Entrepreneurial rents surface not in that single state, but in the dynamic process of moving towards and away from that state by taking actions. These actions can further be separated into two categories that align with the ideas of Schumpeterian rents and Kirznerian rents. Generally speaking, one disequilibrates the market and one equilibrates[3]. The Schumpeterian rent mechanism is based on adding new value (in the form of previously non-existing, not-yet-exploited opportunity) and the Kirznerian rent mechanism is based on the process of discovering and exploiting existing opportunity (without creating any new value).

Returns to entrepreneurship: rent or profit?

Another source of confusion has been over the distinction between rent and profit. Miles, Paul, and Wilhite (2003, p. 394) insist that ‘Returns to corporate entrepreneurial activities have often been incorrectly categorized as profit. Returns that arise from the existence, discovery, and successful commercial exploitation of entrepreneurial opportunities are not profit but rent. Profit is a return to capital while rent is a return in excess of the opportunity costs of all resources used, including capital.’ Other authors however, do not limit the concept of profit to returns on capital.

[3] Chapter 3 reveals nuances to these commonly taken-for-granted assumptions about opportunity creation and discovery.

The distinction by Miles et al. (2003) follows Marshall (1961) who attempted to defend the classical distinction between land, labour, and capital as categories of factors of production. Today, this distinction is considered unnecessary and even problematic (Dooley, 1991; Fetter, 1901) and most models since the neoclassical revolution have abandoned it.

Mathews (2006b) for example, proposes the exact opposite. He distinguishes between returns to entrepreneurship, which are disequilibrium profits, and rents, which are returns in equilibrium. 'Rents have no meaning apart from the concept of equilibrium ... They can only be understood as earnings that accrue to a factor where restrictions apply (in short supply, for example) *at equilibrium*. Away from equilibrium, nothing can be said about rents.' (Mathews, 2006b, p. 61) Mathews looks to Knight (1921) for clarification. According to Knightian theory, the nature of entrepreneurial profit is dynamic and intertemporal, and cannot be attributed to any single factor: 'Knightian profits are earned as the residual after all returns to factors (resources) have been accounted for—that is, present and future contingent liabilities. Such a residual is calculated in relation not to any particular factor—such as a rent, at partial equilibrium--but to the bundle of factors taken as a whole.' (Mathews, 2006b, p. 65). Thus Mathews advocates the use of the term 'profit' instead of 'rent' to discuss the returns to entrepreneurship.

Richard Rumelt (1987) however, has no trouble using both the terms profit and rent, with the difference being simply that 'Rents, unlike *profits,* persist in static equilibrium' (Rumelt, 1987, p. 16). This implies that there are two categories of returns to entrepreneurship, with one being more 'sustainable' than the other. This raises an interesting challenge to Mathews: even if entrepreneurship is a disequilibrium phenomenon, why can't the returns to a particular entrepreneurial action persist due to isolating mechanisms and competitive imperfections? But this presents a challenge to Rumelt as well: by what measure would we distinguish temporary profits vs. sustainable rents? Can disequilibrium and equilibrium returns be distinguished at all?

The continuum of temporary to sustainable rent

We posit that returns to entrepreneurial action should not be viewed in terms of a binary distinction between temporary vs. sustainable, but as a continuum with degrees of temporariness or sustainability. The idea that equilibrium and disequilibrium rents should be distinguished based on the binary logic that the former is stable/sustainable while the latter is temporary—as for example argued by Peteraf and Barney (2003)—loses much of its validity when the underlying economic framework is dynamic. The temporariness or sustainability of profits and rents is conceptualized on the same continuum, determined jointly by actions and the structure of competition.

The non-duality of disequilibrium and equilibrium profits has two implications for our study: first, the distinction made by Rumelt between the words rent and profit is no longer relevant and they can be consolidated into a simpler notion. Fetter (1901) points out that at least since Marshall, one of the ways in which the word rent has been used is simply to denote any surplus value. We follow this line of thinking and simply consider both rent and profit as equivalent to surplus value, while recognizing that no surplus value is ever gained without the passing of time and without uncertainty. Lewin and Phelan (1999) also take the position that rent and profit are one and the same thing: 'rent that follows from a discovered discrepancy between revenue and cost ... *is equal to what we normally understand as "profit."*' This is in fact consistent with much of the modern usage of the words in the strategy and entrepreneurship literatures.

Second, since these rents are determined jointly by action and structure, the only way to distinguish between disequilibrium rents and equilibrium rents would be if the source of those returns could be attributed solely to the entrepreneurial action itself, or solely the isolating mechanisms and competitive frictions in the market. In reality, such a distinction is hard if not impossible, because the two are heavily inter-related. Action creates market imperfection and market imperfection enables or constrains further action. Thus research using empirical data will be limited in what it can reveal specifically about entrepreneurial rent as distinct from non-entrepreneurial rent. However, if artificial worlds can be created in which both the actions of economic actors and the structure of competition could be manipulated in controlled experiments, we may be able to gain fruitful insights that would be otherwise unattainable. This is the approach taken in chapters 2 and 3 as described next.

CHAPTERS 2 & 3: A FORMAL APPROACH TO THE MARKET PROCESS AND ENTREPRENEURIAL RENTS

In chapters 2 and 3 of this dissertation, we use a cooperative game theory (CGT) framework to simulate the market process as described by Austrian economics. In this section we provide background for these chapters by briefly reviewing the history of game theory and particularly CGT in strategy and entrepreneurship research, and elaborating on the ways in which characteristics of the Austrian market process can be modeled in a CGT framework. Appendix A provides the basic math behind the CGT framework and its applications to strategy and entrepreneurship. Appendix B addresses the common misconception that CGT does not apply to competitive analysis.

Cooperative game theory in strategy and entrepreneurship

Game theory has always had a close relationship with strategy. In fact, game theory has dominated the efforts to formalize the structure-conduct-performance paradigm and oligopoly theory in industrial organization economics (Fisher, 1989). In turn, these frameworks have been the basis for one of the main dominant paradigms in strategic management (Conner, 1991). Shapiro (1989, p. 126) referred to game-theoretic work in industrial organization as 'the theory of business strategy' and 'the only coherent way of logically analyzing strategic behavior.' However, for many years most of the works published within the field of strategic management itself have at best taken inspiration from the game theory toolbox, and has mostly left the task of directly engaging with the modeling work to the economists. The barrier to such engagement was not only that learning the mathematical jargon and toolbox would require extensive investment for those not trained in mathematical economics, but also that the returns to such investment did not seem promising: many strategy scholars have been skeptical of the merits of trying to capture complex real world strategic problems within a straightjacket of simplifying assumptions required to render them analyzable with formal tools.

The field is evolving however, and the modern position of game theory in strategic management is beginning to change: first, there is an increased openness to new methods and particularly a renewed interest in formal modeling as evidenced, for example in the recent call for such methods in the Academy of Management Review (Adner et al., 2009). Second, an increasing number of economists and other specialists with relevant training have entered the field. Through their publications—many of which are referenced in this dissertation—these researchers have increasingly persuaded management academia of the practical relevance of game theoretical models, while simultaneously raising the bar in terms of the mathematical sophistication tolerated in management journals. Third, a wave of work applying game theory to strategy has focused on cooperative game theory in particular, which is more flexible and less complex, and thus easier and more intuitive to understand. Finally, the available tools such as computer simulations allow us to impose less restrictive assumptions on formal models rendering the math simpler and also allowing us to better incorporate the dynamics of change over time.

The modern application of cooperative game theory to strategy seems to have begun with Brandenburger and Stuart (1996), elaborated on in Brandenburger and Nalebuf (1995, 1996). Although this work was mostly at a conceptual level, some of the math underlying the conceptual insights can be found for example in Stuart (2001). But the main impetus behind the recent wave of CGT applications in strategy can be traced to the recommendation by Lippman and Rumelt (2003a) who illustrated some basic ways in which the CGT toolbox can serve as a framework for strategic analysis. In particular, they emphasized its capability to help develop micro-foundations for the resource-based view, which unlike IO-based theory is not normally linked to game theoretical foundations.

MacDonald & Ryall (2004) gave this line of work a substantial boost by explicitly operationalizing the central business strategy concept of ‘competitive advantage’ in the context of cooperative game theory. They accomplished this using the notion of equilibrium in CGT known as the core of a cooperative game. Appendix A summarizes their approach in more detail. The strong link established between strategic management and cooperative games has led to further strategy research utilizing more and more advanced cooperative game theory models (Adegbesan, 2009; Adner & Zemsky, 2006; De Fontenay & Gans, 2008; Hecker & Kretschmer, 2010). Brandenburger & Stuart’s (2007) ‘Biform Game’ model in which a first phase modeled as a non-cooperative game sets the stage for a second phase modeled as a cooperative game has also been well received in the strategy literature (Chatain, 2010; Chatain & Zemsky, 2007; Ryall & Sorenson, 2007; Stuart, 2007).

Given the important role of Lippman and Rumelt (2003a) in sparking this wave of research, it is constructive to take a closer look at the main inspiration behind their paper, which is to be found in Makowski and Ostroy (2001). In their paper, Makowski and Ostroy revisit Walrasian equilibrium theory in an attempt to provide a framework that could extend this theory to include what they call the ‘creativity of the market’. Their idea of what exactly ‘the creativity of the market’ entails is particularly interesting to strategy theorists, since it encompasses both opportunistic behavior and entrepreneurial behavior. In fact Makowski and Ostroy (2001) make explicit references to Transaction Cost Economics (TCE) and Austrian Economics, both of which are the basis of important streams of research in strategy that are *not* based on neoclassical equilibrium theory and are critical of it. Thus Makowski and Ostroy (2001) essentially herald the prospect of arriving at an overarching formal framework of analysis, that can incorporate both equilibrium-based theories (such as the RBV and IO-based theories), and newer theories such as TCE, dynamic capabilities, and entrepreneurship all at the same time. This has certainly never been achieved before and would constitute a major advance in strategy theory. In their exposition of how such a framework may be arrived at, Makowski and Ostroy (2001) present their arguments using elements of the CGT toolbox, and this is what inspired Lippman and Rumelt (2003a) to recommend this toolbox to strategy researchers.

Interestingly, given that one of the main intentions of Makowski and Ostroy (2001) was to enable the formal analysis of entrepreneurship, the wave of CGT research in strategy initially inspired by their paper has had little or no spillover to entrepreneurship research. To be sure, a major cause for this lack of adoption of CGT among entrepreneurship researchers is that traditional CGT has a relatively objectivist and static equilibrium-based approach, seemingly running counter to the subjectivism and dynamism principles of Austrian economics. Nevertheless, even before Makowski and Ostroy, other researchers had suggested that CGT can fruitfully be used to model the entrepreneurial market process (Foss, 2000a; Reid, 1993). More specifically, Foss pointed to the early work of Stephen Littlechild (Littlechild, 1979a, 1979b; Littlechild & Owen, 1980) who made initial inroads into modeling both subjectivism and the dynamics of the market process using a CGT framework, but whose work has remained largely under-appreciated since. Appendix A provides a summary of one of Littlechild's models.

A cooperative game simulation approach to Austrian economics

In this section, we take a look at the traditional CGT framework and discuss how it is adapted in chapters 2 and 3 as a structure for computer simulations of the market process, as described by Austrian theory. Specifically, we explore how the CGT simulation approach incorporates the three main principles of Austrian economics: subjectivism, dynamism, and methodological individualism.

The starting point is the traditional mathematical CGT framework that is static and objective. It utilizes a tool known as the characteristic function to model the value structure of an economy. The characteristic function simply assigns a value to every possible coalition of players. Given this function, the traditional approach is to calculate the outcome of the game also known as the solution concept. The most common solution concept is known as the core of the game, and is analogous to neoclassical equilibrium under reasonable assumptions (See Appendix A and Appendix B). In this framework, subjectivism is discarded because the characteristic function is considered to exist objectively, and all players are assumed to have perfect information of it and perceive it in exactly the same way. There is no place left for any player to learn anything new about the characteristic function (i.e., discovery), and there is no place left for any player to actively change the characteristic function (i.e., creation). Given that they have perfect non-changing knowledge, the optimal actions to take are trivial and considered to happen automatically, thus rendering dynamism also discarded. Within this framework, competitive imperfections and imperfectly competitive equilibrium can be analyzed easily, and thus the logic of equilibrium-based theories such as the RBV and IO-based models can be demonstrated. But entrepreneurial action in the form of creation and discovery are glossed over, or intentionally abstracted away from, in order to simplify the analysis and highlight the role of structural conditions. In order to allow for discovery and creation, the process of playing the game should not be trivial, and the characteristic function of the game should be malleable and expandable to reflect new possibilities created by the imagination and actions of innovative actors.

Some authors have used the concept of transfers to model the dynamism within one play of a transferable utility characteristic function game (Billera, 1972; Kalai, Maschler, & Owen, 1975; Stearns, 1968). These authors consider the negotiation process by looking at the sequences of demands made by players to each other when they start from a given profit vector, and the transfers of utility in response to these demands. This research has mostly been in pursuit of the conditions in which the transfer sequences would lead to profit vectors within particular solution concepts. Littlechild (1979a) points out that these models assume that all players have complete knowledge of the characteristic functions; thus, there is no room for the players to discover it as they go along. A more recent literature on coalition formation games (Arnold & Schwalbe, 2002; Hart & Kurz, 1983; Konishi & Ray, 2003; Ray & Vohra, 1999) better models discovery of opportunities by players in the game, and the process of moving towards equilibrium within a given characteristic function. Nevertheless these models are still restricted by the confines of closed-form analytic solutions. A line of work uses computer simulations to move beyond such confines (Chavez, 2004; Chavez & Kimbrough, 2004; Dworman, 1994; Dworman, Kimbrough, & Laing, 1995; Klusch &

Gerber, 2002). These authors use computer simulations to test various algorithms agents may use as strategies in characteristic function games. The results of these simulations reveal which strategies arrive at solutions faster and with higher payoffs, and when these payoffs approach the predictions of game theory's closed-form solution concepts. Some even use evolutionary algorithms run over many repetitions of the same game to allow for strategies to evolve themselves over time. The results may produce clever strategies that would have been impossible for humans to design, as it would be beyond our cognitive capacity.

Thus computer simulation provides the clue to the way in which unpredictable futures can begin to be analyzed. It is very hard to construct a closed-form mathematical model in which possible futures can be extended indefinitely. Wiseman (1983, p. 17) noted that a major barrier to the formal analysis of the uncertainty and dynamics of the market process is that 'we do not have the mathematical techniques to deal with a non-finite set of future outcomes,' but also called for mathematicians to attempt such models. This is especially necessary for modeling the imaginative and creative actors who can shape the future with their actions. Bonabeau (2002, p. 7284) argues that 'game theory is a great framework, but game theorists suffer from self-imposed constraints: being able to prove theorems puts severe limitations to what is possible.' While some analytical models such as dynamic cooperative games have begun to analyze changes in the characteristic function itself (Filar & Petrosjan, 2000), only computer simulations can incorporate changes endogenously created by the players over time, changes that could result in patterns not pre-determined and unpredictable by the modeler. Simulation allows us to study dynamic market processes that can be mathematically intractable. This is why scholars like Axelrod (1997) argue that simulation approaches to game-theoretical models are gainful. Thus chapters 2 and 3 take a computer simulation approach to CGT that incorporates elements of subjectivism and dynamism to model the Austrian market process.

The CGT simulation approach is also largely in line with the methodological individualism of Austrian economics. Methodological individualism refers to the idea that 'societies and social phenomena are to be explained in terms of the actions of their members' (Littlechild, 1983, p. 46) or in other words, that macro patterns should have micro foundations (Abell, Felin, & Foss, 2008). Game theory has always been consistent with this approach, and has since its inception incorporated the individual-level in its models and analysis (von Neumann & Morgenstern, 1944).

Computer simulation is also consistent with this approach, and simulation researchers have always lauded the benefits of simulation in deriving emergent system-level patterns from the aggregation of individual-level behavior (Levinthal & Posen, 2007; Nell, 2010) hence the title of Thomas Schelling's (1978) classic 'Micromotives and Macrobehavior,' considered a pioneer of modern agent-based computational economics.

A further benefit of a simulation approach to game theory is that it overcomes the traditional problem of analytical models in game theory: that often the solution of the model reveals that a very large number of possible outcomes are equilibrium outcomes, and sometimes the solution of the model reveals that equilibrium is not possible at all. For example, the core of a cooperative game often gives us a range of equilibrium values, sometimes very broad, but leaves the exact value indeterminate. Such indeterminacy has frustrated many economists searching for unique equilibria (Grüne-Yanoff, 2011), to the extent that Fisher (1989, p. 116) has referred to it as an 'embarrassment of riches'. This problem is overcome in simulations because in a simulation, as in reality, an outcome is observed for every time point of the simulation, and predictions of the outcome can be generated using averages over thousands of runs to arrive at more narrow predictions than the analytical solutions would allow. Unlike the closed-form models, a simulation will allow us to observe the outcome, even if it is a disequilibrium outcome.

CHAPTER 4: ENTREPRENEURIAL ACTION AND RENTS IN THE REAL WORLD

In justifying the formal approach of chapters 2 and 3, we pointed to the difficulty of clearly distinguishing between entrepreneurial and non-entrepreneurial rents in the real world. On the other hand however, formal abstractions also obscure important aspects of entrepreneurial action and rents as they are materialized in the real world. Chapter 4 of this dissertation takes an empirical approach to emphasize some of these aspects. Importantly, chapter 4 highlights the ways in which both the independent variable (entrepreneurial action) and dependent variable (entrepreneurial rents) of interest in the entrepreneurial approach to strategy may be studied with empirical measures, and how this often introduces new complications compared to the abstractions of formal models.

Exploration and exploitation as entrepreneurial action

While in economic models from the researcher's objective bird's-eye viewpoint it may be possible to define an opportunity formally, in empirical research the difficulties in conceptualizing

(Davidsson, 2012) and operationalizing the notion of opportunity (Dimov, 2011) are paramount. Thus entrepreneurial action in the form of opportunity creation and exploitation of discovered opportunities needs to be translated into empirically measurable constructs. A natural place to look for a starting point is among existing theories in strategy and organization with the following search criteria: a) the theory should be based not on structure or resources (not equilibrium-based), but on actions and dynamics; b) the theory should conceptualize its focal actions of concern in a way that encompasses the creation of new value, and the discovery and exploitation of existing value; and c) the theory should have an established empirical research stream with established empirical measures of its main action constructs.

We argue that these criteria are best met with the exploration-exploitation and organizational ambidexterity line of research (Lavie, Stettner, & Tushman, 2010; March, 1991; O'Reilly & Tushman, 2013; Raisch & Birkinshaw, 2008). Starting with the seminal work of March (1991), a variety of work has been done on finding the right balance or combination of exploration and exploitation (Gupta, Smith, & Shalley, 2006a; He & Wong, 2004; Raisch & Birkinshaw, 2008). These categories correspond in many ways to our categories of creation and discovery. Both are indeed concerned with the distinction between the pursuing new possibilities, and exploiting the existing possibilities.

Conceptually, it can be argued that the link between creation-discovery and exploration-exploitation suffers from a level of analysis issue: ambidexterity research is mostly concerned with the organization level of analysis, while creation and discovery refer to market-level phenomena. Accordingly, discovery activities involving discovery of *existing* market-level value (such as penetrating a market in which there is clear demand for a firm’s product) may translate to *new* activity (exploration rather than exploitation) at the organization level if the firm does not currently have a presence in that market. Furthermore, exploration normally refers to the initiation of new projects or exploring new technologies at the organizational level, which may in fact be focused on nothing new at the market level. In other words, if we espouse this view, exploration is about what is new-to-the-firm while creation is about what is new-to-the-market.

However, the viewpoint espoused here is that the level-of-analysis problem itself derives from the objective bird’s eye view alluded to earlier. In empirical research, it is extremely difficult if not impossible to objectively know what is new to the market and what is not, but it is much easier to know what is new to the firm and what is not. In other words, when it gets down to empirical measurement, exploration-exploitation is possibly the best operationalization of creation-discovery available. Under this viewpoint, there is room for a closer and more integrated relationship between exploration-exploitation research, and not just entrepreneurship research but all action-based theories in strategy classified together in this dissertation under the moniker of an entrepreneurial approach to strategy.

Survival, profit and acquisition as entrepreneurial rent

Translating the dependent variable of entrepreneurial rent to empirically measurable constructs also reveals new insights. In the underlying models (both in the neoclassical and traditional models, as well as the CGT simulations used in chapters 2 and 3) economic rent is conceptualized as a one-dimensional measure of an abstraction we call 'value'. Although the subjectivist theory of value in economics recognizes that different people may value things differently, it does not recognize that they may value things multi-dimensionally. Similarly, the multi-dimensionality of performance is abstracted away in chapters 2 and 3.

In chapter 4, we focus on a context in which the multi-dimensionality of performance is emphasized and is highly consequential for strategy. This is the context of start-ups in which the objectives of surviving, profiting, and getting acquired (i.e., cashing out) are often pursued simultaneously by entrepreneurs. While our data does not allow us to measure exactly which objectives any given start-up in our sample has pursued, we nevertheless demonstrate that the resource allocation among exploration and exploitation matters for the performance outcomes, and matters differently for each performance dimension.

A SMALL STEP

This dissertation is not the first attempt to study an entrepreneurial or action-based approach to strategy. It is not the first to seek economic foundations for strategy in Austrian economics, and it is not the first to utilize formal approaches or computer simulations in the study of strategy. It is also not the first to suggest a link between the notions of creation and discovery and exploration-exploitation. Nor can we claim in any way that our particular take on the entrepreneurial approach, Austrian economics, formal modeling, simulation, and empirical analysis is better than others. But we do take a small step in this dissertation by introducing analyses that are novel in the field of strategic management, and contribute something to strategy theory and research that both builds on the works of others, and opens new possible directions for research.

To the author's knowledge, chapters 2 and 3 constitute the first attempts to use cooperative game simulations to reproduce the dynamics of the market process as envisioned by Austrian economics, and to use this framework to gain new insights on the relationship between entrepreneurial action and rents. Chapter 4 makes a novel contribution in introducing the importance of the multi-dimensionality of performance in the context of the exploration-exploitation strategies of start-ups. We emphasize again that each of the three chapters following this introduction is a stand-alone paper with its own introduction and conclusion, but the concluding remarks in chapter 5 review some of the main insights and contributions of the dissertation as a whole. Chapter 5 also provides suggestions for future research. We hope that this introduction has succeeded in illustrating the common thread that runs through all the chapters, i.e., the relationship between entrepreneurial action and rents that is the core of an entrepreneurial approach to strategy, and invites a renewed attention to human agency in creating and pursuing opportunities. The small step taken here can be—and hopefully will be—one of many.

CHAPTER 2: TOWARD A THEORY OF ENTREPRENEURIAL RENTS

INTRODUCTION

Traditional theories of competitive strategy attempt to locate 'supernormal profit' or 'rent' by examining the structural conditions leading to the existence of product and/or factor market imperfections that create deviations from perfectly competitive equilibrium (Barney, 1986; Mahoney, 2001; Yao, 1988). Two categories of rents due to competitive imperfections, known as monopoly rents and Ricardian rents, have been central to strategy theory (Mathews, 2006b). The former emphasizes favorable *position* as the source of advantage (Porter, 1980) whereas the latter emphasizes *possession* of favorable resources (Barney, 1991). Researchers have noted shortcomings of this structural approach, such as the undervalued role of agency and reliance on equilibrium assumptions (Bromiley & Papenhausen, 2003; Priem & Butler, 2001).

However, more recent thinking in strategy theory has emphasized disequilibrium rather than equilibrium and the primacy of entrepreneurial *action* over *possession* or *position* (Klein, 2008; Sirmon et al., 2011; Teece, 2007). The economic rents attributable to action are commonly referred to as *entrepreneurial rents* (Rumelt, 1987), but our understanding of them is limited. We do not yet know why and how they are created and how—if at all—they can be distinguished from other forms of rent (Amit et al., 1993).

This chapter takes initial steps towards answering these questions. Our goal is to isolate the economic rent mechanisms generating returns to actions of Schumpeterian creation and Kirznerian discovery. The significance of a theory of rents stems from the fact that the imputation of value to its sources is a fundamental concern in strategic management research (Lippman & Rumelt, 2003b; Winter, 1987). Accordingly, we define a theory of entrepreneurial rents as a description of the economic mechanisms by which entrepreneurial action as the main independent variable is linked to performance as the main dependent variable. Such a theory has important implications for strategic decisions regarding resource allocation and the boundaries of the firm (Alvarez, 2007; Noda & Bower, 1996).

Since existing theories of rents are based on underlying formal models, our approach in this chapter is to use formal modeling as a theory building tool. We build on existing strategy research using the toolbox of games in characteristic function form (Adegbesan, 2009; Brandenburger & Stuart, 1996, 2007; Chatain & Zemsky, 2007; Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004) and extend this approach by adding a dynamic aspect to characteristic function games with computer simulations in a way that explicitly builds on Austrian economics as a foundation. We define Schumpeterian creation as the creation of new opportunities (creation of new potential) and Kirznerian discovery as the discovery and exploitation of existing opportunities (realization of existing potential). We start with some basic (but not very restrictive) assumptions about an economy composed of players with varying levels of the capability to perform these actions. Simulation of the market process over time is then observed to produce several basic effects and interactions. Among other results, we find that the value of internal capabilities depends on the structure of competition and the capabilities of other players.

While we model Schumpeterian creation and Kirznerian discovery actions formally, the formalization can be considered an abstraction of real-world activities that firms do and allocate resources to (Darroch, Miles, & Paul, 2005). For example, activities such as research and product development align well with creation of new previously nonexistent opportunities, whereas activities such as sales and market penetration are closer to the idea of discovering and exploiting existing opportunities. In this light, decisions regarding the allocation of resources to creation and discovery represent real strategic decisions firms face. These are decisions that are especially critical in the context of resource-constrained start-ups. Examples include: Is it better to hire a sales team or partner with another firm that already has the sales capabilities? Should an inventor attempt to commercialize an innovation alone or license it out?

BACKGROUND AND PREVIOUS RESEARCH

The concept of rent has been the source of much confusion in the literature. At the heart of neoclassical economics—the dominant paradigm in this field—lies the Walrasian model of perfectly competitive equilibrium, with its assumptions of perfect information, free entry, and price-taking agents (Makowski & Ostroy, 2001). Notably, perfect competition under these assumptions means that no one makes a profit. The model is based on a ‘state in which participants have no incentive to change their present actions, as they are satisfied with the current combination of prices and quantities that are bought or sold ... a pareto-optimal state in which no gains from trade exist’ (Eckhardt & Shane, 2003, pp. 334-335). If there was any profit to be made by selling something at a price above the cost of producing it, another competitor already knows that (due to the perfect information assumption) and has entered (due to the free entry assumption) and offered a lower price, thus undermining the opportunity. With this logic, in perfectly competitive equilibrium all profits are zero.

For theorists taking the perspective of the productive agents of the economy, zero profits are unacceptable. Particularly, for strategy scholars it means no competitive advantage and for entrepreneurship scholars it means no opportunities. For non-zero profits to be possible, competition must either be imperfect and/or the economy must be in disequilibrium. Equilibrium-based / structural strategy theories have focused on the former, whereas entrepreneurship scholars and proponents of action-based theories have mainly studied the latter condition. In either case, the non-zero profits are commonly referred to as *economic rents*. In the context of the resource-based view, economic rents resulting from the inelastic supply of valuable resources (imperfections in the factor market) are commonly referred to as *Ricardian rents*, whereas in the context of positioning-based theories economic rents resulting from market power (imperfections in the product market) are known as *monopoly rents* (Mathews, 2006b). The lack of a counterpart to these theories outside equilibrium impedes our understanding of *entrepreneurial rents*. In a sense, one can think of Ricardian, monopoly, and entrepreneurial rents as each being most relevant to input, output, and process elements of a firm, due to their emphasis on factor markets, product markets, and action respectively. This is also in line with the framework suggested by Hitt *et al.*, (2011) that puts firm resources in the input category and resource orchestration (action on resources as distinct from the resources themselves) in the process category.

What the literature seems to agree on about entrepreneurial rents is that they are intricately linked to action and disequilibrium, each pertinent to a shortcoming of the structural approach. First, by emphasizing equilibrium over disequilibrium and structure over action, the monopoly and Ricardian rents logic undervalues agency by trivializing decision making (Casson, 1982; Eckhardt & Shane, 2003; Priem & Butler, 2001). The argument is based on the assumption that if the competitive situation is structured in a certain way, economic agents will automatically act in a predictable way that ultimately brings about equilibrium (Barney, 2001). Thus human agency takes a back seat to structural inevitability as the driver of competitive advantage. It becomes difficult to provide meaningful recommendations for strategic action if the theory assumes such action to be automatic. This shortcoming is especially critical when attempting to strategize for situations where the firm does not start out with a clear structural advantage (Brush et al., 2001; Madhok & Keyhani, 2012; Miller, 2003). Second, the structural approach's reliance on equilibrium is increasingly seen as problematic because equilibrium is synonymous with stability (Samuels, 1997), and stability is not always—or even usually—characteristic of the context of strategizing, and competitive advantage is often temporary (Bromiley & Papenhausen, 2003; D'Aveni et al., 2010; Foss & Ishikawa, 2007).

Recent streams of work that attempt to address the dynamic aspects of strategy beyond equilibrium unanimously agree on the role of action as the main source of strategic advantage. These include the literatures on competitive dynamics (Chen, 1996; Chen & Miller, 2012), resource management (Sirmon et al., 2008; Sirmon et al., 2007), dynamic capabilities and asset orchestration (Helfat, 2007; Sirmon et al., 2011), and entrepreneurship (Alvarez & Barney, 2007; Klein, 2008; Shane & Venkataraman, 2000). All of these literatures notably refer to Austrian economics (Jacobson, 1992) as an intellectual foundation. At the heart of the market process described in Austrian theory lies the Schumpeterian disequilibration and Kirznerian equilibration mechanisms that are considered to be the 'central premises' of entrepreneurship research (Venkataraman, 1997, p. 121).

Previous research attempting to formally isolate 'entrepreneurial rent' from other forms of rent is scarce. Recent efforts in strategic management research such as Adner and Zemsky (2006), and Grahovac and Miller (2009) have taken important steps in modeling the returns to the value creation capabilities of firms, and they are close to our approach due to their use of value-added analysis and game theory. However, these papers pursue an equilibrium-based comparative statics approach that makes it difficult to attribute rent mechanisms to Schumpeterian disequilibration and Kirznerian equilibration dynamics as envisioned in the Austrian depictions of the market process. Also close to our study is the work of Ross and Westgren (2006) who utilized a system dynamics model and computer simulation to impute economic value to various entrepreneurial capabilities. In contrast to their paper, our framework is based on a simple game theoretical model already established in strategic management research for analyzing rents (Adegbesan, 2009; Brandenburger & Stuart, 2007; Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004) which facilitates cumulative theory development.

ANALYTICAL APPROACH

Formal modeling has many methodological advantages such as clarity, ease of comparability, transparency, logical power and consistency (Adner et al., 2009; Kreps, 1990) and is especially useful when the inevitable imprecision of natural languages has created confusion around a concept in the literature. For the purposes of studying the returns to entrepreneurship, we need a way of modeling an imperfectly competitive market process as it moves both in and out of equilibrium. This will allow us to conduct simulation experiments that keep initial structural advantages fixed, so that rents accrued to entrepreneurial action can be isolated from equilibrium rents. In this section we explore how Cooperative Game Theory (CGT) can provide us with the necessary tools to model structural rents in an economy, and how we may adapt it to model entrepreneurial rents as well. An illustrative example in three scenarios provides the intuition behind our operational model and simulation, and demonstrates how the modeling approach can be a valid representation of Schumpeterian and Kirznerian processes as depicted in the Austrian economics literature. We note that the term ‘cooperative’ in CGT does not mean non-competitive. It is just a label used to refer to a less constrained and more free-form method of modeling games (Brandenburger & Stuart, 1996). In fact, CGT has been fruitfully used to model the product market competition at the centre of general equilibrium theory (Shubik, 1959).

Scenario 1: structural rents in equilibrium

The concept of rent as supernormal profits in imperfectly competitive equilibrium can be captured with a simple model. Suppose a small biotech research firm—call it A—owns a technology that is projected to be worth $10 million to itself if it were to commercialize it on its own, but $20 million to a large generic drug maker (B) if full ownership of the technology were transferred to B. It is then to the benefit of both A and B that they come to terms on a deal for A to sell the technology to B for a price greater than $10 million but less than $20 million. Lower than 10 and the owner firm would be unwilling to sell, higher than 20 and the buyer firm would be unwilling to buy. Anywhere in between is a win-win situation. Suppose they agree on the price of $15 million. Now let B remain the only possible buyer, but suppose A’s technology was not patented and easily imitable, and thus A was facing perfect competition as a producer of this technology. Then other producers would enter into the game and provide the same technology for a lower price, and price competition among them would lower the price to an equilibrium point in which the market price of the technology will equal the cost of production for the most efficient producer, who will be the only one actually able to sell (at zero profit). Similarly perfect competition can be imagined among buyers, driving their rewards to zero as well.

Now suppose imperfect competition, such that A and B are the only players in the economy, and there are perfect barriers to entry. Then by agreeing on the price of $15 million, each is making a profit of $5 million. This can be considered an equilibrium price because there are no remaining competitive pressures on either side, everyone is happy and no one is better off by leaving the exchange. They each have a competitive advantage in this imperfectly competitive equilibrium, because there are no competitors, but the amount of value they are able to appropriate (somewhere between zero and $10 million) depends on their bargaining power in terms of negotiating the price. Often however, imperfections in the economy are such that a certain amount of competitive advantage is guaranteed irrespective of this kind of bargaining, due to the structure of competition. To see this, suppose that in addition to B, a third firm C also would like to purchase the technology and that the technology was worth $30 million to this firm. Now any equilibrium price must be higher than $20 million because any lower price would create a price bidding competition between B and C. If C offers anything above $20 million (and up to $30 million) however, B cannot compete and A could agree to an exchange with C. Thus unlike the previous situation in which A had a possible but not guaranteed rent of $0-$10 million, in the new situation A has a guaranteed equilibrium rent of $10 million with an additional $0-$10 million of possible but not guaranteed returns.

The above two situations involving A, B and C are actually simple examples of cooperative games. The value structure of the economy is modeled using a tool called the *characteristic function*, which simply assigns a value to every possible *coalition* (i.e., group) of players. The characteristic functions for the two games are depicted in Tables 1a and 1b in million dollar amounts. The game in Table 1b is a variation of the 'three-cornered market' in Shubik (1982, p. 151; adapted from von Neumann & Morgenstern, 1944). Given the characteristic functions, the range of imperfectly competitive equilibrium prices can be calculated. The profit distributions that fall in this range are referred to as the *core* of a cooperative game. A central result in cooperative game theory is that under reasonable assumptions the notion of the 'core' formulated by Gillies (1959) is equivalent to the 'equilibrium' of general equilibrium theory (Debreu & Scarf, 1963; Shubik, 1959). Lippman and Rumelt (2003a) recommend CGT as an integrative framework for strategy theory due to its ability to model the structure of competition. Notice that in the above illustration the guaranteed rent of $10 million for player A depends on no action on the part of this player. It is entirely the result of structural conditions. The next two scenarios illustrate how the dynamics of disequilibrium and entrepreneurial action can be added to this framework.

Table 1: The characteristic functions used in this chapter

Coalition	**A**	**B**	**C**	**AB**
Value	10	0	0	20

1a: The characteristic function of the 2-player biotech example

Coalition	**A**	**B**	**C**	**AB**	**AC**	**BC**	**ABC**
Value	12	0	0	22	32	0	32

1c: The 3-cornered market example after an incremental innovation

Coalition	**A**	**B**	**C**	**AB**	**AC**	**BC**	**ABC**
Value	10	0	0	20	30	0	30

1b: Characteristic function of the 3-cornered market example

Coalition	**A**	**B**	**C**	**AB**	**AC**	**BC**	**ABC**
Value	30	0	0	40	50	0	50

1d: The 3-cornered market example after a radical innovation

Coalition	**1**	**2**	**3**	**4**	**12**	**13**	**14**	**23**	**24**	**34**	**123**	**124**	**134**	**234**	**1234**
Value	0	0	0	0	10	10	10	10	10	10	20	20	20	20	30

1e: The default characteristic function used in the simulations

Coalition	**1**	**2**	**3**	**4**	**12**	**13**	**14**	**23**	**24**	**34**	**123**	**124**	**134**	**234**	**1234**
Value	0	0	0	0	10	10	10	10	10	10	20	20	20	20	**50**

1f: The default characteristic function modified to have a larger value for the grand coalition (i.e., size of the economy)

Scenario 2: the Kirznerian discovery mechanism

The view of the market as a process through time is the hallmark of the Austrian approach (O'Driscoll & Rizzo, 1985). In the neo-Austrian school of thought, based on the works of Kirzner (1973, 1997), the economy is seen as always existing in a state of disequilibrium. Profit opportunities exist, mostly due to asymmetric information. That is, prices do not contain complete information about all productive opportunities (Eckhardt & Shane, 2003), and agents have their own subjective perceptions of these opportunities. These opportunities are discovered by entrepreneurs and exploited, such that the gaps in the market are filled and the economy is moved towards equilibrium. This type of entrepreneurship—the discovery and exploitation of existing opportunities—is referred to as *discovery entrepreneurship* (discovery for short) in this chapter. The simplest case of discovery is that of 'arbitrage', where the entrepreneur discovers that he or she can buy low in one place, and sell high in another.

To see how discovery can be modeled in a characteristic function game, consider again Table 1b. We assumed above that all players have perfect knowledge of the characteristic function, but what if it were not so? Suppose that none of them even knew each other and were unaware of any trade opportunities. Now if player B finds player A and becomes aware of how much this firm is valuing its own technology ($10 million) and compares it with its own valuation ($20 million), they would discover a profit opportunity. If B is able to negotiate a price and purchase the technology, it has completed an act of Kirznerian discovery entrepreneurship.

Scenario 3: the Schumpeterian creation mechanism

Even when the economy is in equilibrium, entrepreneurship is possible. Unlike the Kirznerian view, in the Schumpeterian perspective (Schumpeter, 1934) equilibrium is not seen as a situation in which no more opportunities are possible. Entrepreneurs can actively pursue new combinations (new products, processes, organizational arrangements, etc.) that disrupt the existing equilibrium and create new opportunities. In this chapter, we refer to the creation of new opportunities as *creation entrepreneurship* (creation for short). This is the process by which advantage in the equilibrium sense is enhanced or created in the first place, even if the agent does not currently have it.

Suppose that in the game of Table 1b all three firms know of each other and have perfect knowledge of the characteristic function. Now suppose A is able to come up with an innovation that enhances the technology, thereby increasing its value by $2 million for any firm that owns it. Note that unlike the discovery process depicted above, this innovation actually changes that characteristic function (from Table 1b to Table 1c) and the new value is ultimately to the benefit of the innovator in the new equilibrium of the new characteristic function. Now the 'core' outcome is for C to pay anywhere between $22 million and $32 million to A. If they had previously negotiated a price of $21 million, this outcome now becomes unstable as the producer would no longer be satisfied with the deal. If the innovation had been more radical (say $20 million of added value instead of $2 million, as in Table 1d), then none of the previous 'core' outcomes would remain stable. This is why creation is considered to be disequilibrating.

A MODEL AND SIMULATION OF THE ENTREPRENEURIAL MARKET PROCESS

In observing real world markets, it is enormously difficult if not impossible to distinguish between equilibrium and disequilibrium, and thus to isolate entrepreneurial from non-entrepreneurial rents.

It is also difficult if not impossible to empirically distinguish equilibrating vs. disequilibrating processes. In this chapter however, we build on the CGT model to construct a formal analytic framework within which the necessary distinctions are definable. Then by holding all other variables that could result in ‘rent’ due to imperfectly competitive equilibrium constant (for example, initial resource endowments, initial market power, number of competitors, etc.), and experimentally manipulating only levels of entrepreneurial action, we are able to calculate returns to these actions. In other words, we are able to measure disequilibrium rents by holding initial equilibrium rents constant. Under these conditions any remaining rent differentials observed can be attributed to differences in levels of entrepreneurial action.

In recent years strategic management scholars have increasingly utilized CGT to model equilibrium-based competitive advantage in imperfectly competitive markets (Adegbesan, 2009; Brandenburger & Stuart, 2007; Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004). The CGT framework is especially powerful for its flexibility (due to less constraining assumptions than strategic form or extensive form games) and generality, i.e., ‘the possibility of yielding quite general conclusions, applicable to a variety of specific situations’ (Roth & Sotomayor, 1990, p. 11). But despite some early efforts (Littlechild, 1979a, 1979b) and some suggestions (Foss, 2000a; Reid, 1993), entrepreneurship research has not utilized the power of this modeling toolbox. Part of the reason for this dearth of antecedent may lie in the fact that the mathematical CGT literature has traditionally focused on static equilibrium (Foss, 2000a; Shubik, 1982). Thus it is not a trivial matter to adapt CGT to the study of a dynamic market process with entrepreneurial action taking place through time, moving between equilibrium and disequilibrium. Our model builds on the literature on coalition formation games (Arnold & Schwalbe, 2002; Hart & Kurz, 1983; Konishi & Ray, 2003) to model Kirznerian discovery and the process of moving towards equilibrium within a given characteristic function. We also take inspiration from dynamic cooperative game theory (Filar & Petrosjan, 2000) to model Schumpeterian creation using repeated games in which the characteristic function can change over time. Thus our framework adds both an inter-game dynamic and an intra-game dynamic to the traditional CGT model. Table A1 in the online supplement summarizes the modeling literatures we build on that are relevant to each of the rent mechanisms discussed.

Using computer simulation of cooperative games (Chavez & Kimbrough, 2004; Dworman, 1994; Klusch & Gerber, 2002), we capture the dynamics of the market by allowing agent interactions to play out over time. Simulation allows us to impose fewer assumptions and less information requirements on players and to incorporate a higher level of complexity and indeterminateness than purely analytical models would allow (Harrison, Lin, Carroll, & Carley, 2007). Imposing less structure on the model also makes it simpler and easier to understand. The granularity of the CGT model allows us to benefit from the strength of agent-based simulation in deriving system-level patterns that emerge from individual-level behavior (Nell, 2010).

Preliminaries and definitions

A standard cooperative game with transferable utility is used to structure our model of the market. A non-changing set $N = \{1,2, \dots, n\}$ of self-interested players constitutes the agents that interact in this market. Agents can form coalitions and each possible coalition (including the singleton coalitions) is given a value representing the maximum value that can be appropriated by all members of that coalition. Agents create value by increasing the value of these coalitions, and appropriate value by actually forming these coalitions and bargaining to divide the value between them. By *possible coalitions*, we are referring to the set of all non-empty subsets of N. At any point in time, the set of *actual coalitions* is the term we use to refer to the subset of possible coalitions that have actually formed. Formally, the full potential value of each possible coalition (the *value of a coalition*, for short) at any point in time is given by a *characteristic function* $v: \Omega \rightarrow \mathbb{R}_+$ where $\Omega = \{T_1, T_2, \dots, T_{2^n}\}$ denotes the set of all possible subsets of N and $v(\phi) = 0$, i.e., the value of the empty set is zero. We refer to the value of the grand coalition or $v(N)$, as the *size of the economy*. The set of actual coalitions at any point in time is given by a *coalition structure* $CS = \{S_1, S_2, \dots, S_m\}$ where $\bigcup_{k=1}^{m} S_k = N$ and $S_k \cap S_l = \phi,\ \forall k \neq l$, i.e., CS is a partition of N into non-empty subsets.

After a coalition structure is formed, the actual value appropriated by each player is determined through a *bargaining* process, and represented by a profit or *payoff distribution*. Formally, the *payoff distribution* at any point in time is a vector $x = (x_1, \dots, x_n) \in \mathbb{R}_+^n$. The sum of the payoffs of members of any given coalition S, denoted by $x(S) = \sum_{i \in S} x_i$, is referred to as the *payoff of coalition* S. If $x(S) = v(S)$, then we say that the payoff distribution x is *efficient for* S, because the members of S are appropriating the entire pie afforded to them by the characteristic function.

The bargaining process determines how each actual coalition's pie of value is divided between members. For simplicity, by default we assume equal bargaining power, meaning that such pies are distributed equally. For robustness tests on changing the equal bargaining power assumption in these fixed-pie negotiations, refer to the online supplement.

Note that this type of negotiation over a fixed pie is only one aspect of bargaining. To clarify, the term bargaining power in the intuitive sense can translate to two different aspects in our model of the market process: 1) Bargaining power from market structure. In the three-cornered market game of Table 1b described in scenario 1, firm A can play B and C against each other because there are two of them and no competitor for A. This is the bargaining power that guarantees a \$20 million minimum equilibrium price for A's technology. We do not assume this away or assume equality of it in our model. 2) Bargaining power from division of the pie beyond what is determined by market structure. In the same game, if A forms a coalition with C, the market structure (i.e., characteristic function) establishes only that A and C will agree on a price between \$20 and \$30 million and leaves indeterminate how the exact point is determined in this range. This bargaining *within* the range of values determined by the structure of competition is what we are referring to in our equal bargaining power assumption. Under this assumption A and C agree on \$25 million. For consistency, we reserve the term 'bargaining' in this chapter to refer to this aspect of bargaining that is independent of market structure.

The act of *discovery* is modeled as follows: Suppose a coalition structure is formed and all players are appropriating value according to the payoff distribution x (which may or may not be efficient for any actual coalition). If some members of currently formed coalitions realize that for some possible coalition T not currently formed we have $x(T) < v(T)$, then they may find it worthwhile to actually form T. In game theoretic terms this process is called the *blocking* of payoff distribution x by the *blocking coalition* T. The *excess* value that motivates the blocking can be measured by the difference between what these players could get if they form T and what they are currently getting, i.e., $v(T) - x(T)$. Excess is an objective measure of the size of the *profit opportunity*. In this chapter we model *discovery* as the blocking and subsequent bargaining and dividing of value between the members of the blocking coalition. We take one agent, whom we call the *discoverer*, as responsible for identifying the profit opportunity and rallying other members to form the blocking coalition and exploit it. Among the possible coalitions with excess to choose from, we assume the discoverer chooses based on the criteria of highest excess per capita. But we also assume that players are not perfect exploiters of the value they discover. We set the default exploitation efficiency to 0.7 (i.e., 70% of the objective value of the opportunity, which we call ‘discovered excess’, is divided among the blocking coalition’s members).

In this modeling approach we have built on the works of Littlechild (1979a, 1979b) and Reid (1993) who suggest that entrepreneurship can be modeled as the discovery and exploitation of excess in a characteristic function game. Since coalitions in cooperative games have traditionally been used to model economic transactions between buyers and sellers (Debreu & Scarf, 1963; Shubik, 1959) where the characteristic function depicts the potential gains from trade, discovering and exploiting excess through coalition formation in such games is representative of economic agents discovering and exploiting opportunities to profit by securing contracts in an economy.

If the coalition structure and payoff distribution are such that, for members of actual coalitions, there are no possible but not currently formed coalitions with excess, then the game is said to be in equilibrium, and the payoff distribution is said to be in the *core* of the characteristic function. Given a characteristic function, the range of payoff distributions that are in the core can be easily calculated. If the core is empty (some characteristic functions do not have any core values rendering equilibrium impossible) or the current payoff distribution is not in the core then the economy is in disequilibrium. The *distance from equilibrium* is measured here by the average amount of positive excess for all possible (formed and not formed) coalitions.

The act of *creation* is modeled as follows: The difference between the value of a coalition S and the value of that coalition if we were to take away a player i from it, i.e., $v(S) - v(S/\{i\})$ is defined as the *marginal contribution* of player i to coalition S. If player i increases his or her marginal contribution to one or more possible coalitions that include i, then we call i a *creator* and refer to this process as *creation* or innovation. In this modeling approach, we have built on Afuah (2009, p. 291) who suggests that innovation can be modeled as the act of increasing marginal contribution in a characteristic function. Since the characteristic function has traditionally been used in economic applications to model potential gains from trade or opportunities available to agents in an economy, increasing values in the characteristic function is representative of new opportunity creation. Note that our definition of creation assumes that no innovations are value-destroying. This could apply to contexts where entrepreneurial creation efforts are not zero-sum, i.e., when they are not trying to solve the same problem. For example, this definition would apply to a context of innovative biotech firms each searching for drugs to cure different diseases, and not to contexts where the innovating firms are all searching for the cure to the same disease.

For simplicity, we model an act of creation as increasing marginal contribution by adding value to *all* possible coalitions that include the creator. By default, such value increases are equal to one unit of value (this is the 'innovation magnitude' in Table A2 in the online supplement). In each time period, the market is fully specified by a triple (v, CS, x) i.e., the characteristic function, coalition structure, and payoff distribution. The outline and flowcharts of the simulation algorithm provided in the online supplement explain exactly how these three components change over time in our simulations of the market process.

Default conditions, simulation mechanics and main variables

The main results of this chapter are produced with some variables kept at default values. As we report throughout the chapter, robustness checks indicate that the simulation results are relatively robust to changes in these values. The defaults were chosen for visual simplification and ease of implementation. Table A2 in the online supplement provides a complete list of the main parameters and variables used, how they were operationalized in our model, the default values used and how these defaults were tested for robustness. The robustness tests were conducted for all experiments, but only elaborated on for cases where additional insight were gained or results altered in important ways.

At each time period, either nothing or at most one instance of each type of action (creation or discovery) can occur. Each time period can be interpreted as the period for which a coalition structure (and the associated payoff) remains a binding agreement (Konishi & Ray, 2003). At the end of each period, each player receives a payoff according to the payoff distribution at the end of that period. The main independent variables that we give as inputs to the model are the capabilities of each player in creation and discovery. Each of these capabilities is represented by a *probability of action* for each player, determining how likely a player is to initiate that type of action at any time period. Acts of creation change the characteristic function of the game and acts of discovery change the coalition structure and payoff distribution. With four players where each can have either creation, discovery, none or both capabilities, we have 35 possible combinations. Among these, we explore some combinations in more depth but since many produce similar patterns (see online supplement), we only report those that generate new insight.

Our main dependent variable is the performance of each player measured by their cumulative payoff over time. Unless stated otherwise, each run or trial of the simulation has a time horizon of 1000 time periods, and all data points reported in figures are averages calculated over 200 runs. The simulation code was written and executed in MATLAB 7.10.

ANALYSIS AND RESULTS

Returns to discovery and creation

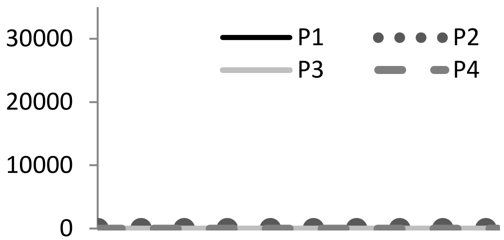
We start our analysis with the simplest case of just one active agent with only one entrepreneurial capability. If that capability is pure creation (Figure 1), there is no exploitation going on in the economy, thus leaving no one able to profit (Figures 1a and 1b). The size of the economy (i.e., the value of the grand coalition, $v(N)$) grows however (Figure 1c), reflecting the increasingly created value. Increasingly created but unexploited value continuously increases the level of disequilibrium in the economy (Figure 1d). A roughly corresponding hypothetical real-world example would be the case of an inventor who keeps on inventing new products but no one, including him or herself, has the initiative or capability to commercialize any of them, neither alone nor in partnership with others.

If on the other hand, the only active agent only has discovery capability (Figure 2), no new value is created and the size of the economy stays constant (Figure 2c). The players all appropriate value however, because the discoverer quickly takes the economy to equilibrium, where players have payoffs within the core of the game (Figure 2d). Since the rent structure of the characteristic function (Table 1e) is such that all players have equal advantage in equilibrium, on average they end up with a similar share of the rents when all opportunities have been exploited (Figure 2b). Once equilibrium has been reached no other changes occur, and in each time period from there on the same constant profit is accumulated by each player; hence a linear cumulative profit curve (Figure 2a). An example would be the case of four firms each producing one product (say a video game console, two video games, and a motion sensing camera) that are failing to compete well in their own product category. One of these firms may notice that by combining the four products into one package, the package may sell better than the sum of its parts. Once the four firms form a partnership, they are in equilibrium because no one benefits and everyone loses from the removal of any of the four parts from the package.

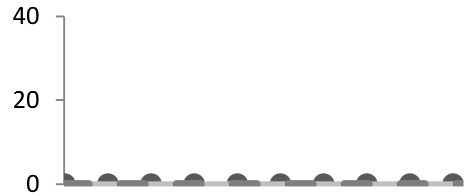
One might expect that the discoverer (i.e., the firm that identified the coalition opportunity and initiated its formation) should have some kind of performance advantage in this case compared to the passive players. The reason it does not is that the most advantageous coalition for it is the grand coalition in which the core (equilibrium) can be realized. So the player continues to exploit opportunities by forming coalitions until the grand coalition has been formed. But once that coalition has been formed, since we assume it has equal bargaining power with all other players, the shares are divided evenly among them.

The results so far are encouraging because they serve to verify the computational representations of our model by replicating the propositions of existing theory (Davis, Eisenhardt, & Bingham, 2007). Figures 1d and 2d demonstrate that our operational model of discovery has the effect of equilibrating the market, making it representative of the Kirznerian discovery process (Kirzner, 1997), and our operational model of creation has a disequilibrating effect on the economy, making it representative of the Schumpeterian creation process (Schumpeter, 1934). See also Table A1 in the online supplement for further description of the alignment between these theories, our model, and the illustrative example provided earlier.

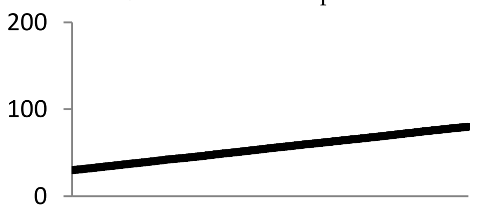
Inputs:	Players' Probabilities of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0	0	0	0



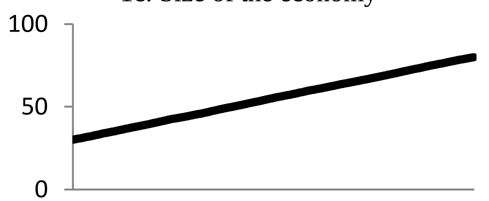
1a: Cumulative profit (performance)



1b: Non-cumulative profit



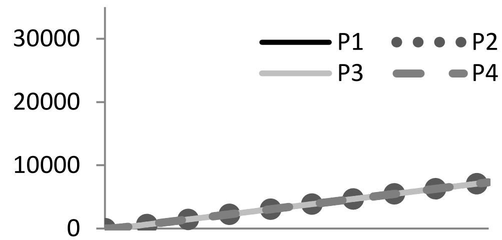
1c: Size of the economy



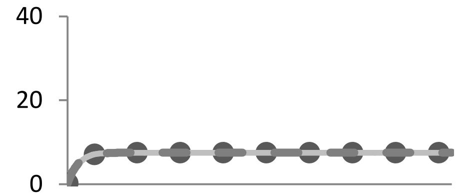
1d: Distance from equilibrium

Figure 1: Base case of one creator

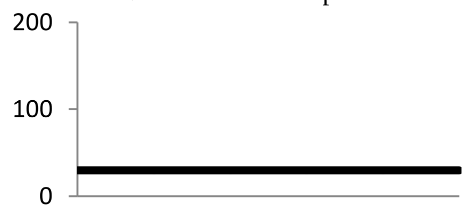
Inputs:	Players' Probabilities of Action			
	P1	P2	P3	P4
Creation	0	0	0	0
Discovery	0	0.05	0	0



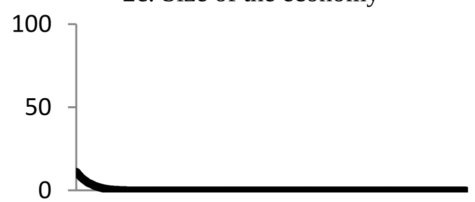
2a: Cumulative profit (performance)



2b: Non-cumulative profit



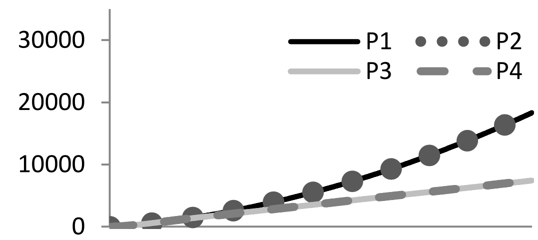
2c: Size of the economy



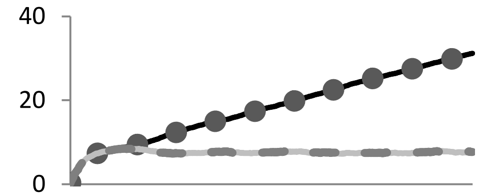
2d: Distance from equilibrium

Figure 2: Base case of one discoverer

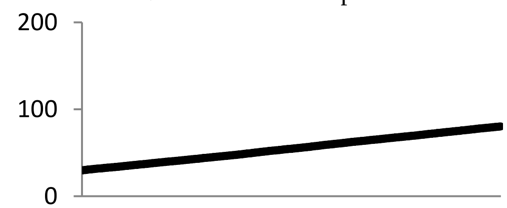
Inputs:	Players' Probabilities of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0	0.05	0	0



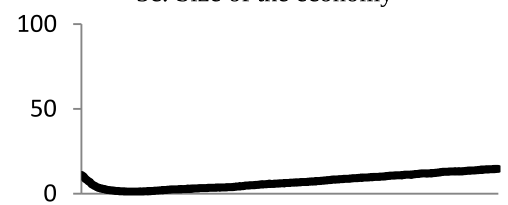
3a: Cumulative profit (performance)



3b: Non-cumulative profit



3c: Size of the economy



3d: Distance from equilibrium

Figure 3: One creator and one discoverer

The characteristic function for all figures is Table 1e. The horizontal axis in all figures represents 1000 time periods. For each time period the figures show average quantities over 200 runs.

Since the default starting characteristic function is not giving anyone an advantage over others, the only way such an advantage may arise is through creation. But as we have seen, a pure creator cannot profit alone; some discovery action is needed as well. Figure 3 shows the results for an economy with one discoverer and one creator. Together, they are able to outperform the passive players considerably, each requiring the other's support. The creator gets help from the discoverer to exploit the advantages it creates in the characteristic function. The discoverer is able to locate and exploit the opportunities made available by the creator whereas the passive players do not recognize these opportunities or take initiative to exploit them. This setup resembles a situation in which a scientist or engineer invents new products but does not know how to patent, commercialize and market them. Another player is a businessman well-versed in patenting and commercializing but does not have the scientific and engineering knowledge to create or enhance the underlying technologies. Other players either have no exploitation skill or are unaware of the potential value of the inventions and are also unable to invent. Note that as shown in Figure 3d, it takes a while before the creator's innovations add up to enough new value to substantially destabilize (disequilibrate) previously equilibrium outcomes. Before that point, the market process looks very much similar to the case where no creator was present because the discoverer is able to equilibrate the market.

Whereas in Figure 3 the creation and discovery capabilities are assigned to different players, similar results are derived if they are assigned to the same player. In sum, the simulation demonstrates that the combination of creation and discovery capabilities, even when assuming no other bargaining power or initial structural rent advantage, can lead to sustained superior performance over time by creating multiple opportunities, discovering and exploiting them. This can be interpreted as a process of concatenating a series of temporary advantages (D'Aveni et al., 2010; Wiggins & Ruefli, 2005).

Returns to improved creation and discovery capabilities

In the setup of Figure 2, the discoverer with a 0.05 level discovery capability, along with other players reach a payoff of 7.5 on average in equilibrium and a cumulative performance of approximately 7300 over 1000 time periods (a bit less than 7500 because it takes some time to reach equilibrium). How would this performance change if the discoverer had a different level of discovery capability? Would the discoverer gain much from increasing this capability? To investigate this, we can measure the final performance (at period 1000) against a changing level of discovery capability for player 2. The results are shown in Figures 4a and 4b.

The figures demonstrate that, for any constant level of creation activity, returns to improving discovery capability are high but quickly diminish beyond a saturation point. They increase up to the point where all the opportunities afforded by the characteristic function and the creation activity can be exploited by the discovery activity in the given time horizon. Beyond that point there are no returns to increasing discovery capacity. As long as the discoverer's level of activity is enough to keep up with the creation activity, no more of it is needed. Before that point is reached however, in the area in which returns to improved discovery are increasing, these returns also benefit everyone else in the economy to the extent allowed by the initial rent structure, and benefit the creator beyond that (Figure 4b) to the extent that the potential created by the creation activity allows. The experiment in Figure 4d illustrates the saturation point phenomenon further. When a discoverer faces three different levels of creation activity in other players, for each of these creation agents there is a saturation point beyond which no further discovery capability is needed to take full advantage of the opportunities they create. The higher the level of creation activity, the later the saturation point is reached.

Comparing Figures 4a and 4b also gives us an idea of the shape of returns to improved creation capability, which is explicitly considered in Figure 4c. While discovery is required to reach the ceiling of possible profit, creation activity pushes up the ceiling. For a given level of discovery activity, returns to improved creation capability are linearly increasing as they change the value structure of the economy and push beyond existing possibilities. These increasing returns also benefit the discoverer with any given discovery capability, because they could not be appropriated without discovery. Increased creation activity has no effect on passive players as long as the level of discovery going on in the economy is beyond the saturation point.

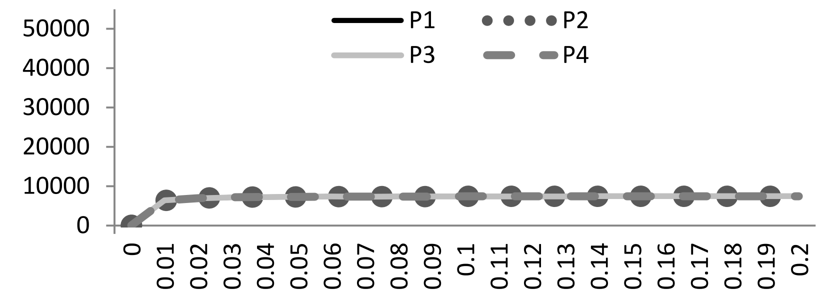
No saturation phenomenon is observed for creation, because acts of creation are always adding something new to the economy. This is in line with the ideas of Shackle (1979a) who views human imagination as literal creation of something that did not exist before. The result also depends on our modeling assumption that acts of creation are not value-destroying, i.e., have no negative externalities. However, the appropriation of the value added by creation does rely on acts of discovery. Robustness analysis showed that, in the setting of Figure 4c, when we reduce the discovery level to values below the saturation point, the slope of increasing returns to creation is reduced, and win-lose (zero-sum) competition between the creator and passive players begins to arise. That is, we begin to see the performance of passive players reduced as the performance of the creator rises. With discovery levels high enough, all creators and passive players can appropriate the value they create with the help of discoverer(s), but when acts of discovery are rare, competition over them intensifies. We explore the issue of competition explicitly in the next section.

Returns to discovery and creation under competition

Although the characteristic function has been employed to model the structure of competition in an imperfectly competitive equilibrium setting (Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004), our adding of disequilibrium dynamics necessitates additional analysis of the interaction between creation and discovery actions performed by more than one player. We start with the setup in Figure 5a (reproduced from Figure 3a for convenience), and add an additional discoverer. This would be similar to a situation in which two manufacturing firms compete for the same inventions of one R&D firm. The result of competition among the discoverers is devastating to them, and hugely beneficial to the creator (Figure 5b). In fact, the performance of the discoverers is reduced to the level of a passive player. Since they add no new value, discoverers are perfect substitutes for each other. This allows the creator to fully appropriate the new value created by playing the two discoverers against each other. As noted earlier, this type of market power should not be confused with bargaining power that is independent of market structure. Since the creator could not profit at all if it were not for the discovery activity, discoverers have strong incentive to engage in collusive arrangements. For example, they could agree not to compete for the same inventions or to only bargain with the R&D firm as a joint entity, reducing the market structure to Figure 5a. Further analysis of collusive arrangements is beyond the scope of this chapter.

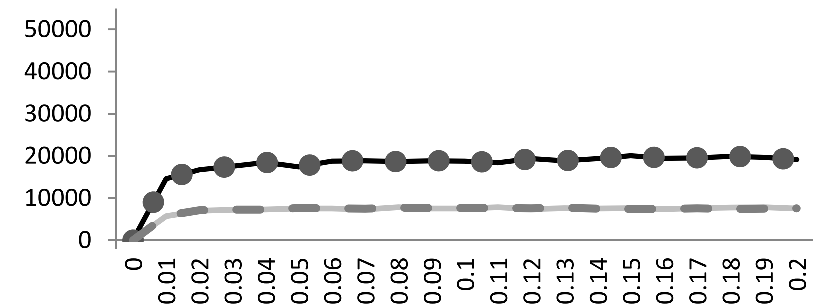
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0	0	0	0
Discovery	0	x	0	0

4a: Returns to improving discovery while keeping creation level fixed at 0



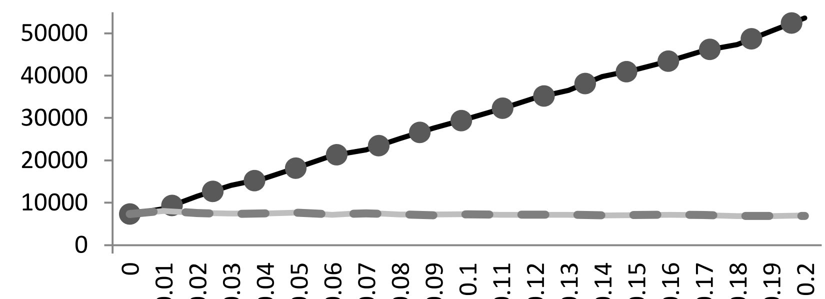
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0	x	0	0

4b: Returns to improving discovery while keeping creation level fixed at 0.05



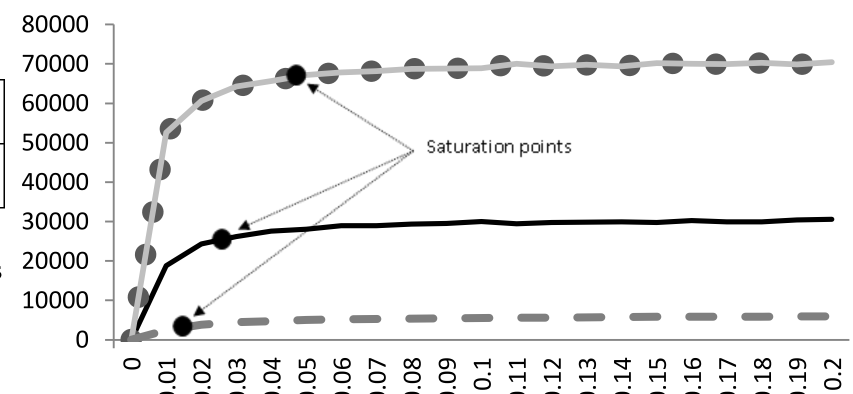
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	x	0	0	0
Discovery	0	0.05	0	0

4c: Returns to improving creation while keeping discovery level fixed at 0.05



Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0.25	0
Discovery	0	x	0	0

4d: Returns to improving discovery while other players have creation levels at three different levels (0, 0.05, and 0.25)



The characteristic function for all figures is Table 1e. The vertical axis represents performance (cumulated profit) at time period 1000, while the horizontal axis represents levels of x in the input tables. For each data point the figures show average quantities over 200 runs.

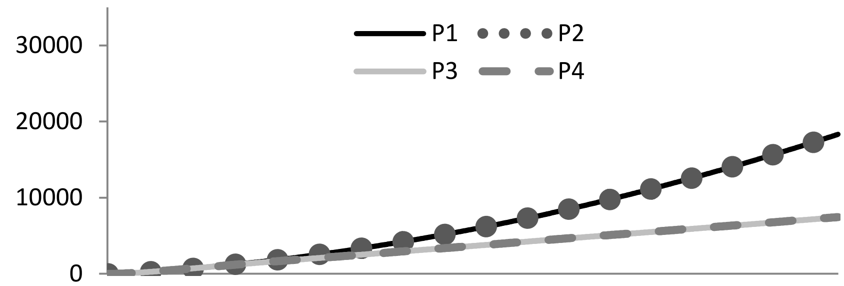
Figure 4: Returns to improving creation and discovery capability

Moving on to competition among creators, suppose we have only one discoverer but two creators (Figure 5c). For example, two R&D companies may be producing patents but only one producer exists to manufacture and market them. Figure 5c indicates that no player is hurt by the competition and the creators and the discoverer are all in fact better off and appropriating equally. The reason is that creators in this model are adding purely new value, and their inventions do not reduce the absolute value of previous inventions (i.e., their creations have no negative externalities and are not value-destroying). They are not substitutes but complements and so do not really compete head to head in a zero-sum situation. However, Figure 5c assumes that the discoverer has enough capability to keep up with the inventions of both creators (i.e., the discovery capability is at or beyond the highest saturation point). If this were not so, the creators would need to compete for the limited time or attention of the discoverer, who would be unable to attend to all possible opportunities. Hence the performance of the three would decline and be limited by the upper bound allowed by the discoverer's capability. Robustness analysis indicates that when discovery levels are below the saturation point, competition among creators begins to take on a co-opetitive form (Brandenburger & Nalebuff, 1996) with the win-lose zero-sum aspect surfacing in competition for the attention of the discoverer, in addition to the win-win aspect of the complementarities developed through acts of creation.

However, for a discoverer with enough discovery capability, it seems curious that in Figure 5c the discoverer is unable to clearly surpass the performance level of the two creators by taking advantage of the fact that he or she can jump between them, always forming coalitions with whichever innovator has created the most value. Robustness analyses showed that in 5 and 6 player situations, when we increase the number of creators competing for the services of one discoverer from two to three and from three to four competitors, the discoverer does gain a performance advantage over the creators. We also conducted tests to compare markets in which one discoverer faces a deep narrow innovation market vs. a wide shallow one (i.e., a market with only one creator with 0.15 creation capability vs. a market with three creators each with 0.05 creation capabilities). Although *relative* to the creators, the discoverer does slightly better in the wide shallow market, the *absolute* performance is much higher in the deep narrow market due to faster access to greater opportunities with each successful discovery action.

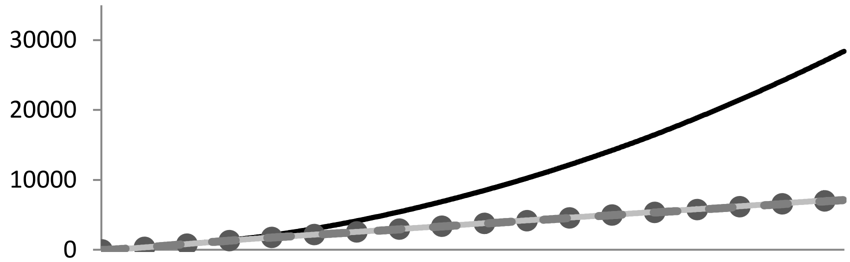
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0	0.05	0	0

5a: Only one creator and one discoverer, no competition. Reproduced from Figure 3a.



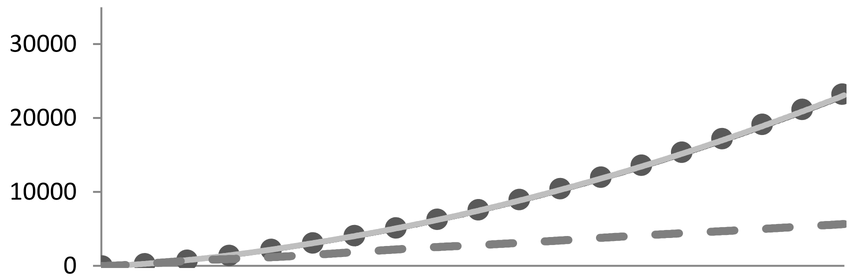
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0	0.05	0.05	0

5b: One creator with two discoverers



Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0.05	0
Discovery	0	0.05	0	0

5c: One discoverer with two creators



The characteristic function for all figures is Table 1e. The vertical axis represents performance (cumulative profit) and the horizontal axis represents 1000 time periods. For each period the figures show average quantities over 200 runs.

Figure 5: Returns to creation and discovery under competition

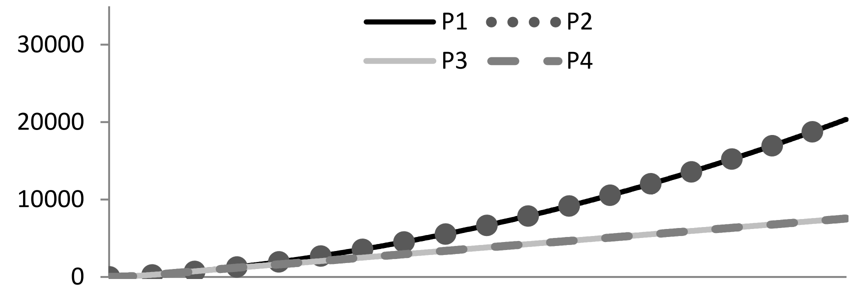
Returns to dual (discovery and creation) capability

So far we have assumed that players are either strictly creators or strictly discoverers, although the complementarity and substitution effects observed in previous sections already give us some hints on the returns to dual capability. Again we start with the base case of Figure 5a. If we suppose that the discoverer develops a small level of creation capability (Figure 6a), the results are that no one is hurt and the two active agents do slightly better. The reason is that, as we learned from Figure 5, creators are complements for each other and not substitutes. The small level of creation activity that is added to the economy complements the earlier creation activity and increases the value of the coalitions that the two entrepreneurs profit from. While absolute profits for both players are higher, the dual capability does not create any particular *relative* advantage for player 2 (the dually capable entrepreneur) over player 1 (the pure creator) because the best opportunities for player 2 still involve player 1. But if the creator was to learn a small level of discovery capability (Figure 6b), the pure discoverer would be devastated in both absolute and relative terms. This is due to the substitution effect among discoverers already seen in Figure 5b. This effect allows a player with dual capabilities to be able to appropriate the rents from both the creation and discovery activity even if sometimes partnering with a pure discoverer. Because returns to discovery reach saturation quickly (Figures 4a, 4b, and 4d), even relatively small levels of discovery are enough to substitute for larger levels of discovery. The low performance (almost at the level of passive players) for the pure discoverer (player 2) in Figure 6b means that in most instances during the game in which player 1 (the dually capable player) has entered a contract (i.e., coalition) with player 2, player 2 has only been able to charge a minimal price, because player 1 already had access to a substitute for player 2's capability internally and thus has largely already discovered the attractive opportunities, leaving player 2 very little to bring to the table.

Figure 6c shows an economy in which two dually capable entrepreneurs exist, but one of them specializes in discovery while the other specializes in creation. The figure shows that the dually capable entrepreneur who specializes in creation (player 1) gains a competitive advantage over the one who specializes in discovery (player 2). However, it should be noted that this advantage is relative. It depends on the relative magnitude of the value added by the creation activity compared to the size of the economy. To illustrate, observe that when we increase the size of the economy from 30 (Table 1e) to 50 (Table 1f), with the same setup of Figure 6c, the results are different such that the creation specialist starts to gain a competitive advantage over the discovery specialist much later in time (Figure 6d).

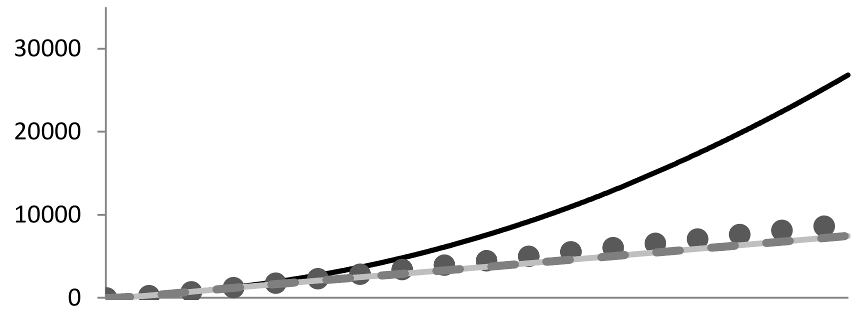
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0.01	0	0
Discovery	0	0.05	0	0

6a: One creator and one dually capable entrepreneur



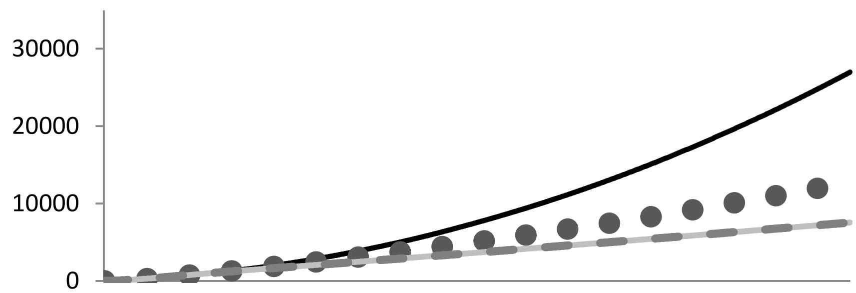
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0.01	0.05	0	0

6b: One discoverer and one dually capable entrepreneur



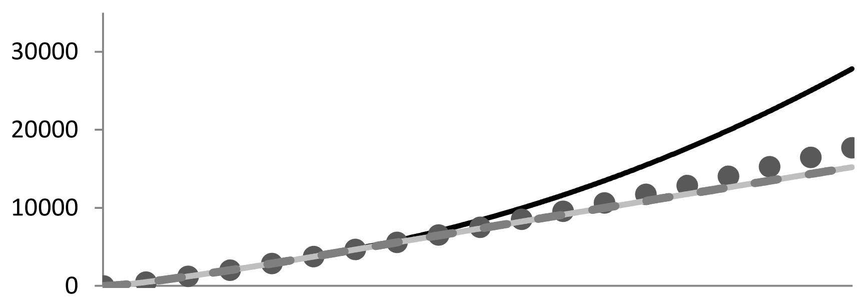
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0.01	0	0
Discovery	0.01	0.05	0	0

6c: Two dually capable entrepreneurs



Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0.01	0	0
Discovery	0.01	0.05	0	0

6d: Two dually capable entrepreneurs in a larger economy



The characteristic function for figures 6a, 6b and 6c is Table 1e and the characteristic function for figure 6d is Table 1f. The vertical axis represents performance (cumulative profit) and the horizontal axis represents 1000 time periods. For each period the figures show average quantities over 200 runs. The inputs for Figure 6d are identical to Figure 6c with the difference that the size of the economy has been increased from 30 to 50.

Figure 6: Returns to simultaneous creation and discovery

DISCUSSION AND CONCLUSION

Implications and contributions to literature

Our results reveal several simple but not trivial effects from the interaction of basic mechanisms such as the complementarity of creation capabilities, the complementarity of creation and discovery, the substitutability of discovery capabilities, the saturation of opportunities, and the relativity of advantage compared to market size. We find that creation and discovery are highly synergistic and complementary (Figure 3a) and of limited value in isolation (Figures 1a and 2a), which supports theoretical arguments by previous authors (Darroch et al., 2005; Zahra, 2008). The implication for practice is that creators must either find partners for discovery or develop discovery capabilities themselves.

Since the costs of teaching and convincing others of the value of one's ideas are often high, entrepreneurs often prefer to start their own firms; and if they already have firms they often prefer to invest in sales and marketing to take their product to market themselves. While this general argument has been made by previous authors (Casson, 2005; Langlois, 2007), our theory suggests two additional reasons why developing a small level of discovery capability by starting one's own firm or investing in sales and marketing capabilities can be more attractive than directly partnering or contracting with others who have large levels of discovery capability, such as incumbents with already huge sales and distribution networks: First, small levels of discovery capability are often enough for an entrepreneur to profit substantially from creations (i.e., value-adding ideas and innovations) (Figure 6b). Discovery capabilities greater than that needed to reach the saturation point are of negligible value for as long as the entrepreneur does not envision the level of creation growing much beyond that point (Figures 4a, 4b and 4d). Second, an entrepreneur who establishes a firm with even a small level of discovery capability is in a much better position to negotiate with potential partners due to the powerful substitution effect among discoverers (Figures 5b and 6b compared to 5a). However, we did find that as the size of the economy and potential value of the creation activity increase, higher levels of discovery capability are needed to saturate rents (Figure 6d), and thus these conditions will increase the value of partnering with others who already have large levels of discovery capability (e.g., in the form of large distribution networks and various sales channels). This could contribute to an explanation of licensing decisions, where a lone inventor or start-up with a technology may feel that the potential market is so large that they can appropriate considerable value merely by licensing the technology to other firms without enduring the additional costs of taking products to market on their own.

Our theory also suggests decision rules for firm growth and boundaries in the form of resource allocation among creation and discovery capabilities over time (Figure 4): (i) If the level of discovery capability that the firm has access to is below saturation level, it is profitable to invest in increasing this capability. The level of profitability compared to investing in creation capability depends on the already existing level of discovery and the rate by which an investment could increase the magnitude/efficiency and frequency of creation or discovery; (ii) If the level of discovery capability is exactly at the saturation level, it is profitable to invest in increasing this capability only if simultaneously investing in increasing creation capability; and (iii) If the level of discovery capability is beyond the saturation point, it is not profitable to invest in increasing this capability until creation levels have increased by enough to reach the saturation point. These logics could help explain why some start-ups decide to focus on innovation and rely on potential partners and acquirers for exploitation (Granstrand & Sjölander, 1990; Lehmann, Braun, & Krispin, 2011; Lehto & Lehtoranta, 2006; Mayer & Kenney, 2004) while other start-ups aim to rely on internal capabilities for both innovation and exploitation.

Because discoverers are substitutes, competition is considerably devastating for them and hugely beneficial to creators (Figure 5b). Thus pure discoverers have a strong incentive to collude and raise barriers to entry, as well as encourage creators to specialize purely in creation (Figure 6b). Pure creators, however, do not lose anything from the entrance of other creators, since their creation activities are complementary (Figures 5c and 6a). As long as there is some level of discovery happening, it never hurts anyone to increase creation activity. Thus creators have incentive to encourage competition among discoverers and do not mind and even benefit if discoverers also learn to create some new value (as long as it is completely *new* value, it does not substitute for their own efforts). These results could explain why start-ups that see themselves as creating genuinely new value compared to competitors often do not consider competition among their chief strategic issues (McFarland, 2011).

Our contribution has been to further the development of a theory of entrepreneurial rents where action is emphasized over possession or position (but not necessarily to the ignorance of them). We have utilized a game theoretic framework to model both the imperfectly competitive structure of the economic space (usually associated with monopoly and/or Ricardian rents) and the movement of players through this space from disequilibrium to equilibrium and vice versa (usually associated with Schumpeterian, Austrian, disequilibrium or entrepreneurial rents). Following Lippman and Rumelt (2003a) we have been inspired by Makowski and Ostroy's (2001) attempt to reformulate traditional Walrasian equilibrium theory to incorporate the 'creativity of the market'. Accordingly, our model allows for entrepreneurship, price-making through bargaining instead of just price-taking, and market-making through innovation instead of just market-taking. However, we do not enforce full appropriation or perfect competition assumptions.

Our framework and results are also in line with the evolutionary capabilities approach (Langlois & Robertson, 1995) that sees the evolution of business institutions and firm boundaries as solutions to coordination games to optimize value creation and production as opposed to prisoners-dilemma games that emphasize the resolution of incentive conflicts as in the organizational economics approach (Holmstrom & Milgrom, 1994; Jensen & Meckling, 1976; Williamson, 1979, 1985). Our model specifically abstracts away from incentive alignment issues, contract forms and governance mechanisms to isolate the role of entrepreneurial capabilities needed for value creation and appropriation as the basis for boundary decisions in a disequilibrium context. This is in line with other works that consider rent generation or value creation to be an opportunism-independent factor in determining firm boundaries (Conner, 1991; Conner & Prahalad, 1996; Kogut & Zander, 1992).

Limitations and opportunities for future research

Although robustness analyses provided additional insights for some experiments, the overall finding of the robustness checks outlined in Table A2 in the online supplement was that the main results listed above were generally highly robust to choice of particular values. But other than particular values, it is possible to experiment with entirely different operationalizations of creation and discovery. For example, in this chapter we have assumed that all innovations add completely new value, whereas future studies could consider a spectrum of newness or even value-destroying innovations and various externalities. Furthermore, while this chapter has focused on creation and discovery capabilities, our analyses suggest that some rents can be imputed to related capabilities not explicitly modeled. These include anti-discovery and anti-creation capabilities, meaning the ability to keep an economy in disequilibrium when equilibrium is disadvantageous and the ability to keep an economy in equilibrium when disequilibrium is undesirable. These capabilities may rely on opportunistic behavior corresponding to what Makowski and Ostroy (2001) recognize as the opportunistic element of the 'creativity of the market'. An effort to incorporate this element could help integrate organizational economics and particularly transaction cost economics with other theories of strategy within the same underlying formal model. Such an integration is far from trivial in a CGT model since it requires going beyond the 'coalition' to investigate different governance structures that each coalition of players could take on. The characteristic function model views each firm as a black box and thus has little to say on the details of the processes that operate to enable entrepreneurial capabilities. While some efforts have been made to model the inside of firms with CGT (Aoki, 1984), multi-level analyses that integrate different levels are lacking.

Another limitation of our approach deriving from the underlying CGT framework is the lack of explicit modeling of costs. Within the CGT literature and its applications, it is commonplace to assume that the numerical values in a characteristic function represent final utility values after all benefit minus cost calculations have already been made (Stuart, 2001). Exacerbating the issue is another commonplace assumption that the values of a characteristic function can be normalized (Ordeshook, 1986) such that there are no negative values, without any impact on the interpretation of those values as containing both cost and benefit information. We consider these commonplace assumptions to be questionable in many applications involving processes that occur through time, mainly because they require overlooking the difference made by the timing and sequence of accrued costs and revenues, and the material impact of positive and negative utility accrued in the present on economic activity in the future. Positive utility can translate to income that an agent may invest in the next time period, whereas negative utility in the form of losses can threaten the very survival of a firm, even if the losses are temporary and future gains are expected. Extensions of this chapter's framework could bring costs into the model in at least two ways: by decomposing the characteristic function into two distinct functions for cost and revenue, and by defining separate functions for the cost of developing and maintaining creation and discovery capabilities. It is foreseeable that in such extended models, optimal resource allocation to creation and discovery will differ based on the amount of slack resources available, the frequency and magnitude of investments required before an innovation can generate revenue, and the pace and scale in which such revenue is accrued. Furthermore, the explicit modeling of the effect of losses and revenues on future time periods is called for.

Other variables we have left out of the picture in order to focus on others provide further opportunities for future research. For example, the dynamics of player exit and entry, learning and improvement of entrepreneurial capabilities over time, and the role of possible exogenous shocks to the economy are all worthy of further study. Notions of distance and network structures can allow more richness in the way relationships among players are modeled, and simulations with larger numbers of players can more fruitfully analyze societal-level variables other than equilibrium (e.g., inequality, diffusion, etc.). All of these and more can be fruitfully studied by making adjustments and amendments to the integrative framework developed in this chapter, and perhaps utilizing other software tools for agent-based simulations. We have merely taken the first steps.

CHAPTER 3: THE EQUILIBRATING AND DISEQUILIBRATING EFFECTS OF ENTREPRENEURSHIP

INTRODUCTION

What is the impact of entrepreneurship on the market? In the rapidly changing technological environment of our times, the word 'entrepreneur' often conjures up images of hero-like figures who present the world with technological marvels. They are often strong forces of economic change that overhaul existing industries or create entirely new ones. Light bulbs, airplanes, automobiles, personal computers, multi-touch phones and micro-blogging are all examples of their products that have impacted millions around the world and changed the way we live forever. The academic literature usually refers to their accomplishments as Schumpeterian 'creative destruction'. But not all entrepreneurship is so dramatic. Many entrepreneurs jump on the bandwagon of technological breakthroughs created by others, or simply start a business based on already existing tried and true technologies and routines. In fact, many of the aforementioned disruptive technologies would not have had their full impact if it were not for the efforts of many of these more banal entrepreneurs. Mom-and-pop shops do not necessarily create something entirely new to the world, but nevertheless exploit opportunities they detect around them. Their efforts are not necessarily disruptive, and can even be stabilizing.

The sheer variety and range of phenomena that can fit under the label of entrepreneurship has been problematic for researchers. What kind of entrepreneurship are we referring to for example, when we talk about the impact of entrepreneurship on the market? When is entrepreneurship disruptive and when is it stabilizing? Academics often refer to the stability of the market as 'equilibrium' and indeed there is a long lasting and ongoing debate in the economics of entrepreneurship—particularly in the Austrian school—on whether entrepreneurship is equilibrating or disequilibrating (Kirzner, 1999; Vaughn, 1992, 1994).

Resolution of the debate has not been forthcoming among economists (Kirzner, 2009), and entrepreneurship scholars in the management disciplines have shown little interest in attempting it. The consensus position seems to be to accept *both* equilibration and disequilibration as natural *co-existing* effects of entrepreneurship (Venkataraman, 1997; Zahra, 2008), and to think of them as associated with two different ways of conceptualizing entrepreneurship: creation of new opportunities vs. discovery of existing opportunities, respectively (Alvarez & Barney, 2007;

Chiles, Bluedorn, & Gupta, 2007). It is taken for granted that creation of new opportunities has a Schumpeterian disequilibrating effect and discovery of existing opportunities has a Kirznerian equilibrating effect, and that these processes form the 'central premises' of entrepreneurship research (Venkataraman, 1997, p. 121).

We posit that after many years of taking them for granted in entrepreneurship research, it is time to take a closer look at these premises. Is creation always disequilibrating and discovery always equilibrating? If not, then under what conditions do these propositions hold? In this chapter we delve into the matter more deeply by first taking stock of existing theory through a concise review of existing positions in the Austrian economics of entrepreneurship. For entrepreneurship researchers, Austrian economics represents a crucial improvement over the neoclassical school because it relaxes the assumption of static equilibrium. However, the more realistic assumptions have come at the expense of formal analyzability. Thus the Austrian school has traditionally shown resistance to formal mathematical modeling (Littlechild, 1986; Rothbard, 1962), even though this insistence has lessened in recent years (Benink & Bossaerts, 2001; Benink, Gordillo, Pardo, & Stephens, 2010; Fillieule, 2007; Fusari, 2005; Littlechild, 1979a, 1979b).

While the discursive approach of the Austrian school continues to produce many insights, it is not an ideal way to overcome the lack of conceptual clarity, definitional disagreements, and theoretical ambiguities that prevail in the entrepreneurship field (Davidsson, 2012; Gartner, 1990; Lumpkin & Dess, 1996; Shane & Venkataraman, 2000). Adner et al. (2009) noted that such definitional ambiguities arising from the imprecision of natural languages are common in the social sciences, and suggested that formal approaches using more precise language such as mathematical modeling and simulation can make valuable contributions to the advancement of research in these fields. Formal modeling is considered to have many methodological advantages such as clarity, ease of comparability, transparency, logical power and consistency (Adner et al., 2009; Kreps, 1990).

Hence the main contribution of this chapter is to refine existing theoretical propositions on the equilibrating and disequilibrating effects of entrepreneurship by introducing a formal analysis of entrepreneurship in the market process as described by the Austrian schools. To facilitate cumulate theory development, we build on a game-theoretic toolbox recently gaining traction in the strategic management field (Adegbesan, 2009; Brandenburger & Stuart, 2007; Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004). Foss (2000a, p. 53) refers to this toolbox as 'the best existing analytical vehicle to choose to the extent that Austrians want to dress their arguments in more formal garb'.

But formal analysis of equilibration and disequilibration dynamics is not a trivial task in this game-theoretic framework due to its traditional static equilibrium focus. The model we employ builds on more recent developments in coalition formation games and dynamic cooperative games to incorporate the dynamics of disequilibrium in the model, and uses computer simulation to analyze these dynamics through time. We do not take the position that Kirznerian vs. Schumpeterian or creation vs. discovery perspectives are incompatible views of the same phenomena. Rather, we formally define and distinguish creation and discovery such that they do not overlap functionally and can co-exist as individual-level actions, and show that various combinations of them in the market produce population-level outcomes that may be closer to those envisioned by one school or the other. With this approach, our formal analysis allows us to shed light on the debate over the equilibrating vs. disequilibrating role of the entrepreneur. In particular, we present challenges and suggest refinements to the commonly accepted propositions that discovery is equilibrating and creation is disequilibrating. Our analysis reveals important nuances that must qualify these and related propositions.

ENTREPRENEURSHIP AND DISEQUILIBRIUM

Many authors have noted the dearth of analytical models studying entrepreneurship, attributing it to the neglect of this phenomenon in mainstream economics (Baumol, 1993a; Kilby, 1971; Mathews, 2006b). This is due to limitations such as the neoclassical tradition's focus on static equilibrium and its accompanying assumptions of perfect objective information, unbounded rationality as well as a trivialized conception of time (O'Driscoll & Rizzo, 1985). These constraints leave little room for the function of entrepreneurship in the neoclassical models. Implicit and explicit assumptions of equilibrium have been called out by some authors as a serious limitation in management and organization research in general (Bromiley & Papenhausen, 2003; Mathews, 2006a, 2006b; Meyer, Gaba, & Colwell, 2005; Rumelt, Schendel, & Teece, 1991). The equilibrium assumption results in assuming away entrepreneurship and other interesting strategic phenomena (Rumelt, 1997).

Equilibrium can be defined as a situation in which agents have no incentive to change their behavior or in which they have exploited all opportunities known to them (Meyer et al., 2005;

Rumelt et al., 1991), but entrepreneurship is all about exploiting opportunities (Shane & Venkataraman, 2000). Equilibrium has been described as a metaphor for statics and stability (Samuels, 1997) but entrepreneurship is all about dynamics and change. For these reasons, it has been suggested that organization and management scholars must move beyond the assumption of equilibrium in order to study entrepreneurship. But the direction of attention to disequilibrium raises particular questions: what creates disequilibrium? How does a system move from equilibrium to disequilibrium and vice versa? Does disequilibrium eventually fade away, stay constant or intensify? These are important questions in the study of social systems in general (Hagen, 1961), and yet relatively understudied in the management literature.

In a system in disequilibrium, both equilibrating and disequilibrating forces may be at work. ‘Equilibrium is a modeling technique, a tool, not a definition of reality. Equilibration and disequilibration take place but no actual equilibrium exists’ (Samuels, 1997, p. 79). While equilibration is usually considered an endogenous phenomenon, explanations of disequilibration often rely on exogenous shocks (Meyer et al., 2005). However, entrepreneurship can serve as a mechanism to explain both equilibration and disequilibration endogenously. Austrian economists have indeed conceptualized and studied entrepreneurship as such. Thus in contrast to the neglect of entrepreneurship in neoclassical economics, within the Austrian perspective as developed by the likes of Menger, Mises, Hayek and particularly Kirzner (1973, 1997) the entrepreneur gains a prominent role as the engine of the market economy, to the extent that ‘one could almost define the Austrian theory as entrepreneurial economics’ (Minniti & Koppl, 2003, p. 82). Although Kirzner’s account of the market process is considered the mainstream neo-Austrian position, there are also important variations of this thinking presented by the likes of Schumpeter (1934, 1943) and Lachmann (1976, 1986). While the Schumpeterian school has received considerable attention in the entrepreneurship literature, the ‘radical subjectivist’ school of Lachmann remains on the sidelines (but see Chiles et al., 2007; Chiles, Tuggle, McMullen, Bierman, & Greening, 2010). The next section reviews the current perspectives in the literature on the relationship between entrepreneurship, equilibration and disequilibration within the dynamics of the market process.

THE MARKET PROCESS AND THE ROLE OF ENTREPRENEURSHIP

The Austrian tradition of viewing the market as a process helps to understand the functional role of entrepreneurship in the economy. But there are different constructions of this process by different schools of thought (Littlechild, 1986). We review several perspectives in this section—Neoclassical, Schumpeterian, Kirznerian and Kaleidic—each providing its own unique angle on the nature of the market process and the equilibrating / disequilibrating role of the entrepreneurial function in it. This review allows us to take stock of what we know about the equilibrating and disequilibrating effects of entrepreneurship and will later help us link our simulation results to existing theoretical propositions.

The neoclassical market process

The neoclassical tradition is heavily focused on the notion of equilibrium under perfect competition as a single state in which all prices have been correctly set and supply and demand have been coordinated (Debreu, 1959). Prices are assumed to convey all the relevant information and the economic agent has only a mathematical calculation to perform to solve an optimization problem based on this information (Baumol, 1993b), and this calculation is an instantaneous act. To the extent that any 'process' is imagined, it is the process of tatonnement by the fictitious Walrasian auctioneer (Walras, 1984) who is taken to be an omniscient agent exogenous to the system, announcing prices to individuals inside the system who then adjust themselves to these announcements such that equilibrium is reached. But this is just an imaginary construction to explain a series of formulas and not a description of the market process. 'Adherents of neoclassical economics assume away the fundamental dynamic characteristics of competition… Even though they describe equilibrium, their analysis does not explain the competitive process that led to this outcome' (Jacobson, 1992, p. 789). The model is based on a 'state in which participants have no incentive to change their present actions, as they are satisfied with the current combination of prices and quantities that are bought or sold ... a pareto-optimal state in which no gains from trade exist' (Eckhardt & Shane, 2003, pp. 334-335).

The Kirznerian market process

Within the Austrian school of thought, the mainstream view of entrepreneurship is attributed to the contributions of Kirzner (1973, 1997), whose work is intended to elaborate on the view of the market process put forward by von Mises (1949). This tradition views the market as a process, which is never really in equilibrium, but is always tending towards it. The underlying theme differentiating this view from the neoclassical perspective is that the exploitation of gains from trade will not take place automatically (Ricketts, 1992). Disequilibrium exists because economic actors are ignorant, and are often ignorant of their ignorance. Thus opportunities are found not just by searching (Fiet, Piskounov, & Patel, 2005), which implies that the searcher knows what he or she is looking for, but more importantly by discovery (Kirzner, 1997). If prices in a transaction are not equilibrium prices, it is because one or both sides are not aware that these prices could be different. The role of the entrepreneur is to discover these inefficiencies and act on them in pursuit of profit. The entrepreneur's main characteristic is 'alertness' to any such opportunities that may arise so that he or she may recognize them part by luck and part by effort (Aimar, 2009; Kirzner, 2000). The simplest case of Kirznerian entrepreneurship is that of 'arbitrage', where the entrepreneur discovers that he or she can buy low in one place, and sell high in another. For this reason the literature often considers the arbitrageur as the quintessential Kirznerian entrepreneur (Lachmann, 1986; Ricketts, 1994; Sautet, 2000).

In the Kirznerian model, entrepreneurial actions equilibrate the market because they fix errors and remove inefficiencies. The association of the Kirznerian notion of entrepreneurship with equilibration has become standard in the literature. Klein goes so far as to say 'what Kirzner calls entrepreneurial discovery is simply that which causes markets to equilibrate' (2008, p. 180). The neo-Austrians assume that the market is full of such entrepreneurs and thus always has a general tendency towards equilibrium (Aimar, 2009), a point in which no more profit opportunities exist.

As summarized by Ricketts (1992) (see also Buchanan & Vanberg, 2008), the Kirznerian model assumes an objectively existing and stable benchmark for the 'state of the arts' allowed by the technological, scientific, and legal background. The Kirznerian entrepreneurs discover the unexploited profit possibilities allowed by this state of the arts until all opportunities are exhausted, but they do not act to change the state of the art itself. 'In terms of neoclassical 'textbook' concepts, Kirzner suggests that the entrepreneur moves the economy to a suitable point on the 'production possibility frontier' where no further gains from trade exist. The frontier itself, which represent all the production possibilities attainable with given resources, is not objectively known by anyone and has to be discovered by entrepreneurial alertness, but there is a sense in which it exists, and in which its existence does not depend upon the discoverer' (Ricketts, 1992, p. 73). In this sense, Kirzner's 'discovery' view of entrepreneurship can be distinguished from the 'creation' perspective (Alvarez & Barney, 2007). 'I view the entrepreneur not as a source of innovative ideas ex nihilo, but as being *alert* to the opportunities that exist *already* and are waiting to be noticed ...

as responding to opportunities rather than creating them' (Kirzner, 1973, p. 74). In his 1973 work, Kirzner emphasized that this distinction sets apart his notion of the entrepreneur from that of Schumpeter.

The Schumpeterian market process

Schumpeter (1934, 1943) is touted as the champion of the innovative entrepreneur, taking a situation of equilibrium as his starting position rather than the situation of disequilibrium where the Kirznerian opportunities exist. Whereas in the Kirznerian model there would not be room for entrepreneurship in such a position, Schumpeter emphasizes the ability of entrepreneurs to create 'new combinations' beyond the current production possibility frontier, thus improving the 'state of the art.' The newness introduced in this way, for example as embodied in new products or processes, disrupts the existing compatibility between individual plans, thus disequilibrating the market. This effect is famously referred to as 'creative destruction' (Schumpeter, 1943) but is ultimately beneficial and is the main force behind economic growth, expanding the production possibility frontier of society (Baumol, 2009). 'For Schumpeter the essence of entrepreneurship is the ability to break away from routine, to destroy existing structures, to move the system away from the even, circular flow of equilibrium' (Kirzner, 1973, p. 127). Schumpeterian entrepreneurs, in contrast to Kirzner's, are 'men of action and not merely of reaction' (Lachmann, 1986, p. 109).

While the innovative entrepreneur's role is disequilibrating in Schumpeter's view, he considered this to be a temporary effect that would eventually dissipate due to the competitive equilibrating forces of the market. His thinking largely retained a Walrasian understanding of economic order (Vaughn, 1994) in which the 'default' condition is equilibrium and 'the long-term forces of competition wash over' any short-term disruptions (Lachmann, 1986, p. 109), although the post-disruption equilibrium is an improvement over the pre-disruption equilibrium. This process of long-term equilibrium with short-term interruptions is often described by alluding to the evolutionary biology concept of 'punctuated equilibrium' (Eldredge & Gould, 1972). Alvarez and Barney (2007) refer to Schumpeter's innovative entrepreneur as a 'creation entrepreneur' pitted against the 'discovery entrepreneur' of Kirzner.

The kaleidic market process

An altogether different perspective on the nature of the market process is espoused by Lachmann (1976, 1986) who introduced the Austrians to the 'radical subjectivist' ideas of George Shackle (Shackle, 1961, 1972, 1979a). In this view, creation is not a rare achievement that can only be accomplished by exceptionally innovative entrepreneurs. Rather, every act of choice is creative because it constructs the future in a unique way. Ignorance is prevalent but not as easily 'fixable' by entrepreneurs as the Kirznerian process describes, because many creative decisions are unpredictable, rendering the future unknowable. Thus for Lachmann, a fundamental indeterminateness characterizes the market process. It cannot be predicted to always follow a generally equilibrating or punctuated equilibrium pattern in the long-term. Rather, there are both equilibrating and disequilibrating forces at work and the specific pattern of the market at any given time depends on the relative strengths of these forces.

The general strength of equilibrating forces however, is much weaker in Lachmann's view than in Kirzner's or Schumpeter's. The radical subjectivists were much more skeptical of the ability of the market to coordinate the plans of individuals because they argued that even if the market process can distribute information and knowledge in society (Hayek, 1945), for the most part it cannot coordinate imaginations. The issue is not just information or knowledge asymmetry, but also expectation and imagination asymmetry, meaning that different individuals with unique, active and free minds may construct heterogeneous subjective expectations of the future given the same information (Koppl, 1998; Lachmann, 1976). This led Lachmann to conclude that continuous disequilibration in the 'kaleidic society' as Shackle (1972, p. 76) had called it, was a more plausible description of the market process compared to the equilibrium-oriented descriptions of Schumpeter and Kirzner (Chiles et al., 2007). 'In a kaleidic society the equilibrating forces, operating slowly ... are always overtaken by unexpected change before they have done their work, and the results of their operation disrupted before they can bear fruit ... equilibrium of the economic system as a whole will thus never be reached' (Lachmann, 1976, pp. 60-61). [4]

[4] Different interpretations of the radical subjectivist view on the shape of the market process are possible. Chiles et al. (2007, p. 469) explicitly use the phrase 'tendency toward disequilibrium' and this is what we are interested here in contrasting with predictions of tendency toward equilibrium or punctuated equilibrium. However, it can be argued that the radical subjectivist school would rather dispense with the notion of market-level equilibrium as a point of

Table 1 offers a comparison of these four views of the market process. The Neoclassical model focuses on a constant state of equilibrium in which there is no entrepreneurship, as opportunities are already depleted. The neo-Austrian perspective of Kirzner starts from market imperfections, which give rise to opportunities that can be discovered by alert entrepreneurs who have an equilibrating effect, the aggregation of which gives the market a general tendency towards equilibrium. The Schumpeterian market includes innovative disequilibrating entrepreneurs that can create opportunities, but also many non-innovative equilibrating agents that discover opportunities. In the long term, equilibrating forces are considered stronger, giving the market process a punctuated shape gravitating around equilibrium. The radical subjectivist school considers choice to be fundamentally creative, and the entrepreneur to have both equilibrating and disequilibrating effects, but emphasizes the strength of the latter. Each school ascribes a different role to entrepreneurship in terms of its equilibrating or disequilibrating effect, and the implications of this effect for the general shape of the market process in relation to equilibrium. To explore these differences rigorously, we need formal modeling tools that are capable of incorporating the dynamic nature of entrepreneurship in the market process.

Table 1: Four views of the market process

School of thought	Literature	Shape of the market process	The function of the entrepreneur	Are opportunities created or discovered?
Neoclassical	Debreu (1959) Walras (1984)	Static equilibrium	None	There are no opportunities
Neo-Austrian	Kirzner (1973, 1997, 1999) Sautet (2000)	Tending towards equilibrium	Equilibrating	Discovered
Schumpeterian	Schumpeter (1934, 1943) Baumol (2009)	Punctuated equilibrium	Innovative entrepreneurs are disequilibrating while market competition is generally equilibrating	Created by innovative entrepreneurs and discovered by others
Radical Subjectivist	Lachmann (1976, 1986) Shackle (1961, 1972, 1979a) Buchanan and Vanberg (2008)	Kaleidic / Tending towards disequilibrium	Equilibrating and disequilibrating	Created

reference altogether, and that Shackle and Lachmann's notion of 'kaleidic' did not always necessarily imply a tendency toward disequilibrium.

ANALYTICAL APPROACH

Cooperative game theory (CGT) has been utilized in a wide variety of applications in many different fields. In recent years, strategic management scholars have started to take advantage of CGT's strength and flexibility as an analytical framework (Adegbesan, 2009; Brandenburger & Stuart, 2007; Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004). Nevertheless, Austrian economists and entrepreneurship scholars have yet to reap the benefits of this powerful and versatile framework, despite the potential that exists. Admittedly, the traditional CGT model has been just as static as the neoclassical model, and much focus has been on notions such as the 'core' of a cooperative game, which is a concept analogous to the notion of equilibrium or production possibility frontier (Debreu & Scarf, 1963; Shubik, 1959). While endorsing CGT for Austrian economic analysis, Foss (2000a, p. 53) cautioned that 'cooperative game theorists should be told that achieving core allocations is not unproblematic; that, too, requires the entrepreneurial process of discovery'. However, incorporating the process element in CGT is not impossible. As Foss himself notes:

> 'Although disequilibrium behavior and the market process in the Austrian sense have not been much treated in game theory, at least some aspects of entrepreneurial behavior and the market process are given to game theoretic formalization. In a splendid, but neglected paper published almost twenty years ago, Stephen Littlechild (1979) tried to accomplish exactly this, arguing that cooperative game theory could be used to model an entrepreneurial bargaining process, and undertook some formal modeling of this. Austrians have unfortunately paid no attention to this work' (2000a, p. 49).

Inspired by Littlechild's work, in chapter 2 we used the CGT framework to structure a computer simulation of the market process, but whereas that chapter is concerned with performance as the main dependent variable, we adapt the model in this chapter to study equilibration and disequilibration effects. The model is centered around a *characteristic function* that assigns a value to every possible coalition of players. It is the main tool in the CGT framework for describing the 'state of the art' or the potential value structure of an economy. A *profit distribution* vector determines how much this potential value has been exploited and by whom. The set of profit distributions that divide all the possible value among players such that each individual or subset of players is receiving a profit at least as much as they could have made on their own, is called the *core* of the game and is analogous to the notion of equilibrium. Discovery can be modeled as the exploitation of already existing opportunities afforded by the characteristic function, while creation can be modeled as changing the opportunity landscape, i.e., the characteristic function itself. These two ‘process’ elements of how the game plays out over time are not explicitly studied in traditional CGT models but can be studied with simulation methods (Chavez, 2004; Chavez & Kimbrough, 2004; Dworman, 1994; Dworman et al., 1995; Klusch & Gerber, 2002).

The individual-level granularity of the CGT model, coupled with the flexibility and computational power of computer simulations, allow us to benefit from the strength of agent-based simulation in deriving emergent system-level patterns from the aggregation of individual-level behavior (Levinthal & Posen, 2007; Nell, 2010). Simulation is an especially powerful approach for theory-building because it allows us to inductively examine the outcome of manipulating individual variables and features of the modeled system (Lazer & Friedman, 2007). Finally as we shall see, building on unambiguous definitions, this approach allows us to obtain a cognitively helpful visualization of the market process depicting equilibration and disequilibration through time.

DESCRIPTION OF MODEL AND SIMULATION

Model outline

A brief re-iteration of the model in chapter 2 including adaptations for present purposes follows. The economy is modeled as a cooperative game with transferable utility in which a characteristic function specifies the value structure of the game in each time period. The actors in the economy are a non-changing set $N = \{1,2, \dots, n\}$ of self-interested players who can form groups called *coalitions* with each other to create and appropriate value. The value that can be created by any coalition at any point in time is given by a *characteristic function* $v\colon \mathbf{2}^N \rightarrow \mathbb{R}_+$ that associates a non-negative real number value to all subsets of N where the value of the empty set is zero. The characteristic functions used in this chapter are fully specified in Table 2. We call the set of all non-empty subsets of N, the set of all *possible coalitions*. The set of *actual coalitions* however, is the term we use to refer to the coalitions that have actually formed at any point in time. This information is given by a *coalition structure* $CS = \{S_1, S_2, \dots, S_m\}$ which specifies a partition of N into non-empty subsets, meaning that $\bigcup_{k=1}^{m} S_k = N$ and $S_k \cap S_l = \phi,\ \forall k \neq l$. Each player is a member of exactly one actual coalition (possibly the singleton coalition if the player is alone) at any time.

Table 2: The characteristic functions used in this chapter

2a

Coalition	1	2	3	4	12	13	14	23	24	34	123	124	134	234	1234
Value	0	0	0	0	10	10	10	10	10	10	20	20	20	20	30

The default characteristic function used in the simulations

2b

Coalition	1	2	3	4	12	13	14	23	24	34	123	124	134	234	1234
Value	0	0	0	0	10	10	10	10	10	10	20	20	20	**30**	30

Player 1 has zero marginal contribution (thus zero profit) in the core

2c

Coalition	1	2	3	4	12	13	14	23	24	34	123	124	134	234	1234
Value	0	0	0	0	10	10	10	10	10	10	20	20	20	20	**20**

A characteristic function with an empty core

2d

Coalition	1	2	3	4	12	13	14	23	24	34	123	124	134	234	1234
Value	0	0	0	0	10	10	10	10	10	10	20	20	20	20	**50**

The default characteristic function modified to have a larger value for the grand coalition

2e

Coalition	1	2	3	4	12	13	14	23	24	34	123	124	134	234	1234
Value	0	0	0	0	10	10	10	10	10	10	20	20	20	20	**200**

The default characteristic function modified to have a very large value for the grand coalition

Although the characteristic function defines how much value can be created in any coalition, it does not say anything about how that value is appropriated, i.e., how it is divided between the coalition's members. Such divisions are described with a *profit distribution* which is a vector $x = (x_1, \dots, x_n) \in \mathbb{R}^n_+$. The *profit of a coalition* S is the sum of the profits of its members, which we denote by $x(S) = \sum_{i \in S} x_i$. A profit distribution x is *efficient for an actual coalition* S if $x(S) = v(S)$, meaning that the members of S cannot achieve a bigger 'pie' to divide between themselves within that coalition according to v. However, some members of S may find it worthwhile to leave that coalition and form another coalition T with other players if $x(T) < v(T)$. This is called the *blocking* of profit distribution x by the *blocking coalition* T. The difference between $x(T)$, the profit that members of T are receiving before they actually form T, and $v(T)$, the larger pie that awaits them, is called the *excess* of T and is what motivates the blocking.[5] Excess is a measure of the objective size of the profit opportunity that T is aiming to exploit. The model assumes that one member of the blocking coalition needs to discover this excess and rally the other members to exploit it. We call this act of blocking *discovery entrepreneurship* (discovery for short) by that member/ After an act of blocking, we assume the members of the blocking coalition distribute

[5] The process of blocking changes the coalition structure. An important question in coalition formation games is what happens to the remaining members of a coalition after some member(s) leave it in the blocking process (Hart & Kurz, 1983). The present model assumes that the remaining members stay together and the pie shared between them is just the sum of the profits they were already getting, unless this sum is larger than the value of their coalition as allowed by the characteristic function, in which case the pie is set to that value.

70% of the discovered excess value equally among themselves (to account for imperfect ‘exploitation efficiency’; see Table 3).

If given a profit distribution $x = (x_1, \dots, x_n)$, no possible coalition has any excess, then the game is said to be in the *core*. This is analogous to the notion of equilibrium in the sense that all gains from coalition formation have been exhausted and players cannot achieve higher profits by changing their coalition (i.e., within the current characteristic function, all profit opportunities have been depleted). They do however continue to receive their core profits in each time period. If the current profit distribution is not in the core or if the core is empty for the current characteristic function, we say that the economy is in disequilibrium and we measure the *distance from equilibrium* by the average amount of positive excess that exists for all possible coalitions. Distance from equilibrium can be considered a measure of the instability of the market because it indicates the level of unexploited opportunities. For example, if a patent owner has not yet sold a patent for which very high offers are being made in the market, the situation is unstable and more so the higher those offers are, because it makes the current situation (patent not sold) less likely to persist.

The *marginal contribution* of a player i to a coalition S that contains i is defined as the difference between the value of S and the value of S without i, or more formally: $v(S) - v(S/\{i\})$. We define an act of innovation or *creation entrepreneurship* (creation for short) by a player as the process by which that player’s marginal contribution to all possible coalitions containing it, increases by one unit of value (this is the ‘innovation magnitude’ in Table 3). We define a *state* of the game as a triple (v, CS, x) that gives a snapshot of the game at any time point by fully describing the characteristic function, the coalition structure, and the profit distribution. It is important to note that the notions of creation and discovery in this chapter are idealized types that do not necessarily correspond to the general notion of entrepreneurship in real life. Most acts of entrepreneurship in reality can be said to involve both creation and discovery. In fact the great difficulty of distinguishing between equilibrating and disequilibrating processes in empirical reality is one of the reasons why a formal approach is necessary to tease out the different effects of each.

Simulation mechanism

Table A2 in Appendix C provides a complete list of the variables used in the model, their operational definitions, default values, and the robustness checks conducted. Part B in Appendix

C provides an outline of the simulation algorithm. The game begins with a default number of four players unless specified otherwise. This number never changes during a simulation. The game starts in a state where each of the four agents is in its own singleton coalition, the default profit distribution is (0,0,0,0), and the characteristic function defining the value structure is given by Table 2a. The last number in the characteristic function reflects the value of the grand coalition or $V(N)$, which we refer to as the *size of the economy* since it is the largest value in the characteristic function.

At each time period either nothing, one instance of discovery, one instance of creation, or one instance of both discovery and creation can occur. The main independent variables we manipulate in our simulation experiments are the capabilities of each player in creation and discovery. Each of these capabilities is represented by a *probability of action* for each player. The probability of creation indicates the likelihood that a player will add new value to the characteristic function. The probability of discovery indicates the likelihood that a player will detect and exploit a better coalition opportunity afforded by the characteristic function. The dependent variable we are interested in is the distance from equilibrium (the core) as defined above. The time horizon for each run of the simulation is 1,000 time periods unless stated otherwise, and all averages of the dependent variable are calculated over 200 runs. The software environment deployed is MATLAB version 7.10.

ANALYSIS

Visualizing the market process

As a starting point, in order to test the intuitive consistency of our model, it is useful to see if the various shapes of the market process as discussed in Table 1 may be reproduced and visualized. The static market can be produced by assuming that the game is in the core of a non-changing characteristic function (Table 2a). Therefore, no creation exists and no opportunity is left to discover, and both the value structure and individual profits are stable through time. In the core of our starting characteristic function, the grand coalition is assumed to have formed and to be sharing a value of 30 among the four players. As shown in Figure 1a, the distance from equilibrium (the core) in such a model of the market is constantly zero.

What happens if we start with a profit allocation of (0, 0, 0, 0) instead of a profit distribution that is already in the core? Obviously, according to the characteristic function there is value to be discovered and appropriated but if no players have entrepreneurial capabilities, then no moves are made to discover and appropriate this value. There is no 'engine' to drive the market process. While keeping all other players passive, if we allow one player to have a positive discovery probability of action (discovery capability), Figure 1b shows that by initiating a number of blocks, the discoverer exploits the existing inefficiencies, decreases average existing excess and eventually equilibrates the market. Similar results are obtained if the same discovery capability is distributed among some or all of the players.

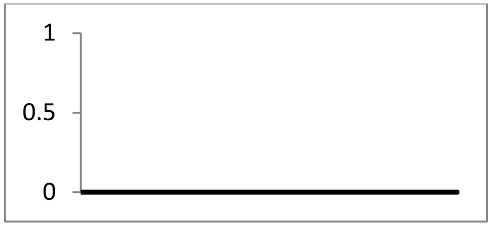
Now let us bring in a creator into the picture. Since creation expands the bounds of possible value, it tends to render the current profit distribution more inefficient. Since core profits are always efficient, creation moves the system away from the core if it is in it. Figure 1c shows that in the case of a creator with a creation capability (probability of action) of 0.1, this disequilibrating force is enough to direct the economy further and further away from equilibrium, despite the equilibrating efforts of the discoverer. This gives the market shape a tendency toward increasing disequilibrium.

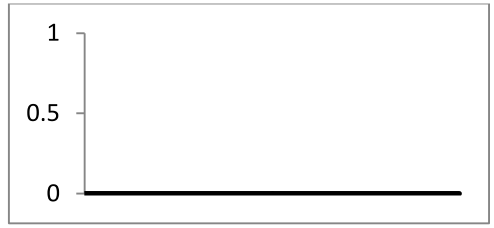
A more complex configuration with all layers having both creation and discovery capabilities is modeled in Figure 1d. Here we observe, first, a punctuated process in individual runs of the simulation, and second, not long-term equilibrium but a constant level of disequilibrium for the shape of the market on average. In other words, when a high enough level of both disequilibrating and equilibrating forces interact in the market, a punctuated process such as that described in the Schumpeterian theory can be observed, although the fluctuations may not necessarily be around perfect equilibrium on average.

Unless otherwise discussed below, robustness checks (listed in Table A2 in Appendix C) indicated that in general increasing creation capabilities and innovation magnitudes in the economy resulted in more pronounced disequilibrating effects, while increasing discovery capabilities and exploitation efficiency amplified equilibrating effects. As discussed later, these effects are always relative to the starting characteristic function. Changes in number of time periods and number of players did not produce qualitatively different results.

	A sample single run	Average over 200 runs	Inputs

1a: The static market in equilibrium

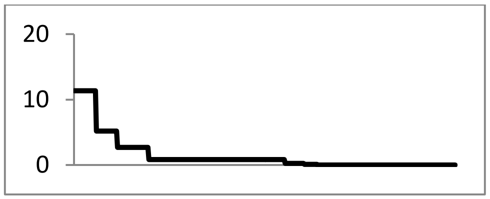


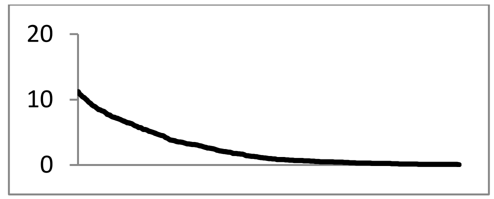


	Probabilities of Action			
	P1	P2	P3	P4
Creation	0	0	0	0
Discovery	Any	Any	Any	Any

Any number of time periods, starting with a core payoff distribution

1b: A market process with equilibrating tendency

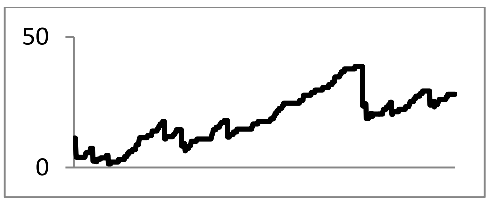


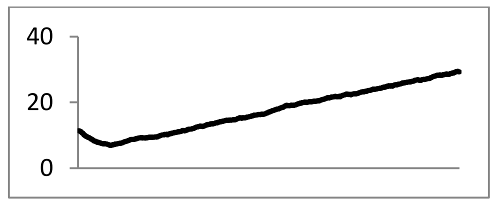


	Probabilities of Action			
	P1	P2	P3	P4
Creation	0	0	0	0
Discovery	0.02	0	0	0

400 time periods, starting with zero payoffs

1c: A market process with disequilibrating tendency

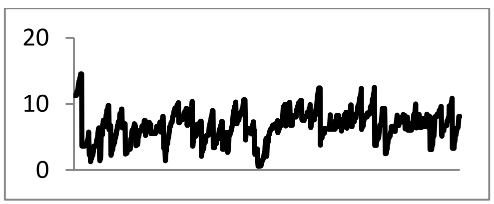


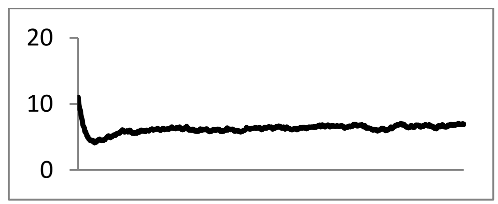


	Probabilities of Action			
	P1	P2	P3	P4
Creation	0.1	0	0	0
Discovery	0	0.02	0	0

1,000 time periods, starting with zero payoffs

1d: A punctuated market process





	Probabilities of Action			
	P1	P2	P3	P4
Creation	0.1	0.1	0.1	0.1
Discovery	0.02	0.02	0.02	0.02

1,000 time periods, starting with zero payoffs

Characteristic function for Figures 1a-1d: Table 2a

Figure 1: Distance from equilibrium in several simulations of the market process

The simulation results thus far are a reassuring first step, because intuitive outcomes are observed that validate our intuitive understanding of the model and verify our computational representation of theoretical constructs (Davis et al., 2007). We have been able to formally reproduce conditions that give rise to each of the market process shapes discussed in Table 1. In the next section we go beyond this first step and attempt to utilize the model and simulations as a theory-building tool in order to derive insights and refine theoretical propositions pertaining to the equilibrating or disequilibrating role of the entrepreneur.

Is discovery entrepreneurship always equilibrating?

Sautet (2000) lists some of the issues that have previously been raised to challenge the Kirznerian school's proposition that entrepreneurship is always equilibrating. The first and most important argument has been that this notion is not compatible with the possibility of creation, although Kirzner himself has dismissed this challenge (Kirzner, 1999, 2009). While the concept of discovery can be interpreted to include creative acts (Minniti & Koppl, 2003), it has been hard to reconcile creation with equilibration. Kirzner's attempt to do this can be summarized as follows: if we consider an ultimate equilibrium in which 'everything that humans may ever imagine, think, or know will be revealed' in 'some final state of universal enlightenment, at the end of all times' (Buchanan & Vanberg, 2008, pp. 386, 395), then every act of creation is a step towards that state. Critics have not been convinced since they argue that such a point is a logical impossibility, if not misleading (Buchanan & Vanberg, 2008; Ricketts, 1992). In our model, we distinguish between creation and discovery entrepreneurship in a precise way, so this challenge does not apply to our notion of discovery. In other words, we are asking: if we distinguish mathematically between pure discovery and pure creation such that they have no overlap, what can we say about their equilibrating and disequilibrating effects?

At the same time as having an equilibrating role, the discoverer is assumed to be a self-interested actor in pursuit of profit (von Mises, 1949). Our analysis shows important situations in which these two roles can be contradicting. In other words, preserving the inefficiencies of the market is sometimes in the best interest of the discoverer. The Kirznerian model assumes that opportunities exist because others have made 'errors' in allocating resources. In fact, for Kirzner the only kind of disequilibrating entrepreneurship is mistaken entrepreneurship (Kirzner, 1997). But some of these so-called errors could actually be deliberate efforts on the part of other entrepreneurs trying to keep the market from reaching equilibrium in order to preserve their advantageous positions in disequilibrium. Sautet (2000) describes the unpublished work of Gilberto Gama Salgado, which seems to touch upon this issue. Our analysis provides a formalization.

Consider what happens if we change the characteristic function of Table 2a according to Table 2b. By changing the value of the {2,3,4} coalition from 20 to 30, the structure of the core of the game changes such that player 1 obtains zero profit in the core. This is because the marginal contribution of player 1 to the grand coalition (the value of {1,2,3,4} minus the value of {2,3,4}) is now zero. Thus if at any point in disequilibrium during the Kirznerian market process player 1 receives any profit at all, then this player would prefer to maintain that position rather than equilibrate the market any further. As demonstrated in Figure 2a, this player will succeed in doing so for as long as other market participants do not discover the discrepancies. In this sense, player 1 in Figure 2a can be interpreted as a Kirznerian waste-reducing and equilibrating entrepreneur until a certain point, and then a destructive, waste-generating and rent-seeking entrepreneur thereafter (Baumol, 1990; Lu, 1994).

We therefore find that the general tendency for discovery to take the market towards equilibrium in the absence of creation requires not just that discovery capabilities exist in 'enough' degree among participants, but also that they be distributed among 'enough' number of participants. In the terminology of McMullen and Shepherd (2006), even if a third-person opportunity (an opportunity for someone) exists, it will not be exploited if it does not translate to a first-person opportunity (an opportunity for a particular actor) for someone with the capability to act on it.

There is yet another sense in which the equilibrating tendency of discovery may be challenged, something not mentioned by Sautet (2000), but which is revealed very clearly in the CGT framework. The notion that the core may be empty is itself a challenge to the equilibration proposition. These are situations in which it is impossible to remove all inefficiency because any effort to improve efficiency in some parts of the economy creates inefficiency in other parts (i.e., Pareto improvements are impossible). When equilibrium is simply impossible given the value structure of the economy, acts of discovery cannot be described as equilibrating. There is no equilibrium to be tending to. Figure 2b shows that a market process in which the core is empty (according to the characteristic function in Table 2c) and all players are discoverers stays at a constant level of disequilibrium on average.

Inputs:	Players' Probabilities of Action			
	P1	P2	P3	P4
Creation	0	0	0	0
Discovery	0.05	0	0	0

Characteristic function: Table 2b

Figure 2a: The only discoverer has a more advantageous position in disequilibrium than in equilibrium

Inputs:	Players' Probabilities of Action			
	P1	P2	P3	P4
Creation	0	0	0	0
Discovery	0.05	0.05	0.05	0.05

Characteristic function: Table 2c

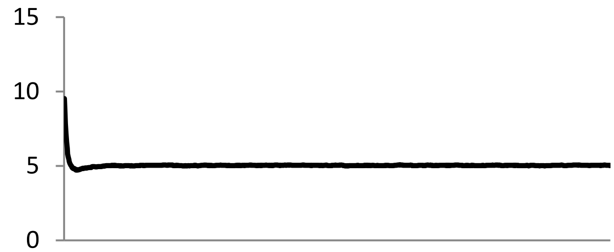


Figure 2b: Even with multiple discoverers, no equilibrium is reached when the game has an empty core

Plots show average distance from equilibrium (vertical axis) in 1,000 time periods (horizontal axis) over 200 simulation runs.

Figure 2: Cases where discovery entrepreneurship is not fully equilibrating

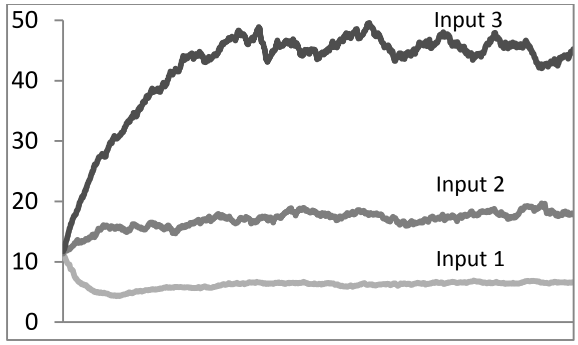
Is creation entrepreneurship always disequilibrating?

While challenges to the equilibration proposition are plenty, the disequilibrating effect of creation seems to be more commonly taken for granted. As Lachmann (1986, p. 126) put it, '[t]he arbitrageur is of course always an equilibrating agent, the innovator a disequilibrating one'. The only serious challenge to the disequilibration proposition is Kirzner's 'ultimate' equilibrium notion mentioned above, which is rather unconvincing as we have seen. However, our analysis demonstrates that theoretical propositions about the disequilibrating role of creation need to be refined in at least three ways.

Consider first that, if creation is disequilibrating, then in the punctuated market process we might expect that if the degree of creation activity is increased relative to the degree of discovery activity, we would start to see a break from the punctuated process and a tendency towards increasing disequilibrium. In Lachmann's terms, we would expect disequilibrating forces to eventually take over. But our analysis as depicted in Figure 3 shows that no matter how strong the creation forces are relative to the discovery forces, beyond a certain point the market neither moves towards equilibrium nor disequilibrium on average, but fluctuates around a *constant* level of distance from equilibrium. We note that this constant level is higher if creation forces are stronger relative to discovery forces (from input 1 to input 3 in Figure 3).

Inputs:	Players' Probabilities of Action P1	P2	P3	P4	
Creation	0.05	0.05	0.05	0.05	Input 1
Discovery	0.01	0.01	0.01	0.01	
Creation	0.2	0.2	0.2	0.2	Input 2
Discovery	0.01	0.01	0.01	0.01	
Creation	0.24	0.24	0.24	0.24	Input 3
Discovery	0.005	0.005	0.005	0.005	

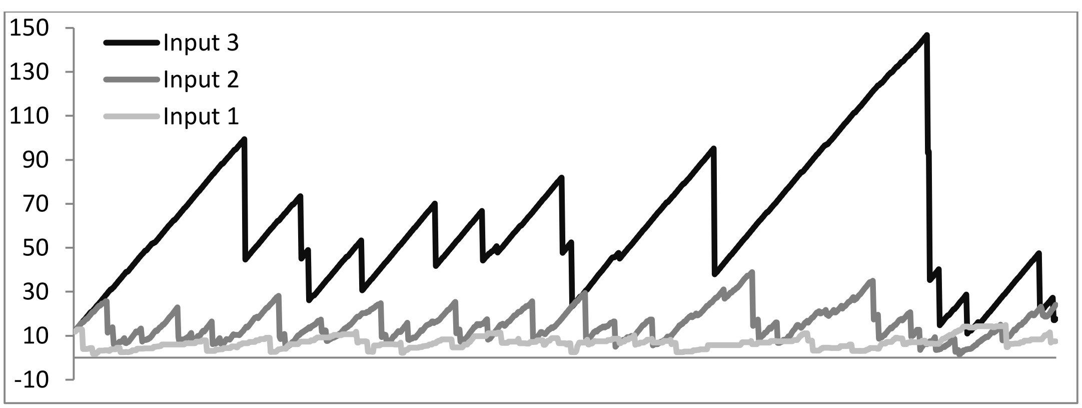
Characteristic function for Figures 3 and 4: Table 2a



Plot shows average distance from equilibrium (vertical axis) in 1,000 time periods (horizontal axis) over 200 simulation runs

Figure 3: The effect of relative strengths of creation and discovery in the punctuated market

An interesting observation in Figure 3 is the increasing waviness of the average market shape with creation increasing in force relative to discovery. This suggests that these markets undergo longer and more intense waves. Visualizations of sample instances of such market processes are provided in Figure 4. Note that here we are not claiming that each individual act of creation is not disequilibrating, only that the disequilibrating forces are not enough to drive a punctuated market towards a trend of increasing disequilibrium. The punctuated market process as manifested in our model in configurations where all players have both creation and discovery capabilities does indeed have a 'center of gravitation' as Schumpeter envisioned, but this center is not the equilibrium he proposed, but rather a constant level of disequilibrium.



Plot shows distance from equilibrium (vertical axis) in 1,000 time periods (horizontal axis) for one simulation run for each input from figure 3.

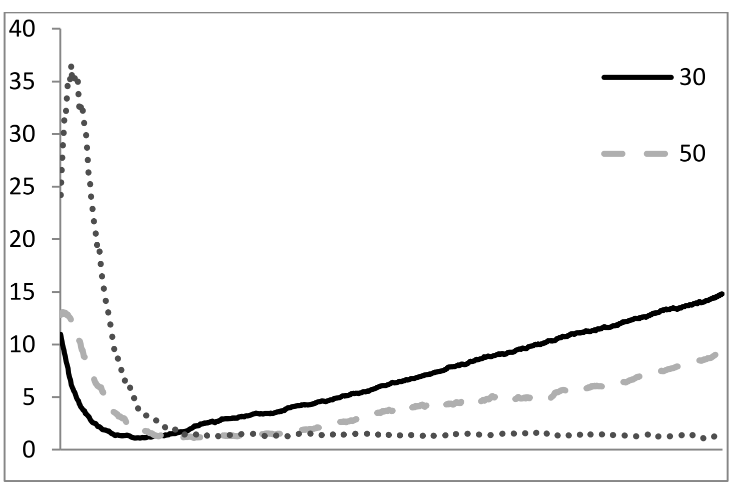
Figure 4: The shape of the punctuated market process for a sample single run

An individual act of creation may not be disequilibrating either, i.e., when the newly created value does not alter the core of the game substantially enough to make the current profit distribution unstable (i.e., block-able). An incremental innovation may create a characteristic function whose core overlaps considerably with that of the previous characteristic function. In such a case, it is plausible that if the previous core had been reached, the same profit distribution would still be in the core (or very close to it) after the innovation.

To illustrate this further, consider the market process of Figure 1c, in which we most clearly observed the disequilibrating effect of creation. We can observe what happens when we make those disequilibrating impressions seem like merely incremental innovations compared to the value possibilities of the economy. We do this by changing the characteristic function such that the value of the grand coalition, which determines the core profits, is substantially increased, while keeping the players' entrepreneurial capabilities the same. As expected, the results in Figure 5 show that when the innovations are very incremental (small in added value) compared to average core outcomes, they have much less disruptive power in disequilibrating the market. The lesson here is that disequilibrating force is relative, since the same innovative capacity that is disruptive in one context, may not be in another.

Inputs:	Players' Probabilities of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0	0.05	0	0

Characteristic function: Table 2a, 2d, and 2e



For each level of the grand coalition value, plot shows average distance from equilibrium (vertical axis) in 1,000 time periods (horizontal axis) over 200 simulation runs.

Figure 5: The relative disequilibrating effect of creation entrepreneurship

Finally, we argued above that the notion that the core may be empty presents a substantial challenge to the equilibration proposition. The same notion presents a challenge to the disequilibration proposition as well. What is it that the creator would be disrupting if there were no core? In fact, an act of creation can likely turn a game with an empty core into a game with a nonempty one in which equilibrium is possible. In such a case the creator can be considered as conducive to equilibration.

DISCUSSION AND CONCLUDING REMARKS

In this chapter we have taken a rigorous and critical look at the theoretical propositions in the Austrian economics literature about the equilibrating vs. disequilibrating roles of the entrepreneur which are considered by Venkataraman (1997) to be the central premises of entrepreneurship research. The relationship between entrepreneurship and equilibrium / disequilibrium is a central issue in Austrian economics (Vaughn, 1992) and debates on the matter are still ongoing. Ioannides (1992, p. 81) notes that the lack of consensus on this issue 'reveals the difficulty of constructing a theory which attempts to describe the operation of market dynamics while, at the same time, explaining the overall cohesion of the market system.' Our analysis has allowed us to shed some light on these diverging opinions, leveraging the definitional and logical clarity of formal modeling.

In particular, we were able to refine theoretical propositions regarding the commonly held views that discovery is equilibrating and that creation is disequilibrating. Although we found general support for these propositions, we also found important ways in which these statements need to be qualified. The cooperative game theory notion of the possibility of an empty core or non-existing equilibrium presents important challenges to both notions of equilibration and disequilibration. Although empty cores are more likely to arise in small numbers situations, they nevertheless present a challenge to equilibrium-based thinking. Furthermore, we show that Kirznerian discoverers may in some cases be motivated to prevent equilibration and succeed in doing so if there are not enough other discoverers in the market. Our argument for how discovery can prevent equilibrium differs from Kirzner's (1997) notion that 'mistaken' entrepreneurs can do so by 'not' discovering, because we attribute intended agency for this equilibrium prevention to the opportunistic discoverer who is in fact not mistaken. As for creation, we demonstrate that the extent to which an innovation of a given magnitude is disequilibrating depends on the relative power of that magnitude compared to the maximum possible value achieved in equilibrium. Moreover, we show that in the punctuated market process as we have modeled it, stronger disequilibrating forces compared to equilibrating ones do not necessarily take the market towards *increasing* disequilibrium beyond a certain point, but can simply keep the market at a higher level of *constant* disequilibrium on average. These refinements are an important step in developing stronger conceptual foundations for entrepreneurship research.

The notion of equilibrium in economics has always had significant normative connotations. The neoclassical economists saw perfectly competitive equilibrium as a socially optimum allocation of resources. In this perspective, any supernormal profits arising from monopoly power of firms is viewed as rents that need to be restricted in order to improve social welfare (Littlechild, 1981). In contrast, Kirzner points out that reaching equilibrium is not automatic, and entrepreneurs motivated by profit are needed to drive society towards the efficient allocations. Thus for Kirzner, in contrast to the traditional mindset of restricting profit, *encouragement of profit* is the only policy that can achieve socially optimum results (Ioannides, 1992). Our analysis in this chapter suggests an important qualification of this recommendation. As we have observed, the profit motive of a Kirznerian entrepreneur may actually drive him or her to expend effort in preventing others from discovering opportunities by opportunistically withholding knowledge from them. Thus the policy implication is that the encouragement of profit making activity is most efficient when accompanied by an effective distribution of knowledge in society that minimizes barriers to entry, independent of the distribution of knowledge left on the shoulders of the market mechanism. The challenge remains to maximize the distribution of knowledge and minimize barriers to entry without undermining the property rights mechanisms that encourage the production of knowledge in the first place (Foss & Foss, 2008).

We end by discussing some limitations and opportunities for future research. An important caveat of this chapter is the issue of multiple notions of equilibrium. In particular, Austrians since Hayek (1937) have used a non-mathematical notion of plan coordination as a subjectivist replacement for the neoclassical equilibrium concept (Harper, in press; Kirzner, 2000; Littlechild, 1982). Consequently the term ‘coordinating’ (discoordinating) often replaces ‘equilibrating’ (disequilibrating) in these discussions, although the terms are sometimes used interchangeably. However, it remains to be considered whether this chapter’s use of the concept of the core in cooperative game theory (a pareto-optimal equilibrium) corresponds to what Austrian economists mean by equilibrium. Kirzner himself considers the two concepts to correspond in the sense that 'a state of full coordinatedness is, of course, Pareto-optimal…Pareto-suboptimality corresponds to imperfect coordination' (Kirzner, 2000, p. 144), especially if we admit the possibility of interpersonal utility comparisons[6].

Aiming to heed the recent calls by organization and management scholars (Adner et al., 2009; Davis et al., 2007; Harrison et al., 2007), this chapter makes an effort to advance entrepreneurship theory using the formal tools of mathematical modeling and computer simulation. Inspired by works such as Foss (2000a), Littlechild (1979a, 1979b), Lippman and Rumelt (2003a), McDonald and Ryall (2004), and Makowski and Ostroy (2001) we have used a cooperative game theory framework to model the market as a dynamic process rather than a state of equilibrium. In applying this framework to new questions, we have gained new insight into central theoretical propositions in entrepreneurship research. However, the adapted framework assumed equal bargaining power among agents, no value-destroying innovations and no exogenous shocks to the economy. Experimenting with changes in these assumptions as well as adding other variables such as communication and network constraints among players, dynamically changing entrepreneurial capabilities, and various kinds of myopic and farsighted learning are promising avenues for future research that can leverage the potential of formal modeling and simulation to develop fresh insights on the conceptual foundations of entrepreneurship theory.

[6] Although this assumption is not necessarily compatible with a subjectivist approach.

CHAPTER 4: EXPLORATION-EXPLOITATION AND THE SURVIVAL, ACQUISITION, AND PROFITABILITY OF START-UPS

INTRODUCTION

The fundamental tension between exploration and exploitation (Lavie et al., 2010; March, 1991), and the imperative to pursue these activities with an optimal balance or ambidextrously (O'Reilly & Tushman, 2013; Raisch & Birkinshaw, 2008) has been receiving widespread interest in management and organization research in the past two decades. Such an imperative is based strictly on the logic that such balance or ambidexterity is necessary for *long-term* performance and survival. As the argument goes, a focus on exploitation can deliver short-term performance but is dangerous in the long term as it reduces adaptability in the face of change and hampers access to new opportunities. Thus exploitation must be balanced with exploration to ensure the long term viability of an organization (Raisch & Birkinshaw, 2008). Although the argument is not without its challengers (e.g., Barney, 1991; Ghemawat & Ricart i Costa, 1993; Wernerfelt & Montgomery, 1988), a variety of studies have empirically verified the long term performance and survival benefits of balancing exploration and exploitation through time, structure, context and domain (Junni, Sarala, Taras, & Tarba, 2013; Lavie et al., 2010).

Whereas it can be argued that resource allocation decisions are even more critical in the context of resource-constrained start-ups, most existing exploration-exploitation (exp-exp) research has focused on large and established firms. Furthermore, it is far from trivial that this research can be readily applied as-is to the context of small and new ventures. The few papers that have studied the context of small and new ventures have noted that the dynamics of exploration and exploitation differ in important ways for these firms.[7] For example, while in large firms achieving ambidexterity through separation of organizational units may make sense, for smaller firms this tactic is often not sensible or not even an option (Chang & Hughes, 2012; Lubatkin, Simsek, Ling, & Veiga, 2006) and ambidexterity in single domains has been found to be less beneficial for younger and smaller firms (Voss & Voss, 2013). Further evidence has accumulated that some exp-exp balance in small firms happens in the inter-organizational level in cooperation with large firms (Rothaermel, 2001; Yang, Zheng, & Zhao, 2014), and that exploitation is less valued in small firms

[7] Even though most such research has studied relatively large SMEs and not completely new and very small start-ups.

compared to large firms (McNamara & Baden-Fuller, 2007). Although these studies represent significant developments in our understanding of ambidexterity in small firms, some important differences between the new venture context and the established firm context have remained relatively unnoticed in exp-exp research.

In this study we aim to extend this stream of research by addressing a critical issue that is different about the start-up context compared to large firms: the value of *short-term* outcomes in terms of both desirability and feasibility. While it may be easier for large established firms to sacrifice short-term profits for the long term, new ventures often depend on short-term profitability for their very existence. As pointed out by Levinthal and March (1993, p. 110), 'an organization cannot survive in the long run unless it survives in each of the short runs along the way, and strategies that permit short-run survival tend to increase long-run vulnerability.'

Furthermore, short-term exits through mergers and acquisitions (M&As) are commonly considered a positive outcome for new ventures rather than failure (Cefis & Marsili, 2011; Collins, 2000; DeTienne, 2010; Wennberg, Wiklund, DeTienne, & Cardon, 2010). Given the context of the modern ecosystem in which start-ups grow and compete, improving the chances of getting acquired cannot be ignored as a potential objective. This ecosystem allows entrepreneurs and investors to harvest wealth quickly from acquisition exits, rendering such exits highly coveted (Bayar & Chemmanur, 2010; Collins, 2000). Most modern acquisitions are friendly rather than hostile, and involve win-win synergistic arrangements between the acquirer and the target firm (Haleblian, Devers, McNamara, Carpenter, & Davison, 2009; Sorensen, 2000). Incumbent firms regularly take advantage of the acquisition option to access technologies and innovations produced by small entrepreneurial start-ups (Ahuja & Katila, 2001; Desyllas & Hughes, 2008; Inkpen, Sundaram, & Rockwood, 2000; Puranam, Singh, & Zollo, 2003). Given that the technologies and innovations sought by acquirers are normally the outcome of exploratory search by start-ups, the lack of exp-exp research that acknowledges acquisition exits as a potentially desirable outcome presents a rather conspicuous gap in the literature. In fact, it is not much of a stretch to say that exp-exp research to date has been completely silent on the exploration and exploitation patterns that influence exit outcomes other than survival. Given the heavy reliance of exp-exp research on the logic of long-term performance and survival, the desirability of getting acquired poses a challenge to existing research since at least some new ventures aiming for short term exits via acquisition may be concerned with neither long-term performance nor survival.

In any attempt to bridge this gap, at least three issues need to be addressed. First, it must be recognized that start-ups pursuing short-term profitability and/or exit are not necessarily un-interested in long-term profitability and survival and vice versa. But they cannot have their cake and eat it too if there are trade-offs between these performance dimensions. The exp-exp balance that optimizes profitability and survival may be different from the balance that maximizes the chances of getting acquired, and any such trade-offs are likely to be particularly pronounced for resource-constrained start-ups. The literature to date has little to say on the existence, form and implications of such trade-offs. Second, since these trade-offs are among different dimensions of performance, they must be studied by empirically measuring distinct performance and outcome variables in relation to exp-exp balance. Although it is recognized that various performance dimensions such as profitability and survival may have different antecedents (Delios & Beamish, 2001; Gimeno, Folta, Cooper, & Woo, 1997) most exp-exp studies to date have ignored trade-offs among different performance dimensions in general, and so the vast majority of empirical exp-exp studies have only one performance dimension as a dependent variable. Third, existing literature has found that optimal exp-exp strategies are heavily contingent on context (Gupta, Smith, & Shalley, 2006b; Sidhu, Commandeur, & Volberda, 2007; Wang & Li, 2008). Specifically, the exp-exp patterns that yield the best results for high technology start-ups are likely to differ significantly from those in low and medium technology industries (Bierly & Daly, 2007; Uotila, Maula, Keil, & Zahra, 2009). Therefore, any study that aims to examine trade-offs among performance dimensions in start-ups needs to be mindful of this important contextual contingency factor.

In this chapter, we tackle the above issues jointly in order to answer the following research questions: Do the traditional balance-is-best relationships between exp-exp and performance hold for multiple performance dimensions in the context of start-ups? Are the exp-exp patterns that lead to start-up exit through acquisition different from those that lead to improved profitability or survival? If so, what are the trade-offs and are these trade-offs different among high-tech compared to low and medium tech start-ups? We build on existing exp-exp arguments and develop our hypotheses by considering the particularities of the start-up context, the nature of acquisition compared to failure as an exit outcome, and the differences among industry technology levels. We put our hypotheses to test using the Kauffman Firm Survey (KFS) data which tracked a representative cohort of firms started in 2004 with a baseline survey and seven roughly annual follow-up surveys until 2011. It is not only one of the most extensive panel datasets available on start-ups, but also provides unique advantages for our purposes such as random rather than matched sampling of acquired and non-acquired start-ups. It is important to note that our goal is not to compare small firms with large firms as our sample only represents start-ups. Our aim is only to highlight how exp-exp trade-offs are observed in relation to multiple performance dimensions in the context of start-ups.

Our contribution is novel—especially in the exp-exp literature—in the sense that it is one of the first to study all three performance dimensions of survival, acquisition, and profitability simultaneously among start-ups where the potential trade-offs among all three are of strategic significance. Thus our results uncover trade-offs previously unrecognized in the literature. In particular, we find that the exploration-performance trade-offs differ in both type and shape among technology levels. For low and medium technology start-ups we find evidence of a trade-off between survival and profitability, and for high-tech start-ups the results point to a trade-off between acquisition likelihood and profitability. We do not find evidence of a trade-off between acquisition likelihood and survival likelihood. Overall, our findings have important implications for exploration-exploitation and ambidexterity research, mergers and acquisitions research, and entrepreneurship research.

BACKGROUND, THEORY AND HYPOTHESES

Exploration-exploitation and performance trade-offs

The most important strategic decisions are usually those that involve trade-offs. The exp-exp literature is thus important to strategy because it emphasizes such trade-offs. But it remains somewhat under-appreciated that exp-exp theory discusses *two* categories of trade-offs: First, there is a trade-off among the independent variables (exploration and exploitation) in the sense that resources allocated to one activity steer those resources away from the other. Second, there is a trade-off among the dependent variables (performance outcomes) in the sense that the exp-exp balance that is best for short-term performance is not optimal for long-term performance and survival and vice versa. Despite this logic of conflicting performance dimensions at the very core of exp-exp theory, most existing empirical studies have focused on the trade-offs among the independent variables rather than the dependent variables. In other words, they have largely focused on the tension between exploration and exploitation activities as realized on one performance dimension, rather than the strategic problem of the trade-offs among multiple performance dimensions.

As a result, most empirical exp-exp studies have only one performance variable, leaving the multidimensional performance trade-offs of exp-exp balance understudied. A review of quantitative empirical studies (not counting simulation or multiple-case studies) listed in recent reviews by Raisch and Birkinshaw (2008), Simsek, Heavey, Veiga, and Souder (2009), Birkinshaw and Gupta (2013), and other recent papers published in top journals revealed 21 studies with only one performance variable and only nine studies that test multiple performance variables (see Table 1).[8] Of these nine studies, six studies found different antecedents or correlates among different performance dimensions, and out of those studies only three actually report on a trade-off among performance variables.

Given that the particular performance trade-off at the heart of exp-exp theory is that between short term performance and long term performance or survival of an organization, it is not encouraging that so few empirical exp-exp studies actually investigate this trade-off. While in simulation studies it is relatively easy to test both short-term and long-term performance (Rivkin & Siggelkow, 2003), for the purposes of empirical testing, data limitations are heavily constraining and even when data permits, any cut-off point between the short term and the long term will inevitably be to a large extent arbitrary. What can be done however, is to study different measures that could serve as imperfect proxies for the theorized performance dimensions (Lavie et al., 2011). This is for example the approach taken by Hill and Birkinshaw (2008) who studied financial performance as a proxy for short term performance and survival throughout the two-year period of study as a proxy for long term performance, and found them to have different antecedents. This is in line with previous research emphasizing the distinction between economic performance and

[8] To be fair, some of the measures of performance used in the literature, especially those that are survey-based, do account for multiple dimensions although they are usually integrated into one measure (e.g. Im & Rai, 2008; Lubatkin et al., 2006), leaving potential trade-offs among the dimensions untested. Similarly, some studies measure multiple performance variables but do so only as a methodological technique to ensure robustness (e.g. Chang & Hughes, 2012; McNamara & Baden-Fuller, 2007).

survival (Carroll & Huo, 1986; Delios & Beamish, 2001; Kalleberg & Leicht, 1991; Meyer & Zucker, 1989).

Table 1: Performance trade-offs of exp-exp balance: a list of quantitative empirical exp-exp studies that test more than one performance dimension as distinct dependent variables.

Author (year)	Performance variables	Differing correlates or trade-offs
Rothaermel (2001)	• New product development • Financial performance	None
Kyriakopoulos and Moorman (2004)	• New product financial performance in first year after launch and second year after launch	None
Rothaermel and Deeds (2004)	• Number of products in development • Number of products on the market	**Trade-offs:** None **Differing correlates:** Exploration alliances are positively related to products in development and exploitation alliances are positively related to products on the market. Viewed as value chain rather than trade-off.
Atuahene-Gima (2005)	• Incremental innovation performance • Radical innovation performance	**Trade-offs:** Exploration is positively related to radical innovation performance and negatively related to incremental innovation performance. Exploitation has the opposite effects.
Auh and Menguc (2005)	• Effectiveness • Efficiency	**Trade-offs:** For all firms, exploration was more positively associated with effective firm performance than exploitation. For prospector firms, exploitation was more positively related to efficient firm performance than exploration.
Hill and Birkinshaw (2008)	• Survival • Performance (financial, technological and entrepreneurial).	**Trade-offs:** None **Differing correlates:** Performance measures but not survival positively related to fit between organizational profile and ideal type (expert-rated). Survival but not performance was positively related to exploitation orientation.
Rothaermel and Alexandre (2009)	• Innovativeness • Financial performance	**Trade-offs:** None **Differing correlates:** External over total technology exploration and exploitation were unrelated to financial performance but had opposing effects on innovativeness
Hoang and Rothaermel (2010)	• Project success (drug approval) • Project termination / survival	**Trade-offs:** External exploitation increases both success chance and termination chance
Lavie, Kang, and Rosenkopf (2011)	• Net profit (proxy for short-term) • Market value (proxy for long-term)	None

Multiple performance dimensions and the strategic trade-offs of start-ups

The distinction between survival and economic performance is especially critical in the context of start-ups, and is a focal point in the burgeoning line of research on entrepreneurial exit (Bates, 2005; DeTienne, Shepherd, & De Castro, 2008; Gimeno et al., 1997; Levie, Don, & Leleux, 2011). The basic insight is that underperforming firms often persist to exist, and not all exits (even closures) are failures, financial or otherwise. Of course start-ups often want to survive and be profitable at the same time. These are both legitimate performance dimensions, and yet the literature has little to say on whether the exp-exp balance that maximizes the chances of survival and profitability is the same or whether there are trade-offs. Thus one of our main goals in this chapter is to investigate these two performance outcomes as distinct dependent variables.

However, in this study we also propose that the addition of a third performance dimension (i.e., getting acquired) is necessary in the context of the modern start-up, and that this addition brings with it two additional *potential* trade-offs, one with each of the previous two performance dimensions (See Figure 1). We emphasize the potential nature of the trade-offs since they have not yet been empirically verified to exist. This is what we set out to explore. The importance of the acquisition dimension for today's start-ups cannot be overlooked. Unlike some of the earlier waves of mergers and acquisitions, most acquisitions today are friendly rather than hostile, and are motivated by the potential for win-win synergistic arrangements (Haleblian et al., 2009; Sorensen, 2000). The increasingly knowledge-driven nature of the economy has resulted in the rising importance of acquiring start-ups as a means for incumbent firms to access technologies and innovations (Ahuja & Katila, 2001; Desyllas & Hughes, 2008; Inkpen et al., 2000; Puranam et al., 2003; Wagner, 2011). A certain division of labour seems to have taken shape, in which start-ups develop innovative technologies but face resource and capability constraints in efficiently and effectively taking these innovations to market and exploiting them, while on the other hand established firms have deeper pockets, better sales and distribution capabilities, as well as experience in commercialization and established legitimacy, but are limited by the scope and amount of research and development (R&D) activity that can be done in-house and the time constraints of entering new markets rapidly enough to stay ahead of competition (Granstrand & Sjölander, 1990; Kleer & Wagner, 2012; Lehmann et al., 2011; Lehto & Lehtoranta, 2006; Mayer & Kenney, 2004). A famous example of such an acquisition ecosystem is that of Cisco and its numerous acquisitions (Mayer & Kenney, 2004).

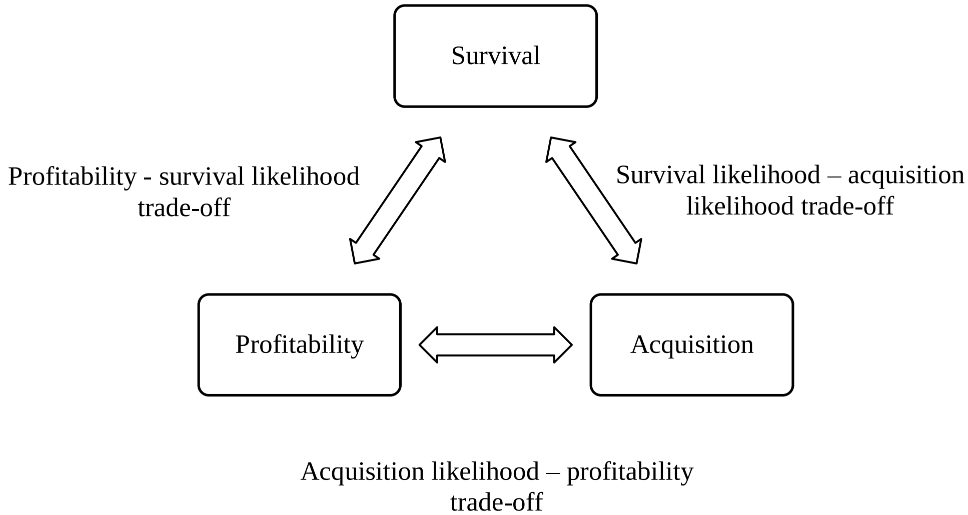


Figure 1: Potential performance trade-offs for start-ups

The existence of a healthy market for acquisitions has resulted in many start-ups actively pursuing such lucrative opportunities from the outset. These firms are sometimes designed and intended from the beginning to survive only for a short period of time, a phenomenon known as 'built to flip' (Collins, 2000; Germeraad, 2001). An acquisition is a lucrative path to 'harvest' cash from a venture, both for the entrepreneurs who have founded the venture and for investors funding the venture (Bayar & Chemmanur, 2010; Collins, 2000). With the money in their pocket, entrepreneurs can often freely move on to other activities or become angel or venture capital investors themselves (Mason & Harrison, 2006). In sum, acquisition presents a desirable and highly coveted exit option for many start-ups due to the tangible benefits for their founding entrepreneurs, their investors, and their employees (Mohr & Garnsey, 2009).

What is less clear is whether or not there are serious trade-offs between maximizing the likelihood of being acquired and maximizing profitability or likelihood of survival as a stand-alone business, and if so, what is the exact nature of such trade-offs. It is likely that maximizing acquisition likelihood involves 'fitting' the start-up to the requirements of potential acquirers. But maximizing complementarity with and attractiveness to potential acquirers may not be entirely compatible with maximizing chances of survival or profit as a stand-alone business. In the terminology of the exp-exp tensions found by Andriopoulos and Lewis (2009), getting acquired could be viewed as a 'breakthrough' outcome that is viewed to be in contradiction with 'profit'.

Conceptualizing the exploration-exploitation continuum

A well-recognized challenge in the exp-exp literature is the existence of a variety of different ways for conceptualizing and operationalizing the notions of exploration and exploitation. Almost any aspect of organization can be thought of in terms of this basic duality (Birkinshaw & Gupta, 2013). However, the terms are given more concrete meaning in empirical studies because they have to be measured. The various ways in which these concepts have been conceptualized based on measurable proxies include—among others—search depth vs. scope (Katila & Ahuja, 2002), products in new markets vs. existing markets (He & Wong, 2004), and upstream (e.g., R&D) vs. downstream (e.g., sales) activities (Anand, Mesquita, & Vassolo, 2009; Hoang & Rothaermel, 2010; Lavie et al., 2011; Rothaermel, 2001; Rothaermel & Deeds, 2004) which is perhaps the most common approach in empirical studies based on objective measures, and is thus the approach we adopt here.

Serious differences exist among researcher's views on whether exploration and exploitation should be viewed as orthogonal, possibly independent variables (Bierly & Daly, 2007; Gupta et al., 2006b; Jansen, Tempelaar, van den Bosch, & Volberda, 2009) or if they should be viewed as involving inherent trade-offs and thus better conceptualized as a single continuum variable (Lavie et al., 2011; Lavie et al., 2010), especially if exploration and exploitation are measured at the same time points. In the context of new ventures, we believe that resource limitations result in pronounced trade-offs and thus adopt the continuum approach. Our measure of exploration is designed accordingly, based on proxies for exploration and exploitation at the same time points. The continuum approach also allows us to distinguish this research more clearly from the literature on the relationship between R&D and innovation and survival or acquisition likelihood. In this approach increased exploration implies decreased exploitation and vice versa by definition. Hence, in what follows we refer to the exploration-exploitation continuum by simply using the term 'exploration,' and the reader should keep in mind that the term means 'exploration relative to exploitation' in the wording of our hypotheses.

Exploration and the performance outcomes of start-ups

Most arguments linking exploration and exploitation to performance and survival predict a Goldilocks effect and thus suggest a middle-ground balance is optimal. Due to prevalent pressures to deliver short-term profit, it is argued that the natural tendency of organizations is to tilt the balance towards too much exploitation and too little exploration (March, 1991), and empirical studies have indeed found this tendency (e.g., Uotila et al., 2009). Although some exploitation is necessary to generate revenue in the short run, in the long term too little exploration can result in reduced adaptability, getting stuck on local peaks in the performance landscape (Gavetti & Levinthal, 2000) or sub-optimal stable equilibria, and an inability to produce new opportunities to exploit (Bierly & Daly, 2007). Too much exploration on the other hand, can create excessive performance uncertainty (Cao, Gedajlovic, & Zhang, 2009), trap the firm in an endless and costly cycle of experimentation and search (Levinthal & March, 1993), without enough harvesting of its fruits. Thus the standard hypothesis is formulated as a balance-is-best prediction, with the performance dimension of interest typically being some measure of either financial performance or survival.

Most exp-exp literature has assumed the equivalence of financial performance and survival, as this has been the traditional view in the broader management literature (Alchian, 1950; Penrose, 1952). The logic is the intuitive 'survival of the fittest' argument: profitability is an indication of evolutionary fitness and thus a criterion of natural selection (Aldrich & Ruef, 2006; Hannan & Freeman, 1977; Penrose, 1952). However, the entrepreneurial exit literature cautions against taking profitability and survival as equivalent since it has been found that underperforming firms often do not dissolve, and many dissolutions are not failures (Bates, 2005; DeTienne et al., 2008; Gimeno et al., 1997; Levie et al., 2011). Hence we test the hypothesis separately for profitability and survival:

H1: There is a curvilinear (inverted U-shaped) relationship between exploration and the survival likelihood of new ventures.

H2: There is a curvilinear (inverted U-shaped) relationship between exploration and the profitability of new ventures.

Moving on to our concern with M&A exits (i.e., acquisitions), we find that the existing literature is silent on the relationship between exp-exp balance and acquisition likelihood. We argue that it is reasonable to expect the general Goldilocks principle to still be operative for acquisition likelihood, although the relationship of this performance dimension with profitability is far from trivial. Too much exploration to the neglect of exploitation can reduce the attractiveness of a venture as an acquisition target, since it can result in too much costly experimentation without the ability to provide proof of market viability to potential acquirers (Gans, Hsu, & Stern, 2002), and it can reduce the incentive of acquisition altogether due to a weak bargaining position. On the other hand, too little exploration will hamper the venture's ability to offer an attractive and unique value proposition to potential acquirers (Desyllas & Hughes, 2009; Srinivasan, Lilien, & Rangaswamy, 2008). Hence:

H3: There is a curvilinear (inverted U-shaped) relationship between the exploration and the acquisition likelihood of new ventures.

On whether or not we should expect a trade-off between survival, profitability and acquisition the evidence seems unclear at first glance. On the one hand, the traditional view on this matter is the market discipline hypothesis (Haleblian et al., 2009; Jensen & Ruback, 1983), according to which poorer financial performance is disciplined by the market for ownership and control, because it is more likely to be indicative of bad management and unexploited potential. On the other hand, it can be argued that higher profitability signals resource value to potential acquirers, and some studies have indeed found that increased financial performance leads to increased acquisition likelihood (Hannan & Rhoades, 1987). In either case, most of the market discipline studies have been conducted on established firms in industries such as the banking sector where the role of technology and exploration is less significant. In the context of modern start-ups and the ecosystem of complementarities between them and established firms (Baumol, 2009; Eliasson & Eliasson, 2005; Mayer & Kenney, 2004), unexploited potential is not necessarily indicative of bad management since entrepreneurs who anticipate short-term exits through acquisition may decide to focus on product development and rely on the future acquirer's capabilities for full-blown marketing, distribution and sales. When the acquisition of knowledge, human capital and technology are important factors in the acquisition decision, high or low profitability of the target may not necessarily be a pre-requisite from the acquirer's perspective.

Such an ecosystem suggests that in the start-up context the opposing forces may be stronger in favour of exploration compared to exploitation when the desired outcome is acquisition likelihood rather than survival or profitability. Such a performance trade-off, if observed, would be a novel finding in the literature. We argue that this trade-off can be expected to exist for multiple reasons. First, because incumbents usually have existing exploitation capabilities, they are more likely to find the new venture's exploitation capabilities as non-complementary and unnecessary. Commenting on the value of this complementarity, Christina Darwall, former executive director of the Harvard Business School California Research Center and founder of an acquired start-up alludes to the Cisco example:

> '[Cisco's] strategy works well precisely because many of the companies that Cisco acquires and integrates are built to flip. Buying such a company -- one that has focused almost exclusively on the creation of a new product or service -- involves overcoming relatively few barriers. In this model, the acquired company is generally young. It has few ingrained beliefs about "the way we do business around here," and so it is more adaptable to the culture of the acquiring company. And because it has not focused on building strong sales and distribution capabilities, its employees welcome what the acquiring company brings to the party' (Jurvetson, Darwall, Sutton, & Pawlowski, 2000).

Second, we know that access to new knowledge and technology is often a key motive in the acquisition decisions of acquirers (Ahuja & Katila, 2001; Desyllas & Hughes, 2008; Inkpen et al., 2000; Puranam et al., 2003), who often find it beneficial to select from the more successful experiments in the market rather than to go through costly experimentation internally (Eliasson & Eliasson, 2005; Foss & Foss, 2002). In fact, larger firms sometimes spin off new ventures precisely to write off costly research activity from their balance sheet and thus show better performance to the public (Germeraad, 2001). These spin-offs are then re-acquired by the original incumbent if they show potential.

Third, there is evidence that acquiring firms use acquisitions as a substitute for internal exploration in the form of R&D (Blonigen & Taylor, 2000), and yet do not capture value from the acquisition if the source of synergistic value creation is only the target firm's resources with little contribution from the acquirer (Capron & Pistre, 2002). Considering these findings, it is reasonable to expect that such acquirers will look for acquisition opportunities in which they can contribute exploitation resources. In this vein, Rothaermel (2001) finds that in cooperating with new entrants to access new technologies, incumbents are better off focusing on exploitation of complementary assets rather than exploration of the new technology. Fourth, anticipating such an inter-organizational division of labor, new ventures aiming for acquisition exits can be expected to allocate less resources to costly exploitation capabilities and the often long, cumbersome process of establishing independent market legitimacy that may never be needed. They are likely to anticipate benefit by waiting to couple their resources with the complementary resources and established legitimacy of acquirers (Stuart, Hoang, & Hybels, 1999; Teece, 1986).

While Capron and Pistre's (2002) finding of the need for resource contribution from the acquirer stems from competitive pressures on the buyers' side (Barney, 1988; Chatterjee, 1992), the market for acquisitions also creates competitive pressures on the targets' side. These pressures induce start-ups to allocate more resources towards exploration and take greater risks in research and development in order to develop more radical innovations. In a study of young bio-tech companies in the UK, Mohr and Garnsey (2009) found a list of factors including breakthrough science improved early exit prospects. Norbäck, Persson, and Svensson (2009) found that the most high quality innovations are the most attractive acquisition targets, and the model by Henkel, Rønde, and Wagner (2010) suggests that firms playing the acquisition game will be driven to produce more and more high risk innovations. In sum, given what we know about the market for acquisitions of start-ups, more of the exp-exp balance is likely to occur at an inter-organizational level rather than internally in start-ups that get acquired (Birkinshaw & Gupta, 2013; Gupta et al., 2006b) and this will both enable and induce the internal exp-exp balance of start-ups competing for acquisition to tilt towards exploration.

H4: Among new ventures, the level of exp-exp balance associated with the highest acquisition likelihood is more tilted towards the exploration end of the exp-exp continuum compared to the level of exp-exp balance associated with the highest profitability (H4a) and survival likelihood (H4b).

Technology level and the performance outcomes of exploration

Many exp-exp studies have noted the important role of environmental factors in determining the influence of exp-exp on performance and survival. In short, the argument is that exploration is more valuable in some environments because a) there is more to explore and b) the risks of not exploring enough are higher. Researchers have looked at different operationalizations of the dynamism (Jansen, van den Bosch, & Volberda, 2006; Lee, Wu, & Liu, 2013; Wang & Li, 2008), munificence (Cao et al., 2009), and technology level (Uotila et al., 2009) of the environment to study this contingency effect, and the results have generally supported the idea that exploration is less beneficial in more stable, munificent and low tech environments. Bierly and Daly (2007) operationalized exploration and exploitation separately and found that among the three aspects of environment, only technology level was a significant moderator of the performance effects of both exploration and exploitation.

High-technology industries are characterized by more uncertainty, ambiguity and complexity (Scott, 2003) rendering the management of knowledge more important in these industries (Uotila et al., 2009). Thus competition in these industries is more heavily based on knowledge-based factors compared to low-tech industries (Bierly & Daly, 2007; Grant, 1996a). Due to the higher uncertainty and dynamism of knowledge-based competition, firms in high-tech industries cannot rely on existing competitive advantages for sustained advantage in the long term, and must explore enough to be able to continually jump from one temporary advantage to another when needed (D'Aveni et al., 2010; Eisenhardt & Brown, 1998; Sørensen & Stuart, 2000). On the other hand, in knowledge-based competition the role of size-based advantages such as economies of scale are less pronounced, and opportunities for small new entrants to create and capture significant value are more abundant (Bierly & Daly, 2007; Grant, 1996a), which translates to higher upside potential returns to exploration for new ventures in high-tech industries (Baysinger & Hoskisson, 1989). Uotila et al. (2009) found that unlike high-tech firms, attempting to achieve a balanced level of exploration was not beneficial and even harmful for the financial performance of low-tech firms.

The inter-organizational division of labor among start-ups and incumbents is also more strongly operative in high-tech industries. Acquisitions seem to be a particularly desirable outcome in these industries where new ventures are often the source of breakthrough innovations but do not have the resources to fully exploit the innovations themselves (Bayar & Chemmanur, 2010; Henkel et al., 2010; Mohr & Garnsey, 2009). Although the importance of technology level as a contingency factor has been recognized before, it has not been applied to multiple performance dimensions. Here, we have argued that the greater benefits of exploration in high-tech compared to low-tech environments can be expected to apply to all three performance dimensions of profitability, survival, and attractiveness as an acquisition target among new ventures. Therefore, we hypothesize that:

H5: Among new ventures, industry technology level moderates the relationship between exploration and survival (H5a), profitability (H5b), and acquisition likelihood (H5c).

DATA AND MEASURES

Data and sample

This chapter utilizes data from the Kauffman Firm Survey (KFS) which has been heralded as one of the only large scale panel datasets available for evidence-based entrepreneurship research (Frese, Rousseau, & Wiklund, 2014). The survey was conducted by the Ewing Marion Kauffman Foundation and collected data on new firms founded in 2004 (the baseline year) with seven (roughly annual) follow-up surveys from 2005-2011. A random sampling frame of 32,469 firms was taken from Dun and Bradstreet's database (D&B) of all new businesses started in 2004 in the United States, excluding non-profit firms, those owned by an existing business, or firms inherited from someone else. Business start was defined in terms of performing at least one of the following activities in 2004 and none in previous years: payment of state unemployment taxes; payment of Federal Insurance Contributions Act (FICA) taxes; presence of a legal status for the business; use of an Employer Identification Number (EIN); or use of Schedule C to report business income on a personal tax return. From this sampling frame, data was collected from 4,928 businesses with either web surveys or phone interviews, where a $50 incentive was provided to respondents. More than 375,000 phone calls were carried out to complete the 2004 baseline survey alone. The sample is statistically representative of 73,278 firms that were founded in the US in 2004. Comprehensive details on the KFS data and sampling procedures are provided in multiple publicly available reports by the Kauffman foundation (Ballou et al., 2008; DesRoches et al., 2007; DesRoches, Potter, Santos, Sengmavong, & Zheng, 2012; Robb et al., 2009).

Advantages of the KFS dataset include a large sample size, a large range of firms from different sizes and industries, the following of firms from birth and short intervals between follow-ups (Nassereddine, 2012). Furthermore, all firms are born in the same year and tracked in the same time period, thus controlling for age, economic cycles and other time-variant noise by design. Also, since the data is managed by the Kauffman foundation, is publicly documented, and numerous other researchers have worked or are working with the same database (e.g., Cassar, 2014; Doms, Lewis, & Robb, 2010; Fairlie & Robb, 2009; Lee & Zhang, 2011; Shane, 2009), objective verification and replication of research findings is facilitated.

For our specific purpose of studying profitability, survival and acquisition simultaneously, the KFS data has the benefit of including a large enough sample in which some firms randomly failed or got acquired. This is in contrast to many other studies which—due to the difficulty of collecting large samples—rely instead on matched sampling techniques to compare a sample of acquired / survived firms with a matched sample of not-acquired or failed firms. Because matched samples are not fully random, their analysis is more prone to error and requires special treatment to control for bias (Cram, Karan, & Stuart, 2009) such that full randomness is approximated as closely as possible (Rubin, 2007). Another advantage of this data for our purposes is the intentional oversampling of high-tech firms. Since these firms on average account for 1.8 percent of the population (DesRoches et al., 2012) and M&A exits are relatively rare events, even a sample size as large as this would likely not include enough M&A exits of high-tech firms to produce meaningful statistical comparisons if high-tech firms were not specifically oversampled.

On December 3, 2013, the Kauffman foundation released a multiply imputed version of the KFS dataset in which the original data was included along with five imputations of the data in which soft missing values were replaced systematically with computer-generated predictions based on available data using the chained equations method (Raghunathan, Lepkowski, Van Hoewyk, & Solenberger, 2001) also known as sequential regression multivariate imputation (SRMI). Generation of multiple imputations (m=5 in this case) helps account for the uncertainty of the predicted values (Rubin, 2004). Hard missing values were kept as missing in all imputations as they represent legitimate non-response (e.g., skip logic or firm closure). Multiple imputation was carried out after extensive logical imputation, data cleaning and editing that increased usability and accuracy of the analyses. Details of the data editing and imputation procedures are available in Farhat and Robb (2013). In the longitudinal panel-form of the dataset only firms that responded to all surveys up to the last year they existed are included. This results in a baseline sample of 3,140 firms, out of which only 1,630 remained in existence in 2011 (200 had exited through M&A and 1,310 had closed). Mathematica Policy Research was contracted to assign sampling weights such that this smaller sample is still representative of 73,278 firms in the broader population (DesRoches et al., 2012). Except for descriptive statistics, all analyses in this chapter are performed on the multiply imputed dataset unless indicated otherwise.

Variables and measures

Indepdenent variables

Exploration

The particular perspective taken by researchers on how to conceptualize exp-exp determines the way in which they measure it (Junni et al., 2013). Those taking the orthogonal view usually measure exploration and exploitation on separate scales and often emphasize the complementarity of the two measured in additive or multiplicative forms as representative of a ‘combined’ dimension of ambidexterity and a subtractive form as representative of a ‘balanced’ dimension (Cao et al., 2009; Junni et al., 2013). On the other hand those taking the strict trade-off or continuum view of exp-exp recommend the use of a single continuum measure so that the trade-off assumption is embedded in the measure itself (Lavie et al., 2010). Taking the latter approach in this chapter and relying on the upstream vs. downstream conceptualization, we constructed an exp-exp continuum measure by combining information from variables that recorded the number of employees and owners working in R&D (as proxy for exploration) and the number of employees and owners working in sales (as proxy for exploitation) reported by survey respondents. For each year we calculated relative exploration according to the following formula:

$$\frac{Number\ of\ employees\ in\ R\&D - Number\ of\ employees\ in\ sales}{Number\ of\ employees\ in\ R\&D + Number\ of\ employees\ in\ sales}$$

We then took the average level of the above value over all the years the firm has reported both components of the measure during its existence, and adjusted these values for industry-year averages to arrive at our measure of exploration. This measure aggregates both simultaneous and sequential exploration and exploitation balance over time. The variable by construction controls for the potential confounding of firm size, exploration and performance, and also accounts for the common presence of multitasking in start-ups. Since the exploration variable has hard missing values for some firms that did not report number of employees in R&D and sales for any years, the sample size is accordingly smaller (N=2,624) for some of our analyses.

We considered alternative measures for the components of the exploration variable. Potential indicators of exploration (conceptualized as upstream R&D activity) and exploitation (conceptualized as downstream sales activity) are available in the KFS in three categories: a) dummy variables indicating yes or no answers to questions such as ‘did the firm have any sales?’ or ‘did the firm spend any money on R&D?’, b) number of employee variables recording integer values in response to questions like ‘On December 31, 2005, how many employees or owners, if any, did [business] have who were primarily responsible for research and development on new products or services?’ or ‘who were primarily responsible for sales or marketing such as sales, market research, customer analysis, or promotional activities?’, and c) amount of money variables in response to questions such as ‘estimate [business]'s total research and development expenses for calendar year 2007, including materials, equipment, space, salaries, wages, benefits, and consulting fees.’

We decided against the use of dummy variables because of the comparative lack of variance and information, and also because dummy variables for exploitation could easily be confounded with performance / profitability. In the case of dummy variables this confounding cannot be adjusted for using a proportional form. For amount of money values, the problem was that expenses on R&D were only measured starting in 2007, making three years of data unusable with this variable. The confounding issue was again a problem with money values for sales which could be considered an indicator of performance. However, the number of employee variables were measured from the baseline survey, provided less confounding with performance, and included enough detail to be able to construct proportions.

We also considered a number of possible alternatives to the exploration formula above. If we were to use only ‘number of employees in R&D’ as our exploration measure we could not account for multitasking and would potentially confound this variable with performance, because better performing firms grow larger and have more employees to spend on R&D. This does not necessarily mean that they are carrying out more exploration relative to their exploitation. We could possibly mitigate this problem by dividing the number of employees in R&D by total employees. However, the firms in our sample are mostly very small firms often with only one or two employees that multitask. In other words, dividing number of employees in R&D by total employees does not distinguish between a two-person firms in which both employees are only focusing on R&D and a two-person firm in which both employees are doing both R&D and sales. In order to address this issue, our denominator specifically counts both R&D and sales employees. This denominator also has the effect of controlling for size, since larger firms may in general have more slack to spend on exploration. Finally, the number of employees in sales is included in the numerator as well in order for the scaling to better capture the variance of exp-exp in the continuum concept adopted. If this subtraction was not included in the numerator, both extremely low exploration and extremely high exploitation would drive the value of the construct to zero. However, in our construct the level of exploration orientation and exploitation orientation are quantified with the same proportions above or below zero, which is more intuitive and easier to understand.

Industry technology level (moderator variable)

The KFS has a stratified sample in which one of the stratification variables is industry technology level following the categorization by the Bureau of Labor Statistics reported in Hadlock, Hecker, and Gannon (1991). Based on this classification, four industries were identified as high tech based on percentage of employment in R&D: Chemicals and allied products, industrial machinery and equipment, electrical and electronic equipment, instruments and related products. All other industries were classified as medium and low tech. Hence our measure of industry technology level is a dummy variable indicating whether or not the firm's industry falls in the high tech category. High tech firms were intentionally oversampled in the data collection and so sampling weights are applied in our analyses as necessary in addition to accounting for stratification. Of the 3,140 firms in the baseline sample, 432 were categorized as high-tech and 2,708 were low and medium tech.

Dependent variables

Outcome events

The KFS provides us with the year in which the firm went out of business and the reason it is no longer in business. We constructed an event variable that for each year takes the value 0 if the firm survived that year, 1 if the firm was merged or acquired that year, and 2 if the firm closed by stopping operations in that year.

Profitability

The KFS included questions that asked participants to indicate whether the business' income in the current calendar year after deducting all expenses and taxes was a total profit or loss. Then the exact amount of this profit or loss was recorded and for participants not willing or able to provide an exact amount, a follow-up question asked for the range of this value in nine categories (zero,

$500 or less, $501 to $1,000, $1,001 to $3,000, $3,001 to $5,000, $5,001 to $10,000, $10,001 to $25,000, $25,001 to $100,000, $100,001 to $1,000,000, and $1,000,001 or more). In the multiply imputed data, the range values were used in the imputation algorithm to compute more accurate replacements for missing values in the continuous variable. The profit and loss variables were then combined by using negative values for loss amounts. For our measure of profitability, we take the average of this combined profit/loss variable over the number of years the firm has been in existence, scaled to $1000 units. Similar to Ebben and Johnson (2005), we also applied 5% winsorization. The Winsor technique is a method for reducing the influence of outlier observations without discarding their data (Fuller, 1991). This is achieved by changing the highest 5% of the values of a variable to the next smallest value, and changing the 5% smallest values to the next largest value. This was deemed necessary due the disproportionate effect of a very small number of outliers. Other potential indicators of performance were considered but ruled out. Growth was deemed unsuitable due to the heavily fluctuating nature of performance over time in the sample and the increased sensitivity of growth calculations to missing values. Relative measures such as Return on Assets were also deemed inappropriate due to dependency on additional variables (e.g., assets) that included a high percentage of missing values.

Controls

Gender

Some previous studies have found differences in performance and survival measures among male-owned and female-owned new ventures (Robb, 2002; Watson, 2003), although this may only be indicative of differences in goals and motivations rather than success or failure (Jennings & McDougald, 2007). We base our gender variable on the sampling stratification of the KFS. This was based on whether the firm was indicated to have a female owner or CEO in the original D&B sampling frame. 70 of the high-tech firms and 541 of the low and medium tech firms were characterized as women-owned.

Education

A recent meta-analysis of research on education and entrepreneurship finds that formal schooling has a significant and positive relationship with performance and survival (Van der Sluis, Van Praag, & Vijverberg, 2008). It is reasonable to expect that more educated founders increase the human capital value of the firm for potential acquirers. The KFS recorded the highest level of education for each owner of the firm in ten ordered categories: 1) less than 9th grade, 2) Some high school, but no diploma, 3) high school graduate (diploma or equivalent), 4) technical, trade or vocational degree, 5) some college, but no degree, 6) Associate's degree, 7) Bachelor's degree, 8) some graduate school but no degree, 9) Master's degree, and 10) professional school or doctorate. For our education measure, we took the numerical value of the category indicated for each owner and calculated the mean of these values across all owners of the firm.

Industry-specific work experience

Work experience is another dimension of human capital that can be expected to influence profitability, survival, and acquisition likelihood. Brüderl, Preisendörfer, and Ziegler (1992) found that work experience, and particularly industry-specific work experience is a significant determinant of new business survival. Arora and Nandkumar (2011) argue that the work experience of entrepreneurs is an indicator of their opportunity costs, and find that high opportunity cost entrepreneurs take more aggressive approaches and prefer a shorter time to success by cashing out through acquisition. In the KFS, the number of years of work experience in the industry of the business was recorded for each owner. For our work experience measure, we computed the mean value of this variable across all owners of the firm.

Previous entrepreneurial experience

The entrepreneur's prior experience in starting a business can influence the performance and survival chances of their current business. Previous experience with business founding and ownership can provide the entrepreneur with valuable learning and a network of contacts that can be leveraged in later entrepreneurial endeavors (Westhead, Ucbasaran, & Wright, 2005). Furthermore, DeTienne and Cardon (2012) found that experienced entrepreneurs are more likely to seek higher-impact and higher-return exits such as acquisitions and IPOs. For our purposes, we measure previous entrepreneurial experience with a dummy variable indicating whether or not any of the firm's owners have previously started a new business.

Venture capital funding

VC financing can be expected to lead to improved performance and survival by providing firms with a wealth of financial and social capital, and is also an indication of objective vetting of the quality and potential of the business in the first place (Baum & Silverman, 2004). However, VC financing is also considered 'impatient capital' and brings with it a preference for short-term exit

(Bayar & Chemmanur, 2010; Collins, 2000). Gans et al. (2002) found that venture-backed firms were more likely to cooperate rather than compete with established incumbents due to the role of their backers in reducing the transaction costs of identifying and contracting with incumbent firms. Mohr and Garnsey (2009) also note that specially if backed by VC, young firms find early exit through acquisition to be an attractive outcome for gaining fast returns on investment. In this chapter, we measure venture financing with a dummy variable indicating whether or not the firm has ever (from birth up to analysis time) had an equity investment from venture capitalists.

ANALYSIS AND RESULTS

Descriptive findings and non-parametric analysis[9]

Before delving into our main hypotheses, some descriptive analyses can help us gain a better picture of the data. Table 2 reports the number of exits (through acquisition or closure) and survived firms by year. The percentage of survived firms is also graphed in Figure 2. The exit and survival statistics are in line with those reported by others (e.g., Evans & Leighton, 1989; Levie et al., 2011) providing further validation of the representativeness of our sample. Non-parametric survival analysis tools such as the hazard function, Kaplan-Meier survivor function, and Nelson-Aalen cumulative hazard function provide further insight. These are detailed in Table 3 and graphed in Figure 3, both separated by technology level. The descriptive findings are consistent with a previous analysis on an incomplete version of the same data (Coleman, Cotei, & Farhat, 2013), although that study did not separate the results by technology level. It can be observed that in general, the hazard of both closure and M&A peaks at around the third year of the firm's life, and that high tech firms generally have a higher hazard of acquisition and lower hazard of closure compared to low and medium tech firms.

[9] Many summary tables and descriptive statistics on the KFS are readily available in the public documentation and previous studies on this dataset. Here, we report descriptive findings most relevant to our hypotheses and variables.

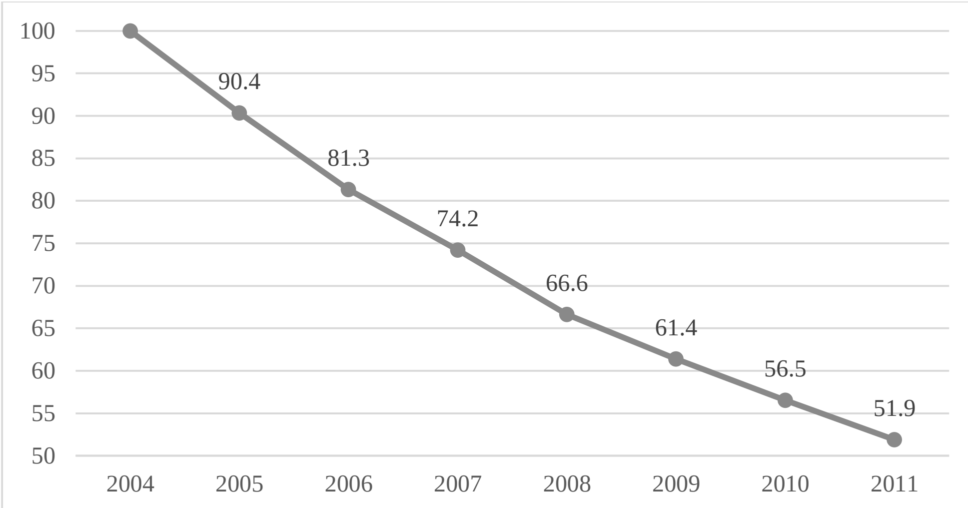


Figure 2: Percentage of survived firms in each year

Table 2: Summary of survival and exit frequencies in each year

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
M&A	43	36	36	25	23	20	17
Closed	260	247	188	213	141	133	128
Survived	2,837	2,554	2,330	2,092	1,928	1,775	1,630

Table 3: Kaplan-Meier survivor and Nelson-Aalen cumulative hazard functions

	Medium and Low Tech				**High Tech**			
Year	Survival from M&A	M&A cum. hazard	Survival from closure	Closure cum. hazard	Survival from M&A	M&A cum. hazard	Survival from closure	Closure cum. hazard
2005	0.9851	0.0149	0.9062	0.0938	0.9799	0.0201	0.9173	0.0827
2006	0.9682	0.0321	0.8080	0.2022	0.9652	0.0351	0.8558	0.1497
2007	0.9569	0.0437	0.7399	0.2865	0.9298	0.0718	0.7903	0.2263
2008	0.9473	0.0538	0.6663	0.3860	0.9176	0.0849	0.7257	0.3081
2009	0.9362	0.0654	0.6138	0.4647	0.9019	0.1020	0.6813	0.3692
2010	0.9259	0.0764	0.5673	0.5405	0.8909	0.1143	0.6560	0.4063
2011	0.9172	0.0859	0.5222	0.6200	0.8852	0.1206	0.6258	0.4524

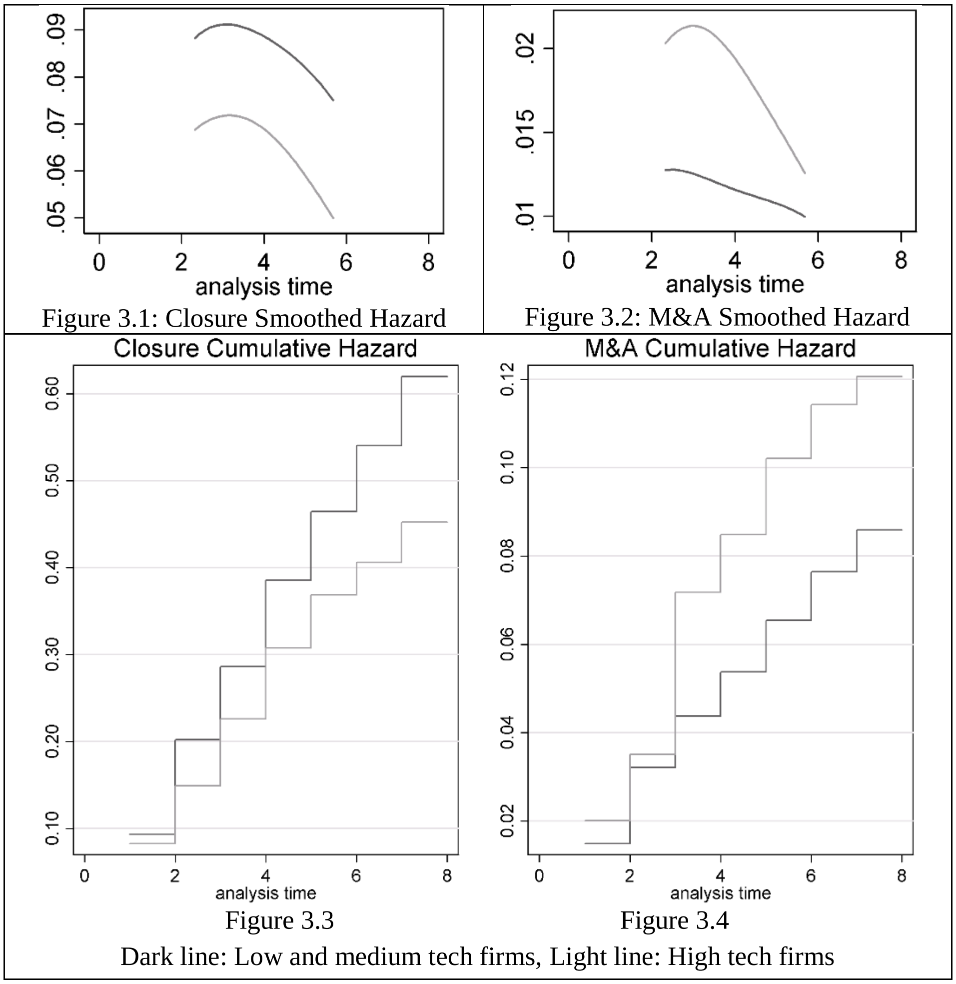


Figure 3.1: Closure Smoothed Hazard

Figure 3.2: M&A Smoothed Hazard

Figure 3.3

Figure 3.4

Dark line: Low and medium tech firms, Light line: High tech firms

Figure 3: Smoothed and cumulative hazard rates for closure and acquisition by technology level

We used a Cox regression based test for the equality of survivor functions (because it has been generalized to sample-weighted data) and found that they differ significantly among technology levels. This indicates the importance of accounting for technology level in our analyses. Of the firms founded in 2004, by 2011 63% of high tech firms and 52% of low and medium tech firms that had not been acquired survived closure, with the difference in survivor functions significant at the 0.001 level. At the same time, 11% of high tech firms and 8% of low and medium tech firms that were not closed were acquired by 2011, with the difference in survivor functions significant at the 0.1 level.

Table 4 reports pairwise product-moment correlation coefficients for all variables incorporated in our models, along with descriptive statistics. The table does not indicate any serious multicollinearity problem since no individual correlation is higher than 0.1 in absolute value.

Consistent with the prediction of exp-exp theory (March, 1991; O'Reilly & Tushman, 2013) and previous empirical research (Uotila et al., 2009), the firms on average are more exploitation oriented than exploration oriented (mean = -.0247).

Table 4: Correlation matrix and descriptive statistics (using un-imputed data)

Variable	1	2	3	4	5	6	7	Mean	SD	Min	Max
1 Exploration	1							-.0247	0.3928	-0.9954	1.2686
2 Profitability	-0.0743	1						14051.71	49313.9	-55572.3	137839.9
3 Female owned	0.0114	-0.0448	1					0.150	0.357	0	1
4 Education	0.0051	0.0169	0.0227	1				6.58	1.83	1	10
5 Work experience	-0.0005	0.0868	-0.0969	0.0573	1			12.22	9.12	0	48
6 Ent. experience	-0.0441	-0.0250	-0.0717	0.0437	0.0377	1		0.60	0.49	0	1
7 VC Funded	0.0592	-0.0850	-0.0259	0.0519	-0.0285	0.0561	1	0.02	0.15	0	1

Profitability is winzorized. Descriptive statistics for profitability and exploration are before mean-centering.

Overview of statistical methods and results

For hypotheses H1, H3, H4, H5a and H5c where our main dependent variable is an event (becoming acquired or closed), event-history or survival analysis is an appropriate method because it specifically accounts for right-censoring (the fact that firms are not observed after exit). Logistic regression is a common tool for semi-parametric survival analysis when event times are discrete, and can be adapted to competing risks analysis using multinomial logistic regression (Allison, 1995)[10]. While standard survival analysis is based on only one type of exit event (hazard / death), competing risks analysis generalizes the method to cases in which different types of exit events can occur, and that the occurrence of one type precludes the occurrence of any other.

Table 5 shows the results of the competing risks analysis for all firms and Table 6 separates them by technology level. Independent variables that are tested for curvilinear relationships are mean-centered to mitigate the problem of non-essential collinearity between a variable and its squared term (Aiken & West, 1991; Dalal & Zickar, 2012). To account for temporal dependence, year dummies were included in all models as standard in the use of logistic regression for survival analysis, but excluded from the reported tables for simplicity. Tables report exponentiated coefficients that represent relative risk ratios or RRRs (similar to odds ratios but adjusted for multiple hazards). RRRs represent the probability of an outcome (acquisition or closure) relative to the probability of the base outcome (survival). Reporting these relative probabilities rather than

[10] The Cox proportional hazards model produces qualitatively similar results.

absolute probabilities is especially useful in nonlinear models because absolute probabilities in these models vary depending on the particular values of other variables (Hoetker, 2007; Wiersema & Bowen, 2009), and although the interpretation of RRRs may be less intuitive than absolute probabilities for some models (Hoetker, 2007), they are intuitive for survival analysis and their use is standard practice in this context (Rabe-Hesketh & Skrondal, 2012). In what follows, we use the term 'likelihood' in reference to RRRs unless indicated otherwise[11].

Table 5: Multinomial logistic regression for competing risks of closure and acquisition

	Model 1	Model 2	Model 3	Model 4	Model 5
M&A					
Female owned	0.842	0.741	0.739	0.737	0.740
Education	1.064	1.063	1.061	1.063	1.061
Work experience	0.969*	0.966*	0.966*	0.966*	0.966*
Ent. experience	1.344	1.306	1.307	1.307	1.308
VC Funded	1.609	1.654	1.591	1.639	1.586
High-tech	1.579+	1.658*	1.584+	1.651*	1.985*
Exploration		0.691	0.661	0.707	0.684
High-tech*Exploration			2.491*		5.404+
Exploration^2				1.106	1.141
High-tech*Exploration^2					0.129+
Constant	0.0097***	0.0102***	0.0104***	0.0101***	0.0102***
Closure					
Female owned	1.288+	1.283+	1.284+	1.281+	1.281+
Education	0.926**	0.928*	0.929*	0.927**	0.927**
Work experience	0.987*	0.987*	0.987*	0.987*	0.987*
Ent. experience	0.806*	0.803*	0.802*	0.804*	0.804*
VC Funded	0.583	0.548	0.552	0.543	0.546
High-tech	0.745*	0.719*	0.725*	0.711*	0.677*
Exploration		1.294+	1.306+	1.309+	1.321*
High-tech*Exploration			0.663		0.641
Exploration^2				1.217	1.213
High-tech*Exploration^2					1.318
Constant	0.285***	0.284***	0.283***	0.280***	0.280***
N	1,374	1,314	1,314	1,314	1,314
Min no. of obs. in imputations	7,364	7,225	7,225	7,225	7,225
F	4207.59	48545.71	2900.14	1933.93	1459.17
Prob > F	0.000	0.000	0.000	0.000	0.000

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[11] There is no consensus on which pseudo R-squared measures are most suitable for logistic regression (Hoetker, 2007; Veall & Zimmermann, 1996), and in either case, no such measures are available for survey clustered data when fitting multinomial logistic models (Archer, Lemeshow, & Hosmer, 2007) because the underlying maximum likelihood methods assume independently and identically distributed observations. Hence Stata uses F-tests instead to assess goodness-of-fit for the 'svy: mlogit' command and these are reported under each model in the tables.

Table 6: Multinomial logistic regression for competing risks of closure and acquisition by technology level

	Low & Medium Tech		High Tech	
	Model 6	Model 7	Model 8	Model 9
M&A				
Female owned	0.718	0.717	1.761	1.836
Education	1.059	1.058	1.086	1.113
Work experience	0.965*	0.965*	0.997	0.998
Ent. experience	1.330	1.331	0.818	0.800
VC Funded	1.338	1.325	5.670**	6.028**
Exploration	0.661	0.684	1.207	2.263
Exploration^2		1.148		0.126+
Constant	0.0107***	0.0105***	0.0087**	0.0091**
Closure				
Female owned	1.293+	1.290+	0.790	0.786
Education	0.929*	0.928*	0.879*	0.874*
Work experience	0.987+	0.987+	0.968+	0.968+
Ent. experience	0.800*	0.801*	0.914	0.920
VC Funded	0.486	0.482	2.226	2.119
Exploration	1.306+	1.322*	0.820	0.823
Exploration^2		1.214		1.486
Constant	0.282***	0.279***	0.295*	0.288*
N	1,083	1,083	231	231
Min no. of obs. in imputations	5,860	5,860	1,364	1,364
F	1915.99	1890.77	3908.54	3600.26
Prob > F	0.000	0.000	0.000	0.000

+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

In Table 5, Model 1 includes all control variables, Model 2 adds exploration as an independent variable, and Model 3 brings in the interaction term of technology level and exploration. Models 4 and 5 take the same steps as Models 2 and 3 but also include the squared term of the exploration variable and its interaction with technology level. In Table 6, Models 2 and 4 are repeated separately for low and medium tech (Models 6-7) and high tech firms (Models 8-9). As recommended by a recent stream of research on best practices in the use of logit models in management research (Hoetker, 2007; Wiersema & Bowen, 2009; Zelner, 2009), it is expedient to separate results for technology levels because the sign, coefficient, and significance of the interaction term alone are potentially problematic indicators in nonlinear models and because the use of an interaction term to compare groups requires the additional assumption that unobserved variance is equal across groups.

The results were followed and supported by further post-estimation analysis of margins using Stata's margins and marginsplot commands (Williams, 2012). Such analysis allows us to a) take absolute probabilities rather than relative ones as the dependent variable, b) to decompose the predicted margins and marginal effects of the independent variables over their full range, accounting for their variation over different values of other variables, c) to provide a visualization of the results as recommended by Hoetker (2007) and d) to help analyze the statistical significance of moderation effects or cross-group comparisons as recommended by Zelner (2009). In order to provide conservative estimates, margins analysis is conducted on the original non-imputed version of the data[12]. Figure 4 graphs the predicted margins (in this case predicted absolute probabilities) of acquisition among high tech firms over the full range of exploration, and Figure 5 does the same for predicted probabilities of closure among low and medium tech firms. To test the moderation effect of technology level, Figure 6 and Figure 7 plot the difference in predicted probabilities among technology levels, with 95% confidence intervals.

The relationship between exploration and profitability was tested using a random effects regression model that employs a weighted average of fixed effect and between effects. The results are reported in Table 7 for all firms, in Table 8 for the sub-population of survived firms, and in Table 9 for acquired and closed firms. Table 8 and Table 9 also separate the results by technology level. In Table 7, Model 10 includes only the control variables, Model 11 adds exploration and Model 12 adds the interaction of exploration and technology level. Models 13 and 14 include the quadratic term for exploration and its interaction with technology level. Models 11 and 13 are repeated in Table 8 and Table 9 for each category and technology level. The random effects regression command in Stata could not control for sampling weights but a robustness check using a fixed effects model that did control for sampling weights yielded qualitatively similar results not reported here.

[12] Note that since the effect of exploration on probability (as opposed to RRR) differs for different values of other variables, there are two ways to compute aggregate margins (Williams, 2012). First is to set all other variables to their means and compute the margins (Marginal effect at the mean, or MEM), the second is to compute the margins separately for all observed values of other variables and to take the mean of those margins as the aggregate margin (Average marginal effect, or AME). The relative merits of each is debated among researchers, but the latter seems to be preferred (Hoetker, 2007; Train, 1986; Williams, 2012). Hence we report only the AMEs, although the graphs for MEMs look very similar.

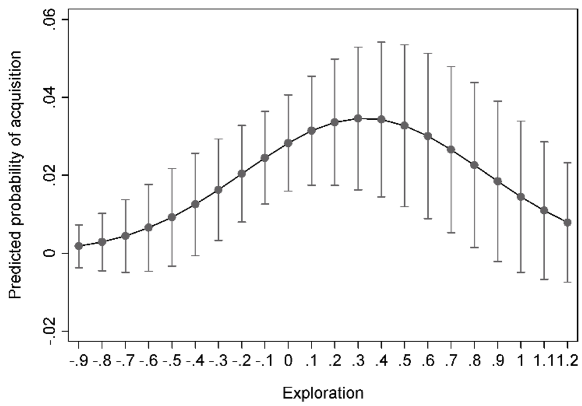


Figure 4: Predicted margins with 95% CIs for the probability of acquisition across the range of exploration in high tech start-ups, based on Model 5.

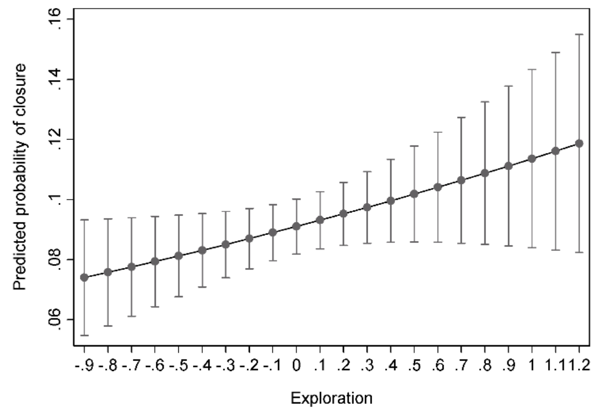


Figure 5: Predicted margins with 95% CIs for the probability of closure across the range of exploration in low and medium tech start-ups, based on Model 4.

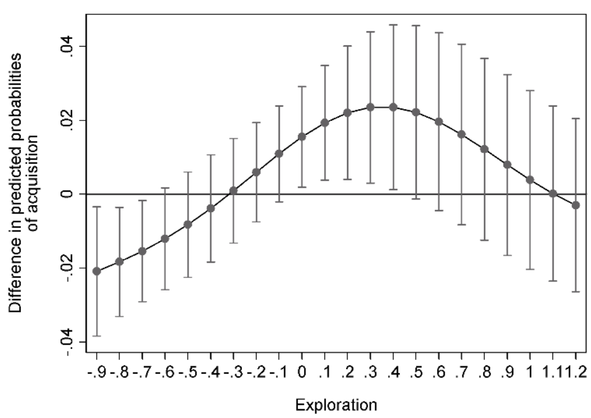


Figure 6: Difference in predicted probabilities of acquisition between technology levels (high tech minus low and medium tech) with 95% CIs across the range of exploration, based on Model 5.

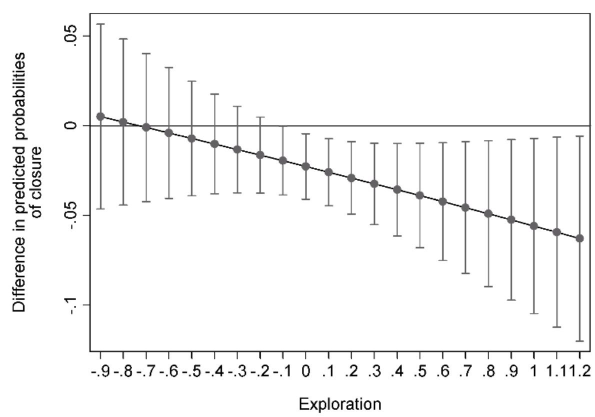


Figure 7: Difference in predicted probabilities of closure between technology levels (high tech minus low and medium tech) with 95% CIs across the range of exploration, based on Model 4.

Tests of main effect and moderation hypotheses

H1 predicted a curvilinear relationship between exploration and survival. Models 2-5 indicate a curvilinear relationship between exploration and the risk of closure (relative to survival) could not be supported, but a positive linear relationship was found instead, indicating a negative linear relationship between exploration and survival.

However, as models 8-9 indicate, this relationship did not hold for high tech firms. H2 predicted a curvilinear relationship between exploration and profitability. Models 13 and 14 strongly support H2. However, when we separate these results among survived, closed and acquired firms (Table 8 and Table 9), we find that the results are driven mainly by survived firms and the exploration-profitability relationship is not supported among either acquired or closed firms. H3 predicted a curvilinear relationship between exploration and acquisition likelihood. Comparing Models 6-7 with 8-9, H3 was modestly supported for high-tech firms but not for low and medium tech firms.

Table 7: Random effects linear regression (DV = Profitability) for all firms

	Model 10	Model 11	Model 12	Model 13	Model 14
Female owned	-2.495	-2.641	-2.507	-2.573	-2.455
Education	-1.229*	-1.312*	-1.260*	-1.288*	-1.231*
Work experience	0.318*	0.296*	0.308*	0.286*	0.296*
Ent. experience	0.190	0.062	0.028	0.298	0.247
VC Funded	-12.17	-10.93	-9.621	-10.68	-9.383
High-tech	-3.368	-3.105	-2.928	-2.544	-1.801
Exploration		-5.894*	-2.521	-7.083**	-4.035
High-tech*Exploration			-15.18*		-13.13+
Exploration^2				-15.41**	-14.02**
High-tech*Exploration^2					-3.487
Constant	0.972	2.094	1.637	4.230	3.554
N	1,374	1,314	1,314	1,314	1,314
Min no. of obs. in imputations	7,364	7,224	7,224	7,224	7,224
F	2.16	2.29	2.39	3.99	3.59
Prob > F	0.0443	0.0248	0.0144	0.0001	0.0001
Rho (fraction of variance explained)	0.693	0.703	0.702	0.704	0.704

+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001, All models: Model F test: Equal FMI, VCE type: Robust

Table 8: Random effects linear regression (DV = Profitability) for survived firms by technology level

	Survived Firms			
	Low & Medium Tech		High Tech	
	Model 15	Model 16	Model 17	Model 18
Female owned	0.541	0.444	-14.62	-12.80
Education	-1.016	-1.240	-6.462**	-5.946**
Work experience	0.294	0.285	0.380	0.357
Ent. experience	-0.709	-0.175	6.658	6.102
VC Funded	-1.127	-1.993	-19.91	-12.20
Exploration	-4.198	-7.019	-18.45*	-19.68*
Exploration^2		-19.69**		-20.91*
Constant	9.816	13.67+	41.41*	41.84*
N	524	524	133	133
Min no. of obs. in imputations	4,088	4,088	1,042	1,042
F	0.75	1.79	3.42	3.84
Prob > F	0.6067	0.0839	0.0022	0.0004
Rho (fraction of variance explained)	0.741	0.744	0.692	0.693

+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001, All models: Model F test: Equal FMI, VCE type: Robust

Table 9: Random effects linear regression (DV = Profitability) for acquired and closed firms by technology level

	Acquired Firms				Closed Firms			
	Low & Medium Tech		High Tech		Low & Medium Tech		High Tech	
	Model 19	Model 20	Model 21	Model 22	Model 23	Model 24	Model 25	Model 26
Female owned	-7.674	-7.631	32.00+	32.46+	0.0777	0.0500	10.41	9.872
Education	-1.066	-1.032	-0.063	0.335	-0.119	-0.0784	-0.166	-0.146
Work experience	-0.311	-0.311	0.885	0.779	0.156	0.152	-0.094	-0.099
Ent. experience	6.760	6.685	-17.13	-17.15	-0.510	-0.467	-1.530	-1.639
VC Funded	-60.86***	-60.45***	17.48	17.71	-24.62***	-25.78***	-18.47*	-18.30*
Exploration	1.385	1.371	12.68	12.97	1.677	1.371	-11.81+	-10.86
Exploration^2		-1.343		-4.183		-5.074		-3.480
Constant	-2.798	-2.737	-44.55	-45.46	-15.02**	-14.37**	-19.87	-19.04
N	83	83	25	25	475	475	73	73
Min no. of obs. in imputations	259	259	81	81	1,511	1,511	241	241
F	25.50	13.58	2.07	1.61	2.45	2.55	2.20	2.19
Prob > F	0.0000	0.0000	0.0536	0.1290	0.0237	0.0133	0.0418	0.0328
Rho (fraction of variance explained)	0.662	0.664	0.854	0.843	0.707	0.707	0.753	0.752

+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001, All models: Model F test: Equal FMI, VCE type: Robust

H5a predicted that the exploration—survival relationship (H1) would be moderated by technology level. Although the interaction term in Model 3 is not statistically significant, interaction terms in logistic models are not sufficient tests of moderation effects (Hoetker, 2007). The fact that the relationship between exploration and survival is observed only for low and medium tech firms

(Models 6-7 compared to Models 8-9) partially supports H5a. H5b predicted that technology level would moderate the exploration-profitability relationship (H2). A modest moderation effect is found in Model 14, but in the opposite direction of what was expected. However, within the subpopulation of survived firms which is the only subpopulation where the main effect holds, we did not find a significant moderation effect for technology level (we tested a subpopulation-restricted model with an interaction term not reported here). Thus H5b could not be supported. H5c predicted that technology level would moderate the exploration-acquisition likelihood relationship (H3). Comparing Models 6-7 with Models 8-9, the difference among technology levels is supportive of a moderation effect (H5c) and the interaction terms in Model 5 is also significant.

Post-estimation analysis of margins largely supports our earlier findings and provides visualization and additional insight on the particular range of exploration in which the moderation effect of technology level is statistically significant. Because the exploration-survival relationship was found to be linear among low and medium tech firms and the exploration-acquisition likelihood relationship was found to be curvilinear among high tech firms, Figure 4 and Figure 6 are based on Model 5 which includes the squared term of exploration, while Figure 5 and Figure 7 are based on Model 4 which does not. As indicated in Figure 6, for the probability of acquisition the moderation effect is significant in a limited range near mean exploration and a limited range at the low end of the exploration spectrum (exploitation orientation). Meanwhile, Figure 7 shows that for the probability of closure, the moderation effect is significant for exploration levels near the mean and higher.

Trade-offs among performance dimensions

Among the possible trade-offs outlined in Figure 1, we had hypothesized an acquisition likelihood—profitability trade-off (H4a) and an acquisition likelihood—survival likelihood trade-off (H4b) but not a profitability—survival likelihood trade-off. To investigate these trade-offs we overlay the margins plots in Figure 4 and Figure 5 on similar margins plots for the exploration-profitability relationship to produce Figure 8 and Figure 9 (note that likelihood in these figures refers to absolute probabilities, not RRRs). We found evidence of the acquisition likelihood—profitability trade-off only among high-tech firms where exploration had a significant relationship with both of these performance measures. Figure 8 shows that the level of exploration associated with the highest acquisition likelihood is greater than the level of exploration associated with the highest profitability-given-survival among high-tech firms. Acquisition likelihood is maximized at a level above the mean while profitability is maximized at a level below the mean exploration of all firms. This lends partial support (at least among high-tech firms) to H4a. H4b could not be tested because neither technology category of firms demonstrated a significant relationship between exploration and *both* acquisition likelihood and survival likelihood.

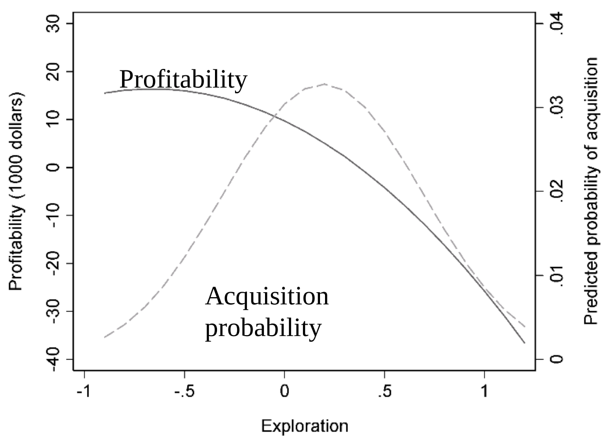


Figure 8: The trade-off among acquisition likelihood and profitability-given-survival for high tech start-ups

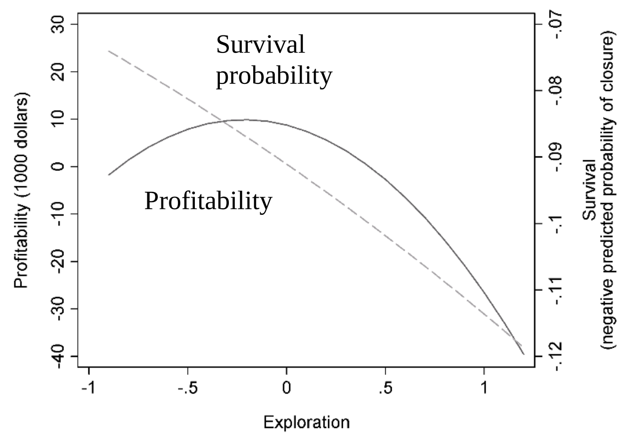


Figure 9: The trade-off among survival likelihood and profitability-given-survival for low and medium tech start-ups

Although we did not formally hypothesize a trade-off between profitability and survival, we have argued that extant theory provides ample grounds to expect such a trade-off, and our findings provide partial confirmation of this expectation but only among low and medium tech firms where the relationship between exploration and both of these performance measures was statistically significant. Figure 9 graphs the linear relationship between exploration and survival (negative probability of closure) alongside the curvilinear relationship between exploration and the profitability of survived low and medium tech firms. The figure shows that at low levels of exploration, there is a trade-off between the likelihood of survival and profitability-given-survival because some level of exploration is needed to maximize profitability-given-survival, but any level of exploration hurts the chances of survival in the first place. The trade-off is only observed at lower levels of exploration however, which could explain the consistency of these results with the finding of a positive relationship between profitability and survival. Note that unlike Hill and Birkinshaw's (2008) study where profitability was a proxy for short-term performance and survival was a proxy for long-term performance, the opposite would be a better description of the profitability and survival dimensions in Figure 9.

Analysis of control variables

A note is also merited on the effects of control variables, all of which were significant in at least some models. Industry specific work experience was the only control variable other than industry technology level to have a significant impact on acquisition likelihood (Models 1-5). However, the effect of work experience on both survival and acquisition was in the directions opposite of that predicted by Arora and Nandkumar (2011). Whereas they suggest that work experience represents opportunity costs, making it more likely that the entrepreneur will let go of failed ventures sooner or aim for a high-gain exit, we found that work experience decreased the likelihoods of acquisition and closure, although its effect on acquisition likelihood lost its significance in the subpopulation of high-tech firms (Models 8-9). Work experience was also found to have an overall positive effect on profitability (Models 10-14), but not when the subpopulation was limited to any subgroup of survived, closed or acquired firms (Models 15-26).

Female ownership was found to have a significant negative effect on survival (Models 1-7) as predicted by previous studies, but not among high tech firms where the relationship was reversed although insignificant (Models 8-9). Among the subpopulation of high tech firms that were acquired, female ownership was found to have a significant positive effect on profitability (Models 21-22). Education was found to increase the chances of survival (1-9) but had a negative effect on profitability (Models 10-14), although when broken down by subpopulation and category, a significant negative effect of education on profitability was only found among survived high-tech firms (Models 17-18). Entrepreneurial experience had no effect on acquisition likelihood or profitability, but did increase chances of survival (Models 1-7), although not among the subpopulation of high tech firms (Models 8-9).

Venture capital funding was not found to have an effect in any outcome in any of the full-sample models (Models 1-5 and 10-14). However, some subpopulations and categories exhibited very strong effects of VC funding. Specifically, high tech firms were 5 to 6 times more likely to be acquired if they were VC funded (Models 8-9) and among high tech firms that were acquired, VC funding had a positive relationship with profitability (Models 21-22). Although this positive relationship was statistically insignificant, it is still interesting because the relationship between

VC funding and profitability was strongly and significantly negative for acquired low and medium tech firms (Models 19-20) as well as for closed firms of both technology levels (Models 23-26).[13]

DISCUSSION AND CONCLUSION

Performance is known to be a multidimensional construct (Richard, Devinney, Yip, & Johnson, 2009), and especially in entrepreneurship research it has been acknowledged that entrepreneurs may pursue different, sometimes conflicting dimensions of performance (Dunkelberg, Moore, Scott, & Stull, 2013). At the same time, a logic of conflicting objectives is at the heart of exploration-exploitation theory: 'what is good in the long run is not always good in the short run' (March, 1991, p. 73) and yet one cannot get to the long run without passing through the short runs along the way (Levinthal & March, 1993). Despite this fundamental premise, empirical exp-exp studies that investigate trade-offs among performance dimensions are scarce, and very few studies even measure more than one. The few studies that do (see Table 1), rarely investigate trade-offs or even overlap in the particular performance dimensions measured. This leaves us with little accumulated knowledge on the multidimensional performance trade-offs of exploration and exploitation.

The present chapter is the first to simultaneously study the effect of exploration on profitability, survival likelihood, and acquisition likelihood as three distinct performance outcomes, and to investigate the existence and form of trade-offs among them (see Figure 1). The choice of these three performance outcomes stems from their importance in the start-up context, where getting through the short run is even more critical, and getting to the long run may not even be desired by those who prefer to harvest. All three are legitimate performance dimensions for entrepreneurs, and the existence and shape of trade-offs among them have not been clearly identified in past research, especially in relation to exploration and exploitation strategies. While we did not find support for a trade-off between acquisition likelihood and survival likelihood in balancing exploration and exploitation, we did find evidence that the profitability—survival likelihood trade-off is operative among low and medium tech start-ups but not among high-tech start-ups, and the profitability—acquisition likelihood trade-off is operative among high-tech start-ups but not

[13] We note that in fixed-effects models where the dependent variable was profitability, most of the relationships reported above with control variables were insignificant because the control variables are largely time invariant.

among low and medium tech start-ups. Moreover, as Figure 8 and Figure 9 demonstrate, the shapes of these trade-offs are not similar.

Table 10 lists the individual relationships we found empirically. The traditionally hypothesized Goldilocks (inverted U shape) relationship in the exp-exp and ambidexterity literature was found between exploration and the profitability of survived firms, and for high tech firms, also between exploration and acquisition likelihood. Other relationships however, did not follow the balance-is-best pattern: exploration was found to linearly decrease chances of survival among low and medium tech start-ups but had no effect on survival likelihood among high tech start-ups or on acquisition likelihood among low and medium tech start-ups. As for the contingency effect of technology level, our results taken together support the relationship suggested in the literature: exploration was found to be more beneficial in high tech industries, even despite the fact that our exploration variable was industry adjusted.

Table 10: Summary of results

	Low & Medium Tech		**High Tech**	
Exploration and acquisition likelihood	No significant relationship	–	Inverted U shape	∩
Exploration and survival likelihood	Linearly negative	\	No significant relationship	–
Exploration and profitability of survived firms	Inverted U shape	∩	Inverted U shape	∩

Theoretical contributions

This chapter contributes directly to at least three distinct literatures: exploration-exploitation and ambidexterity research, M&A research, and entrepreneurship research. First, we contribute to ambidexterity research not only by shedding light on the performance trade-offs of exp-exp balance which is by itself rare in this literature, but also by bringing into the picture an entirely new dimension of performance (i.e., getting acquired) particularly relevant to the modern start-up, which is unprecedented in this literature. Although it can be argued that existing research on the relationship between R&D or innovation and acquisition likelihood has already opened the door to examining the effect of exploration on the chances of getting acquired (Cefis & Marsili, 2011; Desyllas & Hughes, 2009; Heeley, King, & Covin, 2006; Lehto & Lehtoranta, 2006; Srinivasan et al., 2008), this literature does not take an ambidexterity lens and thus never studies the effect of exploration *relative* to exploitation or exp-exp *balance* on acquisition likelihood. This contribution is achieved better via the continuum approach to ambidexterity (Lavie et al., 2010) adopted in this paper as opposed to the orthogonal approach (Gupta et al., 2006b). We also contribute to the exp-

exp literature by further exploring the nuances of exploration and exploitation among newly born start-ups, a context that remains understudied in this line of work.

Second, the merger and acquisition literature has traditionally focused on the acquirer as the main unit of analysis (Haleblian et al., 2009). In this view, the target firm is implied to have very little agency in bringing about the acquisition. However, in the modern economic ecosystem where acquisitions are highly coveted by start-ups, it becomes relevant to ask what strategies entrepreneurs can pursue to intentionally increase their chances of getting acquired. Some research has recently made inroads into the seller's side of the story in acquisitions (Graebner, 2009; Graebner & Eisenhardt, 2004; Graebner, Eisenhardt, & Roundy, 2010), and an important insight from this line of work is that start-ups do actively pursue and court potential acquirers. However, this research does not examine the trade-offs involved in allocating resources to such courtship in the broader context of other, potentially conflicting performance dimensions. We contribute to this line of work by not only considering the exp-exp balance of the target that maximizes acquisition likelihood, but also by investigating the broader strategic trade-offs that this may entail. We find such a trade-off only for high tech firms however, and only with profitability in case of survival. In other words, we did not find evidence that high tech firms hurt their chances of survival by maximizing acquisition likelihood, but we did find evidence that suggests the exploration level that maximizes acquisition likelihood is higher than the exploration level that maximizes profitability in case of survival for these firms. For low and medium tech firms, we could not find any evidence that exp-exp balance matters for acquisition likelihood. Thus we also contribute to the identification of contingency factors that influence the effectiveness of strategies for getting acquired.

Third, our contributions to the entrepreneurship field are to a) study acquisition likelihood as a distinct performance variable in addition to and in conjunction with profitability and survival, b) to help uncover the type and shape of the performance trade-offs that entrepreneurs may face in pursuing multiple performance dimensions, and c) to help understand the multi-faceted value of exploration-exploitation balance for start-ups. The entrepreneurship field has always been open to the idea of multiple performance dimensions, mostly because empirical research has had a difficult time explaining the motives for entrepreneurship based solely on economic performance (Carter, 2011), thus leading researchers to look for other, mainly non-pecuniary gains. However, another reason that the economic returns to entrepreneurship have been under-estimated may be that desirable acquisitions have not been taken into account. If we acknowledge that acquisition can be a success (sometimes great success) outcome for start-ups, then our finding that profitability and acquisition likelihood are unrelated has important implications for calculating the economic returns to entrepreneurship.

Given the inherent conflicts among exploration and exploitation activities, the value of ambidexterity or trying to do both has been questioned in the past (Barney, 1991; Ghemawat & Ricart i Costa, 1993; Wernerfelt & Montgomery, 1988), and researchers have posited that returns to focus vs. ambidexterity may be contingent on various factors (Lee et al., 2013; Van Looy, Martens, & Debackere, 2005). The research program of ambidexterity in new ventures has only recently undertaken the task of uncovering the contingent value of exp-exp balance for these firms. Voss and Voss (2013, p. 1470) found that in single domains, pure focus strategies work better than ambidextrous strategies for smaller and younger firms: ‘smaller, nascent organizations lack the resources, capabilities, and experience required to manage the tensions and trade-offs that escalate when exploration and exploitation manifest within a single domain.’ However, like the0 majority of exp-exp studies, their paper only tests one performance variable.

We contribute to this program by demonstrating that exp-exp balance may have a different impact on different performance dimensions of a start-up firm, and that this impact is contingent on environmental factors such as technology level. Although we find the predicted balance-is-best relationship for the profitability-given-survival performance dimension, we find that for low and medium tech firms, a focus on exploitation is best for the survival likelihood performance dimension. This finding embodies the basic idea that the long run requires sacrifices in the short run. We do not find this trade-off for high tech firms however, but we do find that high tech start-ups may trade off another aspect of short-run performance for maximum profitability-given-survival and that is their chances of getting acquired.

Implications for practice

This paper contributes to an ongoing debate on whether start-ups should be managed specifically with the aim of short-term exit through M&As (built to flip) or if they should always focus on long-term viability (built to last), even if eyeing exit in parallel (Jurvetson et al., 2000). Collins (2000) criticizes ‘built to flip’ companies for harbouring a mindset of wealth entitlement as opposed to the ideal of ‘built to last’ (Collins & Porras, 2005). Others who argue against ‘flipping’ point to cases such as that of eLoan whose founders rejected an acquisition offer of $130 million (more than double the firm’s valuation by other investors at the time), and grew the business to a more than $1 billion valuation by 2000 (Jurvetson et al., 2000). Critics of ‘born to flip’ strategies also suggest that even if acquisition is a desirable exit strategy, managing a firm ‘as though’ it were pursuing an acquisition is dangerous (Thermond, 2014). These critics point to examples such as Hotmail, whose founders rejected many early acquisition offers until their success eventually brought on an offer with a much higher valuation (Jurvetson et al., 2000).

Yet given that acquisitions continue to offer attractive exit prospects for entrepreneurs, practitioners would benefit from research that could better articulate the trade-offs involved in pursuing the acquisition path compared to the survival and profitability paths. This is where our findings present new insight: for high tech firms, maximizing the chances of acquisition does indeed seem to conflict to some extent with maximizing profitability-given-survival. A certain level of exploration is necessary to maximize profitability, but more than that is necessary to maximize acquisition likelihood which would hurt profitability. More exploration than even that, will hurt both acquisition chances and profitability. For low and medium tech start-ups we did not find any significant effect of exploration or profitability on acquisition likelihood.[14]

Limitations & future research opportunities

One of the main achievements of exp-exp and ambidexterity research in recent years has been to uncover the variety of ways in which exploration and exploitation may manifest and exp-exp balance can be achieved through time, structure, context or domain (Lavie et al., 2010). We acknowledge that our measure of exploration is rather limited in the extent to which it covers this variety and all its nuances. Although we do suggest that acquisitions of start-ups may be manifestations of an inter-organizational level of ambidexterity, we do not have data on the acquirers to test this formally. Our measure of profitability can also be challenged, but we found it to be more useful with the KFS data than conventional financial performance measures like growth or ROA due to missing values, zero or negative profits being commonplace.

[14] We should note that the debates surrounding the “built to flip” phenomenon has mostly been in the context of high-growth start-ups, whereas the sample in our study is representative of the entire US start-up population in which rapid growth is actually a rare phenomenon (Shane, 2008).

We find the inverted U relationship between exploration and profitability only among survived firms and no relationship between exploration and profitability for closed or acquired firms. This suggests that other studies on the relationship between exp-exp or ambidexterity and performance (Junni et al., 2013) could potentially be influenced by survivor bias (Brown, Goetzmann, Ibbotson, & Ross, 1992). However, it could also simply be the case that the population of shorter-lived firms did not include enough firms that lived long enough to realize the performance effects of exploration, given that these effects are less likely to realize in the short term (March, 1991). We encourage further research to test the sensitivity of the ambidexterity-performance relationship to survivor bias.

It should also be noted that although we talk about objectives and performance dimensions, in a retrospective empirical study given data limitations, we have no way of knowing which performance dimensions the entrepreneurs in our sample actually pursued subjectively in their minds. We can only investigate the relationship between exploration and the performance outcomes ultimately observed during the period of study. Relatedly, we acknowledge that not all acquisitions are good or desirable exits for start-ups. Some other researchers have attempted to overcome this difficulty by distinguishing between successful and unsuccessful acquisitions (Arora & Nandkumar, 2011; Wennberg et al., 2010). In our case, a weakness of our data was that it did not allow us to take similar measures in distinguishing these types of acquisitions, and acquisitions in general were such rare events that doing so may have reduced our ability to derive statistically meaningful conclusions. However, given the overall statistics on the characteristics and profitability of acquired firms in our sample, it seems reasonable to approximate acquisitions as relatively successful outcomes. This conclusion is also implied by other analyses of the same dataset (Coleman et al., 2013). Nevertheless, even if we completely strip the acquisition outcome of its normative (i.e., successful or unsuccessful) dressing, our findings still provide interesting depictions of the prevalence and antecedents of the start-up acquisition phenomenon. But the door remains open for future researchers to not only distinguish between different types of acquisitions, but also bring in to the analysis other performance dimensions, such as non-pecuniary goals (Dunkelberg et al., 2013), going public (Bayar & Chemmanur, 2010) and maximizing share price afterwards.

CHAPTER 5: CONCLUDING REMARKS

There is no question that there has been a growing relationship between strategic management and entrepreneurship research (Bingham & Eisenhardt, 2008; Foss & Foss, 2008; Mathews, 2006a; Rumelt, 1987). This trend has also prompted debates on the relative scope and boundaries of these two fields (Meyer, 2009). Some have argued that the more established strategic management field is *taking over* entrepreneurship research (Baker & Pollock, 2007), while others have championed entrepreneurship as a distinct domain on its own (Shane & Venkataraman, 2000). While the debates are ongoing (Alvarez & Barney, 2013; Shane, 2012), this dissertation is based on the premise that whether or not entrepreneurship can be thought of as a distinct domain of research. An entrepreneurial approach to strategy makes distinct contributions to strategy research. An outline of the entrepreneurial approach to strategy is provided in chapter 1, where it is argued that the main agenda of this approach is to study the relationship between entrepreneurial action and performance, especially the component of performance identifiable as entrepreneurial rents.

As also argued in chapter 1, the study of the relationship between action and rents can benefit from both formal analysis and empirical research. Thus the three independently standing chapters at the core of this dissertation cover both approaches. The formal analysis in chapters 2 and 3 allows us to clearly investigate the relationship between entrepreneurial action, equilibrium and disequilibrium, and to distinguish between (non-entrepreneurial) rents from structural conditions and (entrepreneurial) rents accrued to action. The empirical analysis in chapter 4 allows us to highlight some of the complexities of the way in which entrepreneurial action and rents are observed in the real world.

While each of the standalone chapters discusses its own contributions, here we highlight some overarching insights gained from the chapters put together. In sum, it is wrong to think of rents as either perfectly temporary or perfectly sustainable. They should be conceptualized on a continuum of temporariness influenced jointly by action and structure. Initiative, discovery and imagination can be the source of rents, and isolating mechanisms can sustain them at the same time. Similarly, it is constructive to think of the market not as necessarily always in equilibrium or necessarily always in disequilibrium, but as a process that can move between equilibrium and disequilibrium, at times being in one and at times the other, given the particular conditions at the time that determine the strengths of forces in each direction. This dissertation also highlights the fact that the abstract one-dimensional notion of rent in economic models translates to a complicated multi-dimensional notion of performance in empirical research, and reveals new insights otherwise unattainable with the one-dimensional conceptualizations of performance.

Another insight of the empirical component of this dissertation is that the creation and discovery of opportunities can be operationalized in terms of exploration and exploitation, thus suggesting that a closer relationship between the two streams of research is possible. This is a corollary of the fact that many recent strategy theories (especially dynamic capabilities theory) have pointed to Austrian economics as their foundation and 'action' as their key source of rent. Thus it is not only ambidexterity research, but also a host of other works in strategy that may have room for integration based on this common foundation. But integration may go even further than that. Makowski and Ostroy's (2001) suggestion that a formal framework may be able to incorporate both neoclassical economics and the creativity of the market, and thus cover the analysis of both structural sources and action-based sources of rent, has been an inspiration for a wave of work in strategic management research, including the present dissertation which has taken novel steps to further illustrate this promise. We elaborate on these points below, followed by a discussion of limitations and future research opportunities.

Formalizing the logic of Austrian economics

The reliance on equilibrium assumptions has been a major point of criticism directed at prevailing theories of strategy such as the resource based view, and the positioning theory based on industrial organization. A range of scholars have called for moving beyond this assumption (Bromiley & Papenhausen, 2003; Mathews, 2006a, 2006b; Meyer et al., 2005; Rumelt et al., 1991), suggesting that when disequilibrium rather than equilibrium is the norm, the relevant economic framework becomes Austrian economics (Jacobson, 1992) with a view of the market as a dynamic process through time constantly driven by entrepreneurial forces of equilibration and disequilibration (O'Driscoll & Rizzo, 1985). However, while equilibrium-based theories are based on formal logic in their underlying economic foundations, Austrian economists have largely avoided formalizing their logic. This dissertation has taken steps to overcome this gap. Despite the fact that so many flourishing lines of work in strategy theory (competitive dynamics, resource orchestration, dynamic capabilities, etc.) all claim foundations in Austrian economics and Schumpeterian and

Kirznerian rent mechanisms, this dissertation is one of the first (to the author's knowledge) to tackle the study of these foundations with a formal framework.

Why is such an effort warranted? Mathematical models and simulations are often touted for their transparency and power to clarify (Adner et al., 2009; Kreps, 1990) due to their clear-cut approach in deriving logical consequences of given assumptions step by step. But on the flip side, this same approach leaves them vulnerable to the criticism of being 'trivial'. The fact is that all mathematics ever developed in the history of science and human achievement can indeed be accused of being trivial, because all of it follows directly from the given assumptions and axioms. That is simply the nature of the deductive method of formal logic. The true value of the deductive method derives from its ability to arrive at findings that are formally trivial—indeed necessary given the assumptions—but more complex than what is cognitively trivial to the human mind. In other words, formal logic allows the human mind to understand the necessary consequences of a given set of assumptions by tracing the path from the assumptions to the conclusions step by step.

For example, in chapter 2 we have started with some basic (but not very restricting) assumptions about an economy, and two simple actions that players in that economy can perform: create new value or discover and appropriate existing value. These basic assumptions were then observed to lead to several basic effects including the complementarity of creation and discovery, the substitutability of discoverers, the complementarity of creators, the saturation of opportunities, and the relativity of advantage compared to market size. These basic mechanisms are (as with any formal analysis) a product of our assumptions and modeling approach. However, the formal analysis is useful because the interaction of these basic mechanisms produces a level of complexity that is not immediately cognitively trivial to the reader's mind.

Even mathematical solutions will not always be able to determine the outcome of a simulation, and thus simulation allows us to take further advantage of the benefits of formal logic in a way that relaxes the confines of closed-form mathematical solutions. Such relaxing is precisely what is needed to move beyond equilibrium-based analysis to the analysis of disequilibrium processes. Reflecting on why Schumpeter's dynamic analysis approach to economics failed to take over the mainstream of the field, Mathews (2006b) points out that 'one reason is no doubt the fact that tools for disequilibrium analysis were not available at the time that Schumpeter was writing; these tools have become available only much more recently, with computer-based modeling and the analysis of complex systems and emergent phenomena.'

In our effort we have built on the cooperative game theory framework already established and gaining traction in the strategy field (Adegbesan, 2009; Brandenburger & Stuart, 2007; Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004), and this facilitates cumulative theory development. We have adapted the cooperative game theory framework, and coupled it with computer simulation in order to model both the imperfectly competitive structure of the market (usually associated with monopoly and/or Ricardian rents) and the movement of players through this space from disequilibrium to equilibrium and vice versa (usually associated with Schumpeterian, Austrian or entrepreneurial rents). Our approach has been inspired by a notable attempt to reformulate traditional Walrasian equilibrium theory to incorporate the 'creativity of the market' (Makowski & Ostroy, 2001) that has also been an important source of inspiration for Lippman and Rumelt (2003a) and other work on the economics of strategy and entrepreneurship (Denrell et al., 2003). Furthermore, we have produced a very transparent framework with clear assumptions and definitions, and the detailed flowcharts and algorithm (See Appendix C) make the research easily reproducible for future researchers to build on. We recognize that there is a degree of subjectivity in the choice of assumptions, and we hope that future research can examine different assumptions.

Although Austrian economics as a field has generally been reluctant to embrace formal analysis, our cooperative game simulation approach demonstrates that a formal approach may begin to incorporate the subjectivism, dynamism, and methodological individualism that are the central tenets of the Austrian school. Although the principle of methodological individualism is a long-standing tradition in the Austrian school, it has been recently emphasized in the strategic management field under the terminology of 'micro-foundations' (Abell et al., 2008; Felin & Foss, 2005; Foss, 2011; Foss & Lindenberg, 2013). Proponents of the micro-foundational approach argue that organizations are comprised of individuals and that the more aggregate concepts such as structure, capabilities, routines, culture and institutions that have dominated strategic management discourse need to be more strongly grounded in an understanding of the individuals that shape them and bring them about with their choices, abilities, goals and expectations (Felin & Foss, 2005). Both cooperative game theory (Lippman & Rumelt, 2003a, 2003b) and simulation methods (Abell et al., 2008) have been suggested as viable tools to advance the micro-foundations agenda, and this dissertation has been one of the first attempts to take advantage of both.

The temporariness and sustainability of rents

In chapter 1 we highlighted the fact that the existing literature suggests that entrepreneurial approach to strategy discards the notion of sustainable advantage, and replaces it with an emphasis on temporary advantage, while acknowledging that a series of temporary advantages may be concatenated. However, we have argued that if advantage can have different degrees of sustainability, then these degrees are also degrees of temporariness and thus the distinction between temporary and sustainable rents is not as fruitful as an examination of the determinants of temporariness or sustainability. Our analysis has shown that these determinants encompass both action and structure, and thus rents and their degree of sustainability are influenced by both entrepreneurial action and isolating mechanisms.

The analysis of chapter 3 suggests that rents can accrue or be sustained in equilibrium or disequilibrium, and as a result of actions that move the market towards equilibrium or away from it. Rents can also accrue or be sustained by efforts that prevent movement towards or away from equilibrium. The market should not be thought of as necessarily in constant equilibrium or necessarily in constant disequilibrium. Rather, the particular state and direction of movement of the market depends on the relative strength of the forces in operation.

Furthermore, our analysis in chapter 2 has shown that the succession of multiple temporary advantages in disequilibrium is not merely a matter of chance and luck (Alchian, 1950; Denrell et al., 2003). But that given certain assumptions, the ability to create multiple temporary advantages and concatenate them together can indeed be attributed to capabilities to perform entrepreneurial action in the form of opportunity creation, discovery and exploitation. This is in agreement with Farjoun's (2007) suggestion that whether or not multiple temporary advantages can be deliberately created and concatenated to form sustained advantage over time is a question of the level of dynamism and change in the environment. In our theory as with Austrian logic, this dynamism is endogenous and attributed to human action. Collis (1994) has pointed out that depending on the way 'resource' is defined in the resource-based view, the capabilities to perform action can simply be considered 'higher level' resources. With this interpretation, differences in the capabilities of players to perform entrepreneurial actions, may itself be a meta-structural condition of the market, and thus action-based theories can be considered ‘higher level’ structural theories.

The empirical analysis in chapter 4 raises further interesting issues regarding the temporariness of rents. While in almost all arguments about rent creation and appropriation in strategic management it has been assumed that more sustainable (less temporary) rent is preferable to less sustainable (more temporary) rent, chapter 4 poses the question: what if temporary rent was more desirable than sustainable rent? In fact, we argue that in the context of the modern start-up, this reversal of the conventional assumption is very common because entrepreneurs and their investors often prefer to get acquired and cash out quickly rather than survive for a long time. This then raises other questions: can sustainability in the long term be sacrificed for increased profits in the short term or vice versa? Chapter 4 finds some evidence to the affirmative.

Imputation of value

The imputation of value to its sources has always been a crucial issue in strategic management (Lippman & Rumelt, 2003b; Winter, 1987). Winter (1987, p. 165) argues that ‘a proper economic valuation of a collection of resources is one that precisely accounts for the returns the resources make possible.’ The argument can be broadened to include both resources and actions. In this dissertation, we have argued that a major benefit of the formal approach in chapters 2 and 3 has been to allow us to better distinguish between the value that can be attributed to action and the value that can be attributed to structural conditions. But we have advanced the imputation agenda even further by examining the portion of the returns to action that can be traced to different kinds of entrepreneurial actions. Specifically, we have distinguished between two types of entrepreneurial capability (termed creation and discovery) and have been able to impute entrepreneurial rents to these capabilities.

Although our approach is unique, other researchers have also examined the imputation of value to types of entrepreneurial action. Gifford (1992) and Gifford and Wilson (1995) model the allocation of entrepreneurial attention between current projects and new projects. Darroch, Miles, and Paul (2005) develop a model of creation and discovery (corporate) entrepreneurship, and suggest that they act as complements in a rent cycle. Ross and Westgren (2006) utilized a system dynamics model and computer simulation to impute economic value to various entrepreneurial capabilities such as innovation and arbitrage.

Shepherd and Lévesque (2002), Lévesque and Maillart (2008) and Choi, Lévesque and Shepherd (2008) investigate the exploration vs. exploitation issue in entrepreneurship and the optimal timing for entrepreneurs to stop exploring opportunities and start exploiting them. This line of research is suggestive of the close relationship between the concepts of creation-discovery and exploration-exploitation. Based on the premise that creation-discovery translates well to exploration-exploitation in empirical measurement, chapter 4 of this dissertation has investigated the relationship between exploration-exploitation and rents empirically. The analysis reveals that imputation is complicated by the multi-dimensionality of performance in the real world.

Integrating theories of strategy

The term 'capability' is often used in the strategic management literature to refer to the dynamic aspects of action taken on resources to produce change rather than the resources themselves, and this distinction has been the hallmark of the dynamic capabilities approach and related studies (Helfat, 2007; Sirmon et al., 2008; Sirmon et al., 2007; Sirmon et al., 2011; Teece, 2007; Teece et al., 1997). In this sense, in this dissertation when we refer to the capabilities to perform entrepreneurial actions of creation and discovery or exploration and exploitation, this is entirely in line with the notion of capabilities in that literature. However, the capabilities literature commonly refers to less abstract and more proximate-to-practice capabilities such as miniaturization, supply chain management, customer relationship management, etc.

The fundamental link between the entrepreneurial approach to strategy and the capabilities literature is the economic foundations underlying the emphasis of action over structure. The capabilities literature explicitly claims that the returns to superior capabilities can be distinguished from the returns to superior resources or positions, because they are of the nature of Schumpeterian and Kirznerian rents rather than monopoly and Ricardian rents (Teece, 2007; Teece et al., 1997). However, this capabilities literature normally stops discussion of the underlying economic rent mechanisms at this level, and proceeds to discuss more proximate-to-practice capabilities. The common economic foundation is nevertheless suggestive of the possibility of further integrating all action-based theories of strategy.

But perhaps integration efforts may set an even higher ambition: bringing action-based and structure-based logic within the same framework. This was indeed the prospect hinted at by Makowski and Ostroy's (2001) suggestion that a formal framework may be able to incorporate both neoclassical economics and the creativity of the market. This dissertation has attempted to explore one approach to building such a framework. Whether or not the strategy field as a whole decides to pursue this journey further, or even deems it desirable is yet to be seen. But if the central goal of strategy theory is to explain the determinants of performance, and if performance is influenced by both action and structure, then there is reason to believe that the effort is worthwhile.

OPPORTUNITIES FOR FUTURE RESEARCH

No one knows the weaknesses and gaps and ways in which things could have been done differently in a research better than the researcher himself. Despite this awareness, even the mightiest doctoral candidate cannot hope to complete a dissertation with anything but a large number of the puzzle pieces still missing. We may hope to use what we have learned so far to identify the missing pieces as best we can, and thus draw a roadmap for future research, at least for those who deem the puzzle worth playing with. But even that effort is inevitably imperfect since the list of potentially missing pieces is inexhaustible. Thus in these concluding remarks, we focus on a narrow set of possible future directions that relate to a core aim of this dissertation: the effort to develop one possible path to formal analysis of the entrepreneurial market process as described in Austrian economics. In order to do so, the major challenges to overcome have been to incorporate subjectivism and dynamism into the formal analysis. Both of these aims are at best partially achieved in this dissertation and could have been approached in a variety of alternative ways. We elaborate below.

Alternative ways of analyzing subjectivism

While we have incorporated some aspects of subjectivism, like the possibility that players can imagine new value potential and discover existing potential they were not aware of before, there are still so many aspects of the human mind and decision making that could be taken into account. Matters like impatience, risk tolerance, mood, values, various psychological characteristics, and a player's perception of the knowledge and entrepreneurial capabilities of other players. No doubt, there is a lot to do. How may we proceed to the next step of expanding the details of subjectivism in our models?

One possible path is to utilize models of knowledge and belief typically used by economists, particularly in the context of games. A natural next step in extending the simple characteristic function model is to have not just one characteristic function, but a separate characteristic function for each player, representing that player's current view of the market. This is the approach taken by Littlechild (1979a). For a further level of complexity we may resort to what Aumann (2005) refers to as *interactive epistemology*, which provides tools for analyzing what the players know about the world and about each other's knowledge. There are two parallel axiomatic formalisms available, which Aumann labels the *semantic*, and the *syntactic* formalisms. The semantic formalism is simpler to use, and has become widespread in economic applications. It considers a set of possible *states of the world*, and for each player, a partition of the states into *information sets*, which tells us what that player knows at each state. For a given player, two states are in different information sets if and only if in one state, the player knows that the true state is not the other state. Shoham and Leyton-Brown (2009, chapters 13-14) provide a concise introduction to this partition model of knowledge and belief based on modal logic, however a more comprehensive guide is provided by Fagin, Halpern, Moses, and Vardi (2003). These formalisms enable the explicit modeling of belief revision in the face of new information, which takes the form of Bayesian calculations when beliefs are stated in the form of probability distributions. Hence this approach is line with recent calls to use Bayesian methods in management research (Zyphur & Oswald, 2013).

Another aspect of subjectivism may be modeled by differently shaped utility functions that represent various attitudes players may have to payoffs. For example, a concave utility function is typically used to model risk aversion or diminishing marginal utility. Kemeny and Thompson (1957) consider eight different utility function shapes corresponding to various attitudes such as fair, reckless, cautious, etc. The transferable utility model needs to assume linear utility, in order for side payments to be able to transfer utility from one player to another. However, extensions of the description and solution concepts of characteristic function games have been developed for non-transferable utility (NTU) situations as well (Hart, 2004; Peleg, 1985). NTU models can be more mathematically sophisticated, but also more consistent with subjectivism and the idea that what one person values, another may not.

Alternatively, different psychological attitudes might represent not the shape of the utility function, but the rules by which an agent goes about negotiating with other agents for coalitions and value splits. For example, Littlechild (1979b) considers 'active' vs. 'passive' negotiators, while Chavez and Kimbrough (2004) consider 'greedy' vs. 'matching' algorithms for artificial agents in simulations of characteristic function games that determine who these players choose to propose offers to. This is a common approach in agent-based simulation studies that experiment with different behavioral rules for agents.

Alternative ways of analyzing dynamism

The elements of dynamism that we model are important: the process of discovering and exploiting new opportunities and the process of creating new opportunities. However, change manifests in many other ways in real world markets that are not covered in our approach. We have assumed the number of players to be constant throughout our simulations, but a more realistic model will allow for dynamic entry of new players and exit of incumbents (which as we have learned from chapter 4 is itself multi-dimensional). Furthermore, we have assumed a closed system under no exogenous influences, no external shocks, and no environmental conditions beyond the characteristic function and coalition structure. The players themselves could be much more dynamic, possibly learning and adapting their behavioral rules over time, and getting better at creation or discovery. Many of these elements of dynamism can be incorporated into simulation models, and in fact such an ability is the strength of simulation methods (Harrison et al., 2007).

Simulation methods are categorized in various ways, but a common taxonomy is that of agent-based simulation, system dynamics, and discrete-events simulation (Borshchev & Filippov, 2004; Dooley, 2002). In chapters 2-3, even though the underlying game theoretical model is to some extent agent-based our simulation approach is closer to the discrete-event[15] type of simulation as for example used by March (1991). Discrete event simulation is the oldest and most established type of simulation modeling. These models are based on a description of a state of the system defined by a series of parameters at any given time (Law & Kelton, 2000). In our models in chapters 2-3 the state was defined jointly by the characteristic function, coalition structure, and profit distribution at any point in time. As time flows in discrete steps, the state changes a finite number of times, triggered by events (e.g., discovery or creation) at specific time points. The discrete-event method is not a particularly strong method for modeling the complex interdependencies among various components and variables, and is also relatively weak in modeling the internal structure of agents and thus their adaptation over time.

[15] Brailsford (2014) has argued that discrete-event models are a subset of agent-based models.

The system dynamics approach models the system of interest as a series of variables and states, which are related to each other with differential equations (Forrester, 1961). These variables and relationships are modeled in the form of stocks and flows (Sterman, 2000). The system dynamics approach is also weak in modeling the internal structure of individual agents that make up the system, but it is instead strong in modeling the complexity of causal interdependencies between various variables. However, instead of growing out of the simulation, these interdependencies have to be defined in advance by the researcher, a task which requires extensive knowledge of the variables involved. In other words, the researcher has to provide a model of the entire system rather than just the agents that make up the system (Harrison et al., 2007). Once the model is defined, the simulation can demonstrate how the interdependencies can shape the behavior of the system in ways not obvious to the human mind. The method is especially useful in demonstrating how negative and positive feedback loops can result in major abrupt effects such as tipping points and disasters arising from seemingly minor influences and gradual changes (Davis et al., 2007; Senge, 1990).

Agent-based approaches are perhaps closest of all simulation approaches to remaining loyal to the methodological individualism and the subjectivism of Austrian economics, and thus also to the idea that strategy theory should be developed based on micro-foundations (Abell et al., 2008). The agent is modeled as an independent entity capable of autonomous behavior based on behavioral rules or schemas (Bonabeau, 2002). The strength of the agent-based approach is that it can analyze changes in these schemas as agents learn and adapt their behavior over time. Thus both learning or knowledge revision, and the derivation of macro-patterns from individual-level micro-behavior are incorporated into the agent-based approach. This is why many have suggested agent-based simulation as one of the most promising future directions for Austrian economics (Nell, 2010) and entrepreneurship research (Crawford, 2009; McMullen & Dimov, 2013; Yang & Chandra, 2013). Within the category of agent-based models, more specific methods such as NK fitness landscapes and cellular automata, as well as specific adaptation heuristics such as genetic algorithms have been particularly popular and promoted among management researchers (Crawford, 2009; Davis et al., 2007; Dooley, 2002; Harrison et al., 2007).

In his keynote at the 2010 OR Society Simulation Workshop, Charles Macal outlined the features of problems that are best tackled by agent-based models (Siebers, Macal, Garnett, Buxton, & Pidd, 2010, p. 205). These include situations that have a natural agent-based representation, when the agents have dynamic and structured relationships with other agents, when learning and adaptation are important, when agents anticipate the reaction of other agents to their actions, and when agents cooperate, collude or form organizations. It is easy to see that many problems in the analysis of the dynamic market process fit all of these criteria.

Perhaps the main challenge of agent-based models is that the researcher has to implement a pre-determined theory of the agent's mind as the behavioral heuristic of the agent. Given the complexity of the mind and human decision making, whatever such theory of mind the researcher chooses will be simplistic and controversial, rendering the outcome of the simulation prone to criticism (Brailsford, 2014). One of the areas in which agent-based modeling has been most successful is pedestrian flow models because it is straightforward to achieve consensus on the behavioral heuristics of pedestrians (e.g., get to the destination as quickly as possible).

While most researchers who engage in simulation studies will stick to a particular method, Dooley (2002) argues that in order to best capture the complexity of the real world, multi-method approaches are necessary. Today, there is a clear lack of simulation studies, particularly of the multi-method variety in the fields of strategic management and entrepreneurship, so this seems to be a promising direction.

A statement of unknowledge

We have concluded this dissertation by imagining what only a few future research directions could be. This capability to imagine is undoubtedly bounded. The possibilities that the future can bring are infinite. George Shackle has argued that under such uncertainty, with our limited knowledge we can at best trace the boundaries of the impossible rather than list the possible: 'the bounds of the possible are bounds of unknowledge' (1983, p. 37). But if history is any guide, even the bounds of unknowledge are bound to tremble; future research will eventually achieve progress that seems impossible to us today. We cannot know what will happen in a field of creative minds engaged in the 'free spontaneous pursuit of imagined glory' (Shackle, 1979b, p. 20). Indeed, the opportunity in this uncertainty is the beauty of it all.

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APPENDIX A: A BRIEF INTRODUCTION TO THE BASICS OF COOPERATIVE GAME THEORY AND MODELS APPLIED IN STRATEGY AND ENTREPRENEURSHIP RESEARCH

COOPERATIVE GAMES

Cooperative game theory is a well-developed area of game theory which studies a set of players, the value that can be created by different groupings of these players, and how this value is then distributed among the players. The most fundamental tool of cooperative game theory is the characteristic function. The characteristic function of an n-person game is a simple mapping that specifies a value for any possible coalition (subset) of players. For example, if A, B, and C are the players, the following table defines a characteristic function on this set of players:

Coalition	**Value**
A	10
B	0
C	0
AB	20
BC	0
AC	30
ABC	30

If these values can be distributed among players, for example by a standard of exchange like money, we say that the game has *transferable utility* (or equivalently, that the game allows *side payments*)[16]. Formally, if the set of players is $N = \{1,2, \ldots, n\}$, the characteristic function $v: \mathbf{2}^N \to \mathbb{R}_+$ is a function that assigns a non-negative real value to each member of the power set of N (i.e., the set of all subsets of N), where $v(\phi) = 0$. The value of a coalition $v(S)$ is the value that members of S can achieve together regardless of[17] any action or composition of players not in S. The pair (N, v) is a *characteristic function form game with transferable utility*. Games in

[16] While there is also a considerable literature on non-transferable utility (NTU) games, our focus in this paper is solely on transferable utility models.

[17] This "regardless of" condition implies a lack of externalities and this is what we assume in this paper. Various authors have extended the study of cooperative games to allow for various externalities and spillovers (e.g. Bilbao, Fernández, Jiménez, & López, 2008; Shapley & Shubik, 1969).

characteristic function form are known as characteristic function games or c-games[18]. They have been studied extensively and have found many applications (Brânzei, Dimitrov, & Tijs, 2005; Curiel, 1997; Peleg & Sudhölter, 2007).

The characteristic function is often constructed to model a specific real world situation. For example the above table models a game known as the 'three cornered market' (Shubik, 1982; von Neumann & Morgenstern, 1944) in which A is a farmer whose land is worth \$10 to himself, \$20 to person B and \$30 to person C. From this information, the characteristic function in the above table is then constructed as follows: Since A has the land, the coalition of A alone receives a \$10 value, and B and C cannot attain any value in this game as singleton coalitions on their own. Nor can the coalition of B and C together achieve any value because none of them owns the land. However, if A agrees to sell the land to B, they have \$20 worth of value to share between them, and if A agrees to sell the land to C, they have \$30 worth of value to share between them. Finally, if A, B, and C form a coalition together, there is still \$30 of value to share because A can sell to C, and B will have an inactive role and unlikely to gain any piece of the pie.

The characteristic function is usually assumed to be *super-additive*, that is, no addition to a group can make the group as a whole worse off. Formally, for all disjoint $S, S' \in \mathbf{2}^N, v(S \cup S') \geq v(S) + v(S')$. In cases where the inequality is strict we can interpret this as the existence of 'synergy' among players.

Solution concepts

Although the characteristic function defines how much value can be created in any coalition, it does not say anything about how that value is divided between the coalition's members. However, in studying characteristic function games, the usual concern of game theorists is to study 'solution concepts' which describe the end state of the game in terms of which coalitions form and how profit is distributed between them. Such divisions are described with profit or payoff distributions modeled as vectors $\boldsymbol{x} = (x_1, \dots, x_n) \in \mathbb{R}_+^n$ also known as payoff allocations or imputations.

[18] Note that extensive form games can be converted to characteristic function form, but this does not always preserve all the necessary information about the game. Shubik (1982) uses the term c-game to refer to games that can be fully described by a characteristic function.

For the game of Table 1, the vector (20, 20, 20) is not a *feasible* profit distribution because it distributes more profit than can be created. The vector (15, 5, 0) is a feasible profit distribution but it is not *stable*. It corresponds to the case where A sells the land to B for $15 which is an unlikely outcome when he can sell the land for more than $20 to C. Properties such as feasibility and stability are among many criteria by which various payoff distributions can be characterized. A more elaborate list of such criteria with formal definitions is provided below:

- A payoff vector is *feasible* if the sum of all profits does not exceed the maximum possible value created jointly by all players (the value that the characteristic function gives the 'grand' coalition, i.e., the coalition of everyone). Formally, a payoff vector is feasible if:

$$\sum_{i \in N} x_i \leq v(N) \qquad (1)$$

- A payoff vector is *efficient* if it exactly distributes the total value (value of the grand coalition):

$$\sum_{i \in N} x_i = v(N) \qquad (2)$$

- A payoff vector is *individually rational* if $x_i \geq v(\{i\}),\ \forall i \in N$ meaning that each player is receiving a profit that is at least as much as he could have made alone.
- A payoff vector is *stable* or *coalitionally rational* if each subset of players is receiving a profit at least as much as they could have made as a coalition. This property leaves no coalition capable of improving the payoffs of all its members. Formally:

$$\sum_{i \in S} x_i \geq v(S), \qquad \forall S \subseteq N \qquad (3)$$

  Clearly, a stable payoff vector is also individually rational and efficient.
- A payoff vector is said to give *zero allocation to null players* if any player who is useless to all players gets no profit. A *null player* is someone who adds no value to any coalition not containing it. Formally, a null player is defined as any player i which satisfies[19]:

$$v(S \cup \{i\}) = v(S), \qquad \forall S \subseteq N \setminus \{i\} \qquad (4)$$

[19]We use the notation S \ T to denote all members of set S not in set T.

- A payoff vector is *symmetric* if symmetric players get the exact same payoff. Two players i and j are defined as symmetric if they can be substituted for each other in any coalition containing one of them. Formally, a payoff vector is symmetric if for any two players i and j, we have $x_i = x_j$ whenever:

$$v(S \cup \{i\}) = v(S \cup \{j\}), \quad \forall S \subseteq N \setminus \{i,j\} \tag{5}$$

If a solution concepts can be described in terms of a set of criteria such as those listed above, it is said that the criteria provide a 'characterization' or 'axiomatization' of the solution concept. Many authors have proposed various solution concepts and characterizations of them. Some solution concepts determine a set of possible profit distributions. Examples of such set valued solution concepts include the 'core' (Gillies, 1959; Scarf, 1967), the kernel (Davis & Maschler, 1965) and the von Neumann & Morgenstern (1944) solution. Other solution concepts are point valued, meaning that they specify exactly one profit distribution vector as the outcome of the game. Point valued solution concepts include the Shapley value (Shapley, 1953), the Banzhaf value (Banzhaf, 1965), and the τ-value (Tijs, 1987) among others.

CGT APPLIED TO STRATEGY AND ENTREPRENEURSHIP

Equipped with the basics above, we are ready to explore some of the ways in which CGT modeling has been applied in the strategy and entrepreneurship literatures. We focus mainly on MacDonald & Ryall (2004) and Littlechild (1979b) as seminal representative works in the two areas respectively.

The core as equilibrium and competitive advantage in cooperative games

The set of feasible and stable[20] profit distributions is referred to as the *core* of a cooperative game. It is the most widely used and widely studied set valued solution concept due to its intuitive appeal: it is the set of profit distributions no one can complain about. The stability (i.e., coalitional rationality) condition means that no group can improve on its total value by defecting and acting for themselves. Thus it is natural to think of the core as a plausible set of outcomes in a competitive situation. The core is conceptually analogous to the notion of equilibrium in the neoclassical theory of markets (Schotter & Schwödiauer, 1980). But the core is especially powerful in the modeling of imperfectly competitive equilibrium, especially in small numbers situations (Lippman &

[20] See the previous section on "Solution Concepts" for definitions of feasibility and stability.

Rumelt, 2003a). Since the idea of rents due to market imperfections in an equilibrium framework has dominated the conceptualization of competitive advantage in the strategic management literature, MacDonald & Ryall (2004) take the core as their basis for calculating the competitive advantage of individual players.

In the game of Table 1, the core consists of all profit distributions between (20, 0, 10) and (30, 0, 0) meaning that the core predicts that player A will sell the land to player C for somewhere between \$20 and \$30. No coalition can 'block' this arrangement. To see why profit distributions outside of the core can be blocked, notice that if player A sells at any price below \$20 to player C, player B can come in and offer a higher price.

Assuming that the core is non-empty, MacDonald & Ryall calculate the maximum (x_i^{max}) and minimum (x_i^{min}) possible payoff player i can expect to receive among the set of payoff vectors in the core. A player is considered to have competitive advantage in the game if $x_i^{min} > 0$. In order to find conditions under which $x_i^{min} > 0$, MacDonald & Ryall proceed in the style of Tijs (1987) to calculate values they call 'marginal product' and 'minimum residual'[21]. The *marginal product* of player i is defined as the difference between the value of the grand coalition (the coalition of everyone) and the value of the coalition of everyone other than i:

$$mp_i = v(N) - v(N \backslash \{i\}) \tag{6}$$

In other words, the marginal product of a player is the value he adds when he comes in last to form the grand coalition. Tijs (1987) and MacDonald & Ryall (2004) both argue that the marginal product is the maximum a player can hope to profit (i.e., that $x_i^{max} = mp_i$) and so a positive marginal product is necessary for competitive advantage. For this reason, Tijs refers to it as the *utopia payoff* of a player. It is argued that a player cannot appropriate more than his marginal product, because if he does, it would be worthwhile for the rest of the players to leave him out of the coalition since he's taking more than he's bringing in. In the game of Table 1, the marginal contribution or product of players A, B, and C are 30, 0, and 10 respectively.

Using this definition of the upper bound on value appropriation, a sufficient condition for having a positive lower bound can be constructed by simply looking at what would be left for a player if

[21] Tijs (1987) refers to the same concepts as "marginal contribution" and "remainder", respectively.

everyone else got their utopia payoff. Thus MacDonald & Ryall define the *minimum residual* of player i as:

$$mr_i = v(N) - \sum_{j \in N \setminus \{i\}} mp_j \tag{7}$$

It is then argued that a positive minimum residual is sufficient to guarantee competitive advantage. In the game of Table 1, players A, B, and C have a minimum residual of 20, 0, and 0 respectively.

The Littlechild model

While the use of CGT has proliferated in the strategic management field in recent years, the entrepreneurship field has not seen such activity. One particular contribution that has remained underappreciated in the literature (Foss, 2000a) is Stephen Littlechild's 1979 paper titled 'An entrepreneurial theory of games' that aims to take a step in capturing some elements of the entrepreneurial market process as described in the Austrian school of economics within the characteristic function game framework. In this section, we take a closer look at this paper, and consider how it may serve as a basis for further research. The paper is a mix of informal narrative accompanied by some formal modeling. While the formal modeling does not cover all of the subjectivism and process dynamics discussed in the narrative, it does provide a basic framework that may be built on.

Littlechild (1979b) starts the formal description of the model as follows (p. 155):

> 'Let (N, v) be a game in characteristic function form where $N = \{1,2,\ldots,n\}$ is the set of players. Let $M = (1,2,\ldots,m\}$, where $m < n$, be the subset of players who choose an active role, i.e., the entrepreneurs. Define an artificial entrepreneur (player 0) permanently offering the value $v(\{\boldsymbol{j}\})$ to any player j cashing-in alone.'

Active players are those who may propose offers to other players. Their behavior in looking for opportunities and proposing offers in order to exploit them justifies their labeling as entrepreneurs in the Austrian sense. The remaining $n - m$ players are passive, meaning that they may only accept or reject offers proposed to them, and do not actively seek opportunities or propose offers to others. Non-zero values for single-player coalitions are not necessary, as the game can be zero-normalized. However, having these non-zero values helps in the intuitive understanding of why a player may choose not to form any coalitions with others. Littlechild continues (p. 155):

At the beginning of each period t, where $t = 0, 1, \ldots$, let $S_i(t)$ denote the set of players already committed to entrepreneur i and $A(t)$ the set of as-yet uncommitted players. These sets are disjoint but collectively exhaust the set of all players. That is, the collection $\{S_0(t), S_1(t), \ldots, S_m(t), A(t)\}$ forms a partition of N.

The requirement that the S_i sets form a partition of N, implies that no two entrepreneurs may deal with each other. When the game starts at $t = 0$ no passive player has decided to cash in alone ($S_0(0) = \phi$), entrepreneurs have no one but themselves in their coalitions ($S_i(0) = \{i\}$, $\forall i \in M$), and so all passive players are still on the market ($A(0) = N \backslash M$). The game is completed at any point $t = T$ when $A(T) = \phi$. Littlechild then begins to go beyond the pure framework of the characteristic function game by explicitly describing a model of the market process (pp. 155-156):

At the beginning of each period, each entrepreneur offers a price for each uncommitted player, and each uncommitted player sets a reservation price. The uncommitted player is signed up by whichever entrepreneur offers the highest price for him, provided this price exceeds his reservation price; otherwise he remains uncommitted. Formally, let $p_j^i(t)$ be entrepreneur i's offer to player j, defined for $i = 0, 1, \ldots, m$ and $j \in A(t)$, where $p_j^0(t) = \boldsymbol{v}(\{i\})$, and let $r_j(t)$ be player j's reservation price, for $j \in A(t)$. Let $B_i(t)$ be the set of players acquired by entrepreneur i as a result of the bidding in period t, so that $B_i(t) = \{j \in A(t) : p_j^i(t) \geq p_j^k(t),\ k \neq i,\ \text{and}\ p_j^i(t) \geq r_j(t)\}$. In case of a tie in bidding, allocate the player arbitrarily to one of the maximum bidders, so that the sets $B_i(t)$ are disjoint.

The sets of committed and uncommitted players are updated by

$$S_i(t+1) = S_i(t) \cup B_i(t),$$

$$A(t+1) = A(t) - \bigcup_{i=0}^{m} B_i(t).$$

Thus we are presented with a concise algorithm to model the game as it is played out through time. The outcome of the game is (p. 157):

A partition of players into coalitions $\{S_0, S_1, \ldots, S_m\}$, where $S_i = S_i(T)$, and a payoff vector $\{x_1, x_2, \ldots, x_n\}$ which distributes the value of each coalition amongst its members so that

$$\sum_{j \in S_i} x_j = v(S_i)$$

And payoffs are distributed as follows (p. 157):

Each passive player gets the amount which he accepted on joining a coalition, and the entrepreneur's payoff is determined by the balance remaining, so that

$$x_i \equiv v(S_i) - \sum_{\substack{j \in S_i \\ j \neq i}} x_j \quad \text{for } i = 1, \dots, m.$$

Although Littlechild does not run a dynamic simulation of the game, the only remaining elements needed to actually run the game are the strategies of the players. The strategies of active players consist of who to offer to, how much to offer them, and how to revise these in each new period, while the strategies of passive players consist of how to set reservation prices and how to revise them in each new period until an offer is accepted. Littlechild does not determine any particular way for the passive agents to set reservation prices, stating only that if they eventually start decreasing their reservation prices by at least a fixed minimum amount in each period, the game is guaranteed to end in finite time. As for the entrepreneur's strategy, Littlechild suggests that if the entrepreneur had a guess for the price it would take to attract each passive player, then the following method could be used for choosing who to offer to, and how much to offer them (p. 156):

> 'Let $\hat{p}_j^i(t)$ be the price which entrepreneur i believes it necessary to bid to secure j's signature, where $\hat{p}_j^0(t) \equiv v(\{j\})$. Let $D_i(t)$ be the set of additional signatures desired by i. By definition $D_0(t) \equiv A(t)$, and for $i = 1, \dots, m$ obtain $D_i(t)$ as the solution to the optimisation problem
>
> $$\max_{D_i(t)} v\big(S_i(t) \cup D_i(t)\big) - \sum_{j \in D_i(t)} \hat{p}_j^i(t)$$
>
> $$\text{subject to } D_i(t) \subseteq A(t).$$
>
> ...Finally, set
>
> $$p_j^i(t) = \begin{cases} \hat{p}_j^i(t) & \text{for } j \in D_i(t) \\ 0 & \text{for } j \in A(t) - D_i(t).\text{'} \end{cases}$$

Littlechild does not determine any particular way by which entrepreneurs may arrive at their guesses or revise them, although some suggestions are implied in that paper's narrative arguments. Note that there is no cost to making an offer, and no limit on the number of offers an entrepreneur can make in each period.

APPENDIX B: DOES COOPERATIVE GAME THEORY MODEL COMPETITION? A CLARIFICATION

Cooperative Game Theory (CGT), also known under related terms such as the theory of Coalition Formation, or games in Characteristic Function or Coalitional form in the mathematics and economics literature is gaining traction in the strategic management field as a modeling toolbox (Adegbesan, 2009; Adner & Zemsky, 2006; Brandenburger & Stuart, 1996, 2007; Chatain & Zemsky, 2007; De Fontenay & Gans, 2008; Grahovac & Miller, 2009; MacDonald & Ryall, 2004; Ryall & Sorenson, 2007). However, the word 'cooperative' contributes to a common misperception about this toolbox: that it can only be a valid mathematical representation of real-world situations that do not involve competition. In this appendix, we argue that this perception is a misunderstanding. With the help of a brief review of the history of CGT in economics and strategic management, we demonstrate that in fact the notion of a 'cooperative' game is just a term used to describe a level of detail in modeling, and that the 'cooperative' form is just another form of mathematically representing games that in no way removes the competitive aspect from them. We point out that previous strategic management scholars using this toolbox have also tried to dispel this misunderstanding, and that in fact CGT has actually never been used in strategic management research to model non-competitive situations.

COOPERATIVE GAME THEORY AND COMPETITION IN ECONOMICS

The term cooperative game theory was introduced in the game theory literature not to describe something entirely different from non-cooperative game theory, but to *add* to non-cooperative game theory the idea that when we go beyond 2-person games to n-person games, the possibility of cooperation among coalitions (subgroups) of players adds a new level of complexity that needs to be studied. Thus the term cooperative game theory was used to model this new level of complexity in n-person games. However, in order to understand the new level, it often abstracts away from the some of the previous levels of detail studied under non-cooperative game theory and focuses only on a more macro level.

More specifically, non-cooperative game theory uses extensive form and strategic form for representing games which are mathematical constructions of the game that involve more detail than the characteristic function or coalitional form used by cooperative game theory to represent the same games. As explained by Shubik (1982, pp. 359-360):

> 'The extensive form stresses the fine structure of the game, the details of moves and information. The strategic form suppresses much of the detail and highlights the strategic choices of the players, the details of the payoffs, and the possibilities for threats. The coalitional form suppresses strategic detail and highlights the joint gains that can be made by the formation of coalitions. A theory of games can be constructed starting with any one of these forms … Starting with the extensive form, one can construct the strategic form in a straightforward manner. Since there is a considerable loss of information in this process, the reverse cannot be done … Starting with the extensive or strategic form, one can construct several different representations of a game in cooperative form … there is no unique way to return to the strategic or extensive form, as much information is lost.'

In other words, adding the possibility of cooperation just adds more detail to extensive form and strategic form games, and so 'cooperation' can be modeled by these tools of non-cooperative game theory[22]. But the cooperative form of these games just abstracts away from some of the details to make it easier to conduct more macro-level analysis. Thus the distinction between cooperative and non-cooperative game theory is just in the levels of game-theoretic analysis (Rapoport, 1970). The distinction really has nothing to do with whether or not one or the other is better suited for applications that involve cooperation, and certainly none of them assumes away competition. This is emphasized by Roth & Sotomayor (1990, pp. 10-11):

> 'The distinction commonly made between "cooperative" and "noncooperative" games is not a very clear one from the point of view of applications … many economic environments can profitable be analyzed with the tools of *both* cooperative and noncooperative game theory. What is relevant to the choice of tools is often not so much the nature of the environment, but rather what kind of question is being asked. What primarily distinguishes the two kinds of theory is that the noncooperative theory works with relatively detailed models that specify the strategic choices available to individual agents, whereas the cooperative theory works with less detailed models that summarize the rules of the game in terms of what outcomes can be obtained by which coalitions of players … These more and less detailed approaches have complementary functions. The more abstract, less detailed models offer the possibility of yielding quite general conclusions, applicable to a variety of specific situations. The more detailed models allow us to reach stronger conclusions about specific situations, and to test the generality of the more abstract models.'

The loss of information when going from extensive form or strategic form to characteristic function form is not always without cost, but for certain classes of games the costs are minimal. A large class of games called *games of consent* or *games of orthogonal coalitions* are adequately

[22] Myerson (1991 p371 and p245) shows how this can be done by adding a "contracting" option to the set of choices available to each player. Using this method for example, the 2 by 2 table of the famous prisoner's dilemma game becomes a 3 by 3 structure.

represented by characteristic functions and commonly arise in economic applications (Shubik, 1982, pp. 130-131). These are games in which the worst a player can do to another player is to refuse to form a coalition with them. In other words, no player can actively hurt another player. This condition is satisfied by a large class of economic applications, i.e., models of pure competition without externalities, where the worst players can do to each other is to refuse to trade with each other.

Such broad applicability of the characteristic function tool in modeling economic competition has allowed the central problems of neoclassical economics to be studied using cooperative game theory. As Moulin (2002, p. 77) points out: 'The fundamental economic example of a cooperative game is the pure exchange economy à la Arrow-Debreu (e.g., Debreu 1959). Every agent owns certain resources (a certain bundle of private goods) and they freely engage in trade by pairs or in any other coalition (i.e., subgroup) of agents.' The realization that the central analysis of general equilibrium theory could be pursued with the alternative toolbox of cooperative game theory was an important factor in the renaissance of game theory in general, since it dispelled the idea that game theory was only applicable to small numbers situations. The historical significance of this development is noted by Schotter and Schwödiauer (1980, p. 480):

> 'The vehicle for this renaissance was Martin Shubik's article "Edgeworth Market Games" (1959b), in which he demonstrated that Edgeworth's classic contract curve was identical to a game theoretical solution concept named "the core" that had been recently developed by Lloyd Shapley (1952), and Donald B. Gillies (1959). The impact of this equivalence was immediate. While the then current analysis of the general equilibrium problem being conducted by Kenneth Arrow, Gerard Debreu, Lionel McKenzie, and others was strictly Walrasian in orientation, treating all agents as perfect price-taking maximizers tied together by a price-making auctioneer, the new game theoretical analysis was Edgeworthian, taking inspiration from Edgeworth's Mathematical Psychics (1881), which viewed the price-formation process as the outcome of a large multilateral bargaining procedure. A long discussion ensued in the literature, in which it was proven that in the limit, as the economies studied get "large" in an appropriate manner, both the Walrasian and the game theoretical (Edgeworthian) analysis converge to the same solution.'

Moulin (2002, p. 80) refers to this as 'the most important result in cooperative game theory' and elaborates:

> 'In exchange economies with a large number of agents (each individual agent holding a small fraction of total resources) the set of core allocations and the set of competitive allocations are equal (Debreu and Scarf 1963) … Therefore, in a broad class of exchange economies, restricted only by the assumption of decreasing marginal rates of substitution,

> the core captures the fundamental idea of competition among traders and sits at the heart of the 'theory of value.' In production economies, the same basic link of the core to the competitive idea is preserved as long as the production technologies exhibit decreasing returns to scale (more precisely, as long as the set of feasible aggregate production plans is convex).'

This demonstrates that not only does cooperative game theory model competition, it has been fruitfully used to model the central competitive processes at the heart of economic theory. In sum, while non-cooperative game theory normally refers to situations in which the possibility of cooperation is ruled out, the mathematical representations developed in this theory (extensive form and strategic form games) can be extended to accommodate cooperation. In n-person situations where additional complexity is added due to the possibility of coalitional competition and cooperation, cooperative game theory helps analyze this complexity by simplifying the structure of extensive form and strategic form games into a less detailed characteristic function form. This form does not rule out competition and in fact models market competition fruitfully.

COOPERATIVE GAME THEORY AND COMPETITION IN STRATEGIC MANAGEMENT

One of the first papers that popularized the use of game theory in strategy chose to use the cooperative game theory toolbox rather than the noncooperative one. Brandenburger and Stuart (1996, p. 7) explain their decision as follows:

> 'Use of a particular noncooperative game model involves making very precise assumptions about the moves and countermoves available to the players. This is awkward when studying situations which are unstructured, as many business situations are. By contrast, cooperative game theory employs a notion of "free-form" interaction between players, which corresponds nicely to the active search for value creation and appropriation opportunities that characterizes business situations.'

To reassure those concerned with the possibility that the term 'cooperative' rules out competition, the authors explain (p. 7):

> 'The terms "cooperative game theory" and "noncooperative game theory" are standard, but can be misleading. They suggest that there is no place for conflict, competition, and the like in the former, and no place for cooperation in the latter. This is not true. Cooperative game theory can be used to study "unbridled" competition …while noncooperative game theory can be used to study the emergence of cooperation. Rather, as indicated, the distinction is between how much specificity about possible plays of the game is required.'

The application of cooperative game theory in strategic management research has particularly grow in recent years, largely influenced by Lippman and Rumelt (2003a). They too, provide a similar clarification (p. 1072):

> 'CGT differs from non-cooperative game theory in that it does not posit a detailed model of move and countermove. The distinction between cooperative and non-cooperative game models alludes not to cooperation, but rather to the amount of structure the game designer provides, with less structure provided by CGT. CGT characterizes the feasible and/or expected outcomes of self-interested bargaining and competition among a group of actors. A so-called 'cooperative' game can embody a situation of unbridled competition.'

More recent papers applying CGT to strategy abound)Adegbesan, 2009; Adner & Zemsky, 2006; Chatain & Zemsky, 2007; De Fontenay & Gans, 2008; Grahovac & Miller, 2009; Ryall & Sorenson, 2007(. These authors, too, have often found it necessary to clarify the misunderstanding implied by the word 'cooperative' in cooperative game theory. For example, Ryall & Sorenson (Ryall & Sorenson, 2007, p. 567) use the term 'coalitional' instead of cooperative 'because the math neither requires nor implies 'cooperation' (in the popular sense of the word) on the part of the actors involved. The cooperative moniker therefore seems a misnomer that can only lead intuitions astray.'

To summarize, cooperative game theory has been fruitfully applied to various types of strategic situations involving both competition and cooperation. In fact, among all the papers that apply cooperative game theory to business and management research, we have not found any that model non-competitive situations.

APPENDIX C: SUPPLEMENT TO CHAPTER 2

A. SUPPLEMENTARY TABLES

Table A1: Correspondence of rent mechanisms with theory, illustrative example, and modeling approach

Rent mechanism	Definition in Theory	Illustrative Example	Operationalized representation in model	Relevant modeling literature
Structural rent (Ricardian or monopoly rents)	Imperfections in factor markets (Barney, 1986) or product markets (Porter, 1980) lead to supernormal returns in equilibrium.	Scenario 1: Firm A is guaranteed to receive a $20 million equilibrium price for its technology due to the structure of the economy modeled in Table 1b.	A characteristic function represents the structure of the economy. We choose a structure for the characteristic function at time zero (Table 1e) that gives all players equal advantage in equilibrium (the core). This allows us to isolate entrepreneurial rents from structural ones.	Modeling toolbox: Traditional (static, non-repeated) cooperative game theory, especially the theory of the core in n-person characteristic function games (Debreu & Scarf, 1963; Rapoport, 1970; Scarf, 1967; Shubik, 1959) Model representativeness: Strategy researchers have suggested that the structure of characteristic function games and their core can represent competitive advantage in the form of Ricardian and monopoly rents (Brandenburger & Stuart, 1996; Lippman & Rumelt, 2003a; MacDonald & Ryall, 2004; Stuart, 2002)
Kirznerian rent	The process of taking the economy towards equilibrium by discovering and exploiting existing opportunities (Kirzner, 1997)	Scenario 2: In any economy (such as Table 1a or 1b) where the possibility of a gain to trade between firms objectively exists but has not yet been realized, one firm may discover the potential and exploit it by engaging another firm and securing a contract.	Discovery: In a characteristic function game, a player identifies excess (non-exploited value) in a coalition, and forms that coalition if it is not already formed. The excess value is divided among the members of this coalition and added to their previous payoffs. See also the entry for 'discovery capability' in Table A2.	Modeling toolbox: Research modeling the process of coalition formation in a characteristic function until equilibrium is reached either in closed-form models (Arnold & Schwalbe, 2002; Hart & Kurz, 1983; Konishi & Ray, 2003) or computer simulation (Chavez, 2004; Dworman et al., 1995; Klusch & Gerber, 2002). Model representativeness: Littlechild (1979a, 1979b) and Reid (1993) model entrepreneurship as the discovery and exploitation of excess in a characteristic function game. Foss (2000a) suggests the use of cooperative game theory to model the Kirznerian market process.
Schumpeterian rent	The process of taking the economy away from equilibrium by creating new opportunities (Schumpeter, 1934)	Scenario 3: Firm A comes up with an innovation that increases the value of its technology for all players, thus taking the economy from Table 1b to Table 1c or 1d, depending on the added value of the innovation.	Creation: In a characteristic function game, a player increases its added value (i.e., marginal contribution) to all possible coalitions including that player. See also the entry for 'creation capability' in Table A2.	Modeling toolbox: Research on repeated n-person cooperative games in which the characteristic function is allowed to change over time (Filar & Petrosjan, 2000). Model representativeness: Afuah (2009, p. 291) suggests that innovation can be modeled as the act of increasing marginal contribution in a characteristic function. Other research also suggests similar modeling representations of innovation in terms of increased added value in cooperative games (Adner & Zemsky, 2006; Chatain, 2010; Chatain & Zemsky, 2007; Grahovac & Miller, 2009).

Table A2: List of variables, operational definitions and values

Variable	**Operational definition**	**Default values**	**Robustness check**
Creation capability (Creation)	The probability that a player will add value to all possible coalitions including that player in a time period. (See also: innovation magnitude)	0 for passive players and 0.05 for active players.	A variety of values between 0.01 and 0.2 were tested systematically. In some cases values from 0.0025 up to 0.9 were tested for additional checks.
Discovery capability (Discovery)	The probability that a player will discover a coalition in which s/he can appropriate greater value, rally others to form that coalition, and divide a percentage of the value s/he can exploit with the members of this new coalition according to each member's bargaining power. (See also: exploitation efficiency, bargaining power)	0 for passive players and 0.05 for active players.	A variety of values between 0.01 and 0.2 were tested systematically. In some cases values from 0.0025 up to 0.9 were tested for additional checks.
Number of time periods (end time)	The number of time periods in each trial.	1000	Shorter time frame results were already visible within the 1000 periods; longer time frames of 2000 and 5000 were also tested.
Starting characteristic function	A function assigning a value to each possible coalition at the start of each trial. (It may later be changed within the trial through acts of creation).	$v(S) = 10(\|S\| - 1)$ as in Table 1e.	Coalition values were altered where relevant to test for the effect of providing some players with a starting potential payoff advantage over others or increasing the size of the economy.
Starting coalition structure and profit distribution	The actual coalitions formed at the start of each trial and the payoff each player in those coalitions is assigned at that time. The payoff distribution depends on the coalition structure because the sum of the payoffs for each player cannot exceed the characteristic function value of their actual coalition.	All players are assumed to start as singleton coalitions and thus receive zero payoffs.	Coalition structures and corresponding payoff distributions were altered where relevant to test for the effect of providing some players with a starting realized payoff advantage over others.
Innovation magnitude	The amount of value that a player's act of creation will add to all possible coalitions including that player.	1	Values between 0.1 and 10 were tested.
Exploitation efficiency	The percentage of the excess value of a coalition that a player's act of discovery can exploit and divide between the members of that coalition. 'Excess discovered' is the excess value of a blocking coalition times the exploitation efficiency of the discoverer.	70% (0.7)	Values between 0.1 and 1 were tested.
Bargaining power	The weight assigned to each player determining the share of value appropriated by that player when joining a new coalition and dividing its discovered value. The share of value appropriated by a player is in proportion to its bargaining power divided by the sum of all other coalition member's bargaining power.	1 for all players	Values were altered from 0.1 (10% of others) to 10 (1000% of others). These changes provided interesting insights and the full implications are beyond the scope of thisdissertation. Therefore, only some general trends are discussed here.
Number of players	The number of players interacting in each trial.	4	Conditions with 5 and 6 players were also tested. Trends indicate that no major results are likely to change for higher numbers.

B. OUTLINE OF SIMULATION ALGORITHM

Variables and parameters in bold type are defined in Table A2. More details are presented along with the flowcharts.

For each time period do the following:

1. Choose a player between all players and a null player to initiate an act of **creation**. The probability of an agent being chosen is their **creation capability**. The probability of the null player (no one) being chosen is 1 minus the sum of all player's creation capabilities.

    1.1. The act of creation is executed by adding the chosen player's **innovation magnitude** to all possible coalitions that include the chosen player. This produces a new characteristic function.

2. Choose a player between all players and a null player to initiate an act of **discovery**. The probability of an agent being chosen is their **discovery capability**. The probability of the null player (no one) being chosen is 1 minus the sum of all player's discovery capabilities.

    2.1. For all possible coalitions S that include the chosen player, calculate total excess of those coalitions as $v(T) - x(T)$.

    2.2. If no possible coalition including the chosen player has total excess above zero, do nothing and move on to step 3.

    2.3. Else, i.e., If one or more coalitions including the chosen player has total excess above zero, choose the coalition with the highest excess per capita as the blocking coalition (if there is a tie, choose randomly between them). This coalition may be the coalition that the chosen player is already in, or a different coalition.

        2.3.1 Calculate the **excess discovered** as the excess of the blocking coalition times the **exploitation efficiency** of the chosen player.

        2.3.2. The new profit distribution and coalition structure are produced as follows: Form the blocking coalition, and increase each player's current profit by an amount equal to their weighted share of the **excess discovered**, where the weights are determined by each player's **bargaining power** (assumed to be equal by default). Reshape the rest of the coalition structure of the game as follows:

            2.3.2.1 For each coalition that has not lost a player to the blocking coalition, keep the coalition and the previous profit allocated to its members.

            2.3.2.2 For each coalition that has lost players to the blocking coalition, the remaining members stay together and the pie shared between them is just the sum of the profits they were already getting, unless this sum is larger than the value of their coalition as allowed by the characteristic function, in which case the pie is set to that value.

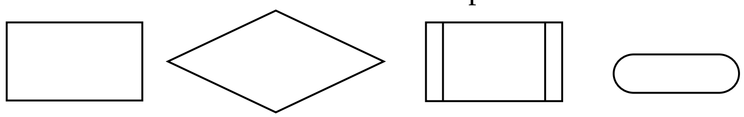
3. Record Distance from equilibrium, current profit of each player, cumulative profit of each player, current characteristic function, and current coalition structure.

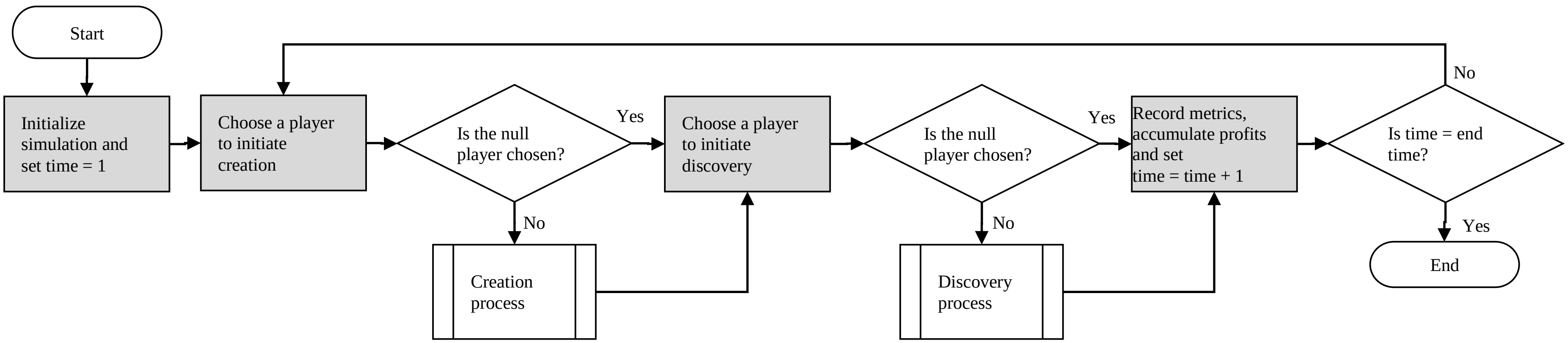
C. FLOWCHARTS & ALGORITHM DETAILS

Top level flowchart of the simulation algorithm

Shaded boxes are described in more detail below the flowchart. The flowcharts for the creation and discovery sub-processes are presented separately.

Legend of Flowchart Symbols: Process: Decision: Sub-process: Terminator:





Initialize simulation: This process involves setting up all the main constructs and giving them the default values shown in Table A2. This includes the characteristic function, the profit distribution, the cumulative profit distribution, the coalition structure, the number of players, the 'end time' or the number of time periods the simulation is to run, as well as each player's creation capability, discovery capability, innovation magnitude, exploitation efficiency, and bargaining power.

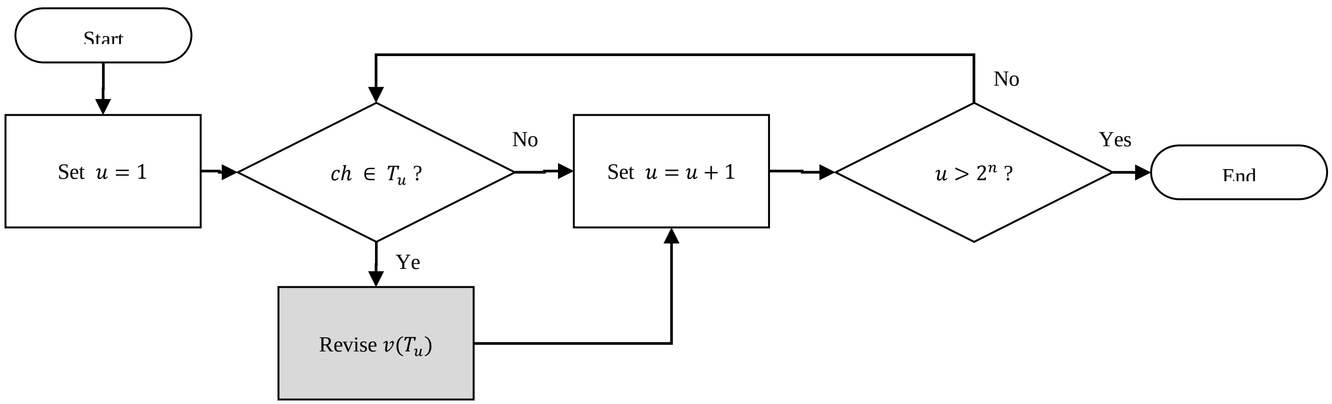
Choose a player to initiate creation: This process uses Matlab's **randsample** function to generate a random weighted sample of size 1 (i.e., choose one player) from the set of all players plus a null player, where the probability of each player being chosen is their creation capability, and the probability of the null player being chosen is 1 minus the sum of all players' creation capabilities.

Choose a player to initiate discovery: This process uses Matlab's **randsample** function to generate a random weighted sample of size 1 (i.e., choose one player) from the set of all players plus a null player, where the probability of each player being chosen is their discovery capability, and the probability of the null player being chosen is 1 minus the sum of all players' discovery capabilities.

Record metrics, accumulate profits and set time = time + 1: At this point the current time period ends so profit is accumulated by adding each player's current profit to their accumulated profit. The status of the game at the end of each period is archived by recording the current profit distribution, characteristic function, coalition structure, and distance from equilibrium.

Flowchart of the creation process assuming player ch has been chosen to initiate creation

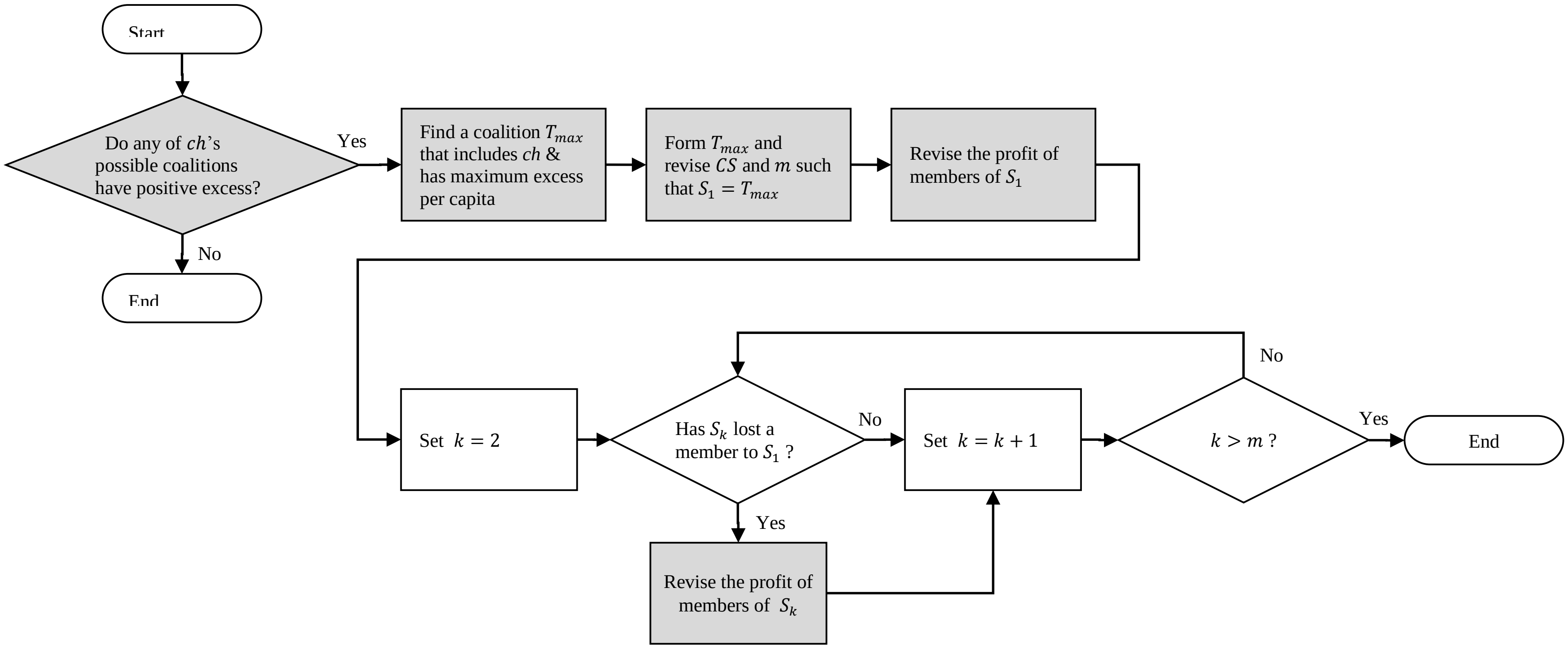
Shaded box is described in more detail below the flowchart. Note that $\Omega = \{T_1, T_2, \ldots, T_{2^n}\}$ denotes the set of all subsets of N or the set of all possible coalitions.



Revise $v(T_u)$: Here we update the value of the characteristic function for the focal coalition. If the chosen player is a member of T_u the value of this coalition is increased by the chosen player's innovation magnitude. In other words, $v(T_u)$ is set to $v(T_u) + innovation\ magnitude\ of\ ch$.

Flowchart of the discovery process assuming player ch has been chosen to initiate discovery

Shaded boxes are described in more detail below the flowchart. Note that $CS = \{S_1, S_2, \dots, S_m\}$ is the set of actual coalitions or the set of coalitions currently formed at the start of the discovery process, where m is the number of currently formed coalitions. $\Omega = \{T_1, T_2, \dots, T_{2^n}\}$ denotes the set of all subsets of N or the set of all possible coalitions. $x = (x_1, x_2, \dots, x_n)$ denotes the profit distribution where x_i denotes the current payoff of player i, $x(S_k) = \sum_{j \in S_k} x_j$ denotes the sum of the current payoffs of the members of S_k, and $b = (b_1, b_2, \dots, b_n)$ is the bargaining power vector such that b_i denotes the bargaining power of player i.



Do any of ch's possible coalitions have positive excess? This decision point asks whether any possible coalition T_u exists that contains ch (i.e., $ch \in T_u$) and that has positive excess (i.e., $v(T_u) - x(T_u) > 0$).

Find a coalition T_{max} that has maximum excess per capita: choose the coalition that maximizes the function $\frac{v(T_u)-x(T_u)}{|T_u|}$ where $|T_u|$ denotes the number of members in T_u. In other words, find T_{max} such that $\frac{v(T_{max})-x(T_{max})}{|T_{max}|} \geq \frac{v(T_u)-x(T_u)}{|T_u|}, \ \forall u \mid ch \in T_u$. If there is more than one coalition that satisfies this condition, choose randomly between them.

Form T_{max} and revise CS and m such that $S_1 = T_{max}$: In this step the coalition structure changes. We save a copy of the current coalition structure in $CS' = \{S'_1, \ldots, S'_{m'}\}$. We create the new CS as follows. First the coalition T_{max} is formed by taking its members out of current coalitions and setting it as the first coalition in the new coalition structure, i.e., $S_1 = T_{max}$. The rest of the coalitions in the new CS are constructed by setting $S_k = S'_{k-1} - S_1$ using Matlab's **setdiff** command and then removing all the S_k sets that are empty. Finally, the number of sets in the new CS is counted and m is set to this value.

Revise the profit of members of S_1: For each $i \in S_1 = T_{max}$ we set:

$$x_i = x_i + excess\ discovered\ by\ ch \times relative\ bargaining\ power\ of\ player\ i$$

In other words, increase the profit of each member of the blocking coalition $S_1$by that player's share of the excess discovered by ch. Excess discovered is calculated by multiplying excess by the exploitation efficiency of the discoverer. The size of each player's share of the excess discovered is determined by their relative bargaining power. More specifically:

$$x_i = x_i + \big(v(T_{max}) - x(T_{max})\big) \times (exploitation\ efficiency\ of\ ch) \times \frac{b_i}{\sum_{j \in T_{max}} b_j}$$

In the default condition where all players' bargaining powers are equal, the above reduces to:

$$x_i = x_i + \frac{excess\ discovered\ by\ ch}{|T_{max}|}$$

Revise the profit of members of S_k: If S_k has lost a member to S_1, the coalition is reshaped and its members may not be able to earn the same amount of profit as when they were in a larger coalition. Whether or not the size of the pie to be divided between the members of S_k is changed, the loss of players changes the relative bargaining power of the remaining players, so another round of bargaining to determine each player's share is also necessary. So in this step, for each $i \in S_k$ we set:

$$x_i = pie \times relative\ bargaining\ power\ of\ player\ i$$

Where pie is the lesser value among $x(S_k)$ and $v(S_k)$. More specifically:

$$x_i = \min\{x(S_k), v(S_k)\} \times \frac{b_i}{\sum_{j \in S_k} b_j}$$

D. FURTHER RESULTS OF ROBUSTNESS CHECKS

Some robustness checks involve manipulating variables not central to our simulation experiments or findings not central to our theory development, yet the results merit mention:

Figure 2 (1 discoverer, 3 passives): Robustness analysis showed that if we increase the bargaining power of the discoverer, the player gains a performance advantage over the passive players exactly proportional to the relative difference in bargaining power. In reality entrepreneurs who discover an opportunity often have to rally incumbent players to join their coalition. These incumbent players can have higher bargaining power than the entrepreneurs themselves. A full discussion of the effect of variations in the bargaining power of passive players is beyond the scope of this chapter. Robustness tests also showed that if the characteristic function had been different, the discoverer may have easily been able to use the passivity of other players to its advantage. For example, if the characteristic function was such that the discoverer had a disadvantage in equilibrium compared to some state in disequilibrium, it would not equilibrate the market beyond that point (see chapter 3). This could happen if the discoverer in our example was one of the game producers, and would like to keep the other game producer out of the picture, because although a two-game package would sell better than one, the other partners would be less dependent on the discoverer if another game producer was involved.

Figure 3 (1 discoverer, 1 creator, 2 passives): Robustness analyses revealed that starting with advantageous positions in the characteristic function or an advantageous coalition structure and profit distribution can hasten the arrival of the breakaway point when the creator and discoverer start making more profit than passive players.

Figure 5b (2 discoverers, 1 creator, 1 passive): Robustness analysis provides further indications of the devastating toll of competition on pure discoverers. Increasing the level of discovery capability or the level of exploitation efficiency (see Table A2) for the competing discoverers is of no help to them. However, a discoverer with higher bargaining power or a potential advantage according to the starting characteristic function may be able to surpass passive players and less advantaged discoverers. Also, the larger the size of the economy, the later the creator is able to break away in terms of performance advantage over passive players and competing discoverers.

Figure 5c (1 discoverer, 2 creators, 1 passive): Robustness tests indicate other variables can also result in a competitive advantage for one creator over another when they are both competing for just one discoverer. A higher creation capability or innovation magnitude gives advantage to a creator compared to another. It also benefits the discoverer as expected. These tests also show that in our model, a lower innovation magnitude can be compensated by higher innovation capability and vice versa. Bargaining power can also set one creator apart from others, and unlike increased creation capability or innovation magnitude, a creator's higher bargaining power does not also benefit the discoverer (i.e., returns to bargaining power are zero-sum rather than win-win).

E. EXPERIMENTAL DESIGN

The main variables we manipulate as the input to our simulation experiments are the creation and discovery capabilities of each of four players. Assuming a binary condition of having or not having each of these capabilities, the total number of possible combinations can be calculated with the following formula: since we have *n*=4 players, each of which can have *r*=4 possible combinations of capabilities (none, only creation, only discovery, both) and since the ordering of players is not important, the formula is[23]:

$$\binom{n+r-1}{r}$$

In our case, this amounts to $\binom{\mathbf{7}}{\mathbf{4}} = \mathbf{35}$ **possible combinations**. We can list them all as follows:

{None,None,None,None} {None,None,None,Discovery} {None,None,None,Creation}
{None,None,None,Both} {None,None,Discovery,Discovery} {None,None,Discovery,Creation}
{None,None,Discovery,Both} {None,None,Creation,Creation} {None,None,Creation,Both}
{None,None,Both,Both} {None,Discovery,Discovery,Discovery}
{None,Discovery,Discovery,Creation} {None,Discovery,Discovery,Both}
{None,Discovery,Creation,Creation} {None,Discovery,Creation,Both}
{None,Discovery,Both,Both} {None,Creation,Creation,Creation}

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[23] The formula and its derivation can be found at:

http://www.mathsisfun.com/combinatorics/combinations-permutations.html

An online calculator for the formula can be found at:

http://www.mathsisfun.com/combinatorics/combinations-permutations-calculator.html

{None,Creation,Creation,Both} {None,Creation,Both,Both} {None,Both,Both,Both}
{Discovery,Discovery,Discovery,Discovery} {Discovery,Discovery,Discovery,Creation}
{Discovery,Discovery,Discovery,Both} {Discovery,Discovery,Creation,Creation}
{Discovery,Discovery,Creation,Both} {Discovery,Discovery,Both,Both}
{Discovery,Creation,Creation,Creation} {Discovery,Creation,Creation,Both}
{Discovery,Creation,Both,Both} {Discovery,Both,Both,Both}
{Creation,Creation,Creation,Creation} {Creation,Creation,Creation,Both}
{Creation,Creation,Both,Both} {Creation,Both,Both,Both} {Both,Both,Both,Both}

Below, we go through various groups of the above combinations and consider how they are addressed in our study. In the {None,None,None,None} combination, nothing happens. **We have 34 remaining combinations to explore.**

The remaining combinations with no discovery happening (4 in total) are all similar scenarios:

{None,None,None,Creation} {None,None,Creation,Creation}
{None,Creation,Creation,Creation} {Creation,Creation,Creation,Creation}

Although potential value and distance from equilibrium are increased due to creation activity, no actual performance is observed because no profits are realized. We have covered this scenario in the base case of Figure 1. The only difference between the combinations would be the coalitions for which potential value (unexploited opportunities) are increased. There is no performance heterogeneity. **We have 30 remaining combinations to explore.**

There are 4 remaining combinations with only discovery happening, and these are also similar scenarios:

{None,None,None,Discovery} {None,None,Discovery,Discovery}
{None,Discovery,Discovery,Discovery} {Discovery,Discovery,Discovery,Discovery}

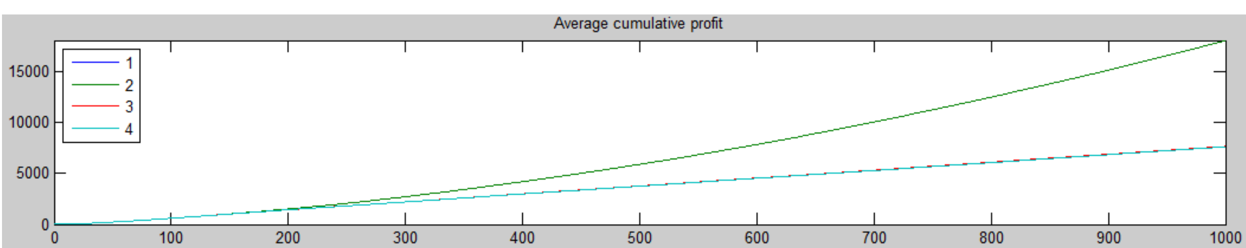
Since there is no creation activity, the characteristic function does not change and throughout the game we are dealing with the starting characteristic function (Table 1e), in which the most profitable opportunity for all players is the grand coalition. Thus in all these scenarios, similar to the one covered in Figure 2, the economy quickly reaches equilibrium and stays there because there is no creation activity to disrupt it. The only difference between the combinations is how quickly equilibrium is achieved. Increased discovery activity speeds up equilibration. Assuming equal bargaining power, the discoverers and passive players all attain the same performance in these scenarios because ultimately the grand coalition needs to be formed and its value is divided equally. So under this assumption Figure 2 is an adequate representative of all 4 combinations.

Experimenting with different bargaining power levels here produces interesting results that due to the need for extended discussion, we have chosen not to cover in this chapter due to length limitations. We may want to assume different bargaining power because we may want to give discoverers more credit for being the one to discover the value divided, or we may want to give passive players higher bargaining powers to model the interaction between start-ups and passive but more powerful incumbents. In either case, our results indicate that relative and absolute performance do not predictably rise with increased bargaining power and the bargaining power – performance relationship in the 'no creation activity' scenarios follows an unusual pattern that needs to be investigated more thoroughly. Currently, we suspect that the unusual pattern observed has to do with the effect of bargaining power in the sequencing of negotiations (i.e., the sequence of coalition changes and bargaining processes before finally reaching equilibrium). **We have 26 remaining combinations to explore.**

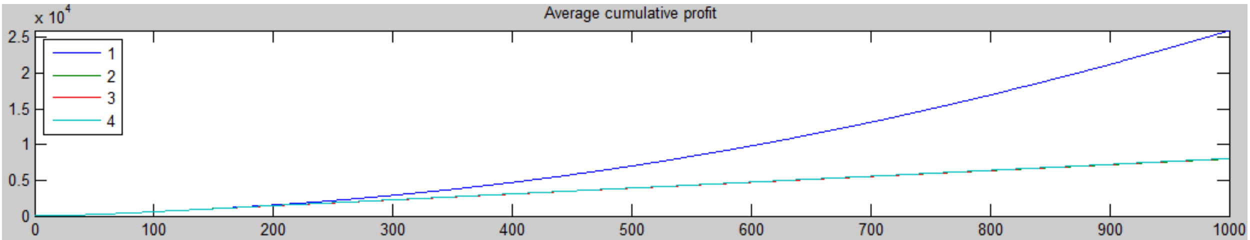
There are 4 combinations in which we only have passive players and players with both creation and discovery capabilities:

{None,None,None,Both} {None,None,Both,Both} {None,Both,Both,Both}
{Both,Both,Both,Both}

The first combination {None,None,None,Both} is analogous to the combination {None,None,Discovery,Creation} that is covered in Figure 3 in the main paper (i.e., chapter 2 of this dissertation). The Figure 3 cumulative performance results are:



The results for the {None,None,None,Both} combination are:

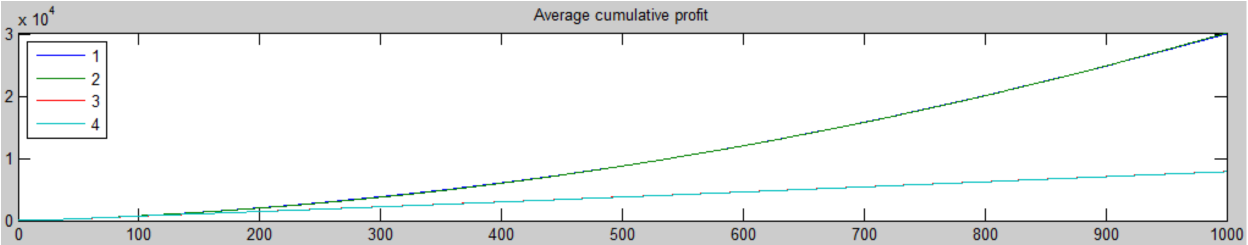


Where player 1 (blue line) is the dual-capability player. In fact this is almost identical with the results of Figure 5b, where competition among discoverers drives their rents to zero to the benefit of the creator. Here too, the creator is the only one benefiting from the discovery activity.

The only difference with Figure 3 is that profits are accrued by one agent instead of two, which is a predictable outcome and the reason why we do not allocate a specific figure to it in the chapter. Though much higher, the profit level is not exactly double the case of Figure 3, because 1) the discovery capability level of 0.05 is higher than the saturation point necessary for the dual-capability player to gain all profits made possible by its own creation activity, and 2) in the partnership scenario in Figure 3, the two players are already able to earn a larger-than-half portion of the maximum profits possible if they were merged into one player. The results for the {None,None,None,Both} combination do not really illustrate anything beyond the synergy of creation and discovery and the non-linear returns to increased discovery, which are both points illustrated by experiments covered in the paper.

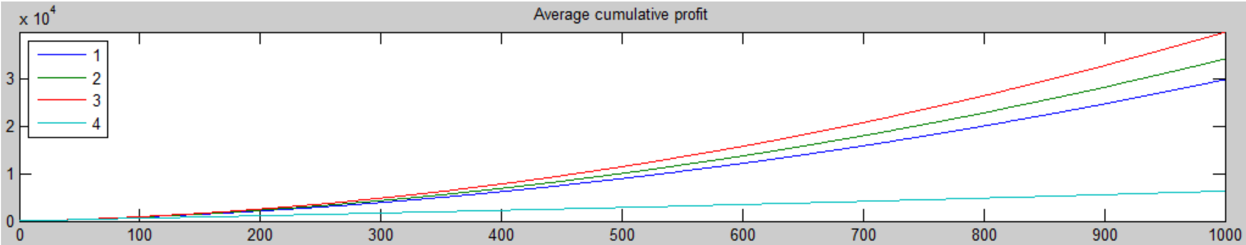
Any additional dual-capability players added to this scenario also produce results predictable from the patterns already discussed in the paper. Any dual-capability players perform higher than passive players and perform exactly at the same level as each other if they have the same level of capabilities. This level is higher than that of the single player mode because players can take advantage of each other's creation activity (and discovery if needed, i.e., if saturation has not yet occurred).

{None,None,Both,Both}
Creation=[0.05 0.05 0 0];
Discovery=[0.05 0.05 0 0];



If we give them different levels of creation capabilities, this will produce a predictable difference in performance between them as suggested by the results covered in chapter 2.

{None,Both,Both,Both}
Creation=[0.05 0.06 0.07 0];
Discovery=[0.05 0.05 0.05 0];



Differences in discovery capability will only create performance differentials if the overall discovery activity available to any players becomes lower than that player's saturation point given the overall level of opportunities made available to it by the overall level of creation activity.

Although the above scenarios serve to further illustrate the points already made in the chapter, they do not significantly add to the findings discussed in the chapter and that is why we have made the decision to save space by omitting them. **We have 22 remaining combinations to consider.**

{None,None,Discovery,Creation} is already covered in Figure 3

{None,Discovery,Discovery,Creation} is already covered in Figure 5b (competition among discoverers)

{Discovery,Discovery,Discovery,Creation} this combination produces results virtually identical to Figure 5b because the mechanism is the same, i.e., competition among discoverers is driving their rents to zero compared to passive players to the benefit of the creator, and the additional discovery activity produces no added value for the creator who already has access to enough discovery activity to reach the saturation point.

{None,Discovery,Creation,Creation} is already covered in Figure 5c (competition among creators)

{Discovery,Creation,Creation,Creation} this combination produces predictable results that further demonstrate the mechanism that produces the results of Figure 5c. The results are similar to Figure 5c with all players performing at the same level, but a higher level than Figure 5c because there is now more creation activity that all players can benefit from.

{Discovery,Discovery,Creation,Creation} this combination also produces results easily predictable given the results already discussed in Figures 5b and 5c. Here, competition among discoverers drives their rents to the level of passive players and the profits are accrued to creator players, who perform at the same level.

Thus the above 6 combinations are either covered or similar to those covered in the chapter. **We have 16 remaining combinations to consider.**

{None,None,Discovery,Both} is already covered in Figure 6b. The addition of more discoverers as in {None,Discovery,Discovery,Both} or {Discovery,Discovery,Discovery,Both} produces results virtually identical to Figure 6b because the mechanism is the same (competition among discoverers driving their rents to the level of passive players). Only the player with some level of creation capability makes superior profits.

{None,None,Creation,Both} is already covered in Figure 6a. The addition of more creators as in {None,Creation,Creation,Both} and {Creation,Creation,Creation,Both} produces results similar to Figure 6a. The results produced demonstrate the same mechanism that produced Figure 5c compared to 5a. The additional creators benefit from each other's creations and the discovery activity of the dual-capability player.

Thus again, the above 6 combinations are either covered or similar to those covered in the chapter. **We have 10 remaining combinations to consider. But the remaining 10 combinations also produce predictable results that demonstrate the same mechanisms covered above**: {None,Discovery,Both,Both} {Discovery,Discovery,Both,Both} {None,Creation,Both,Both} {Creation,Creation,Both,Both} {None,Discovery,Creation,Both}

{Discovery,Discovery,Creation,Both} {Discovery,Creation,Creation,Both} {Discovery,Creation,Both,Both} {Discovery,Both,Both,Both} {Creation,Both,Both,Both}.

Whenever there is more than one player with discovery capability, only players with any creation capability perform better than the passive player level. Whenever there is more than one player with creation capability, the creators complement each other.

In conclusion, the patterns covered in the manuscript (substitution effect of discovery, complementarity effect of creation, saturation of opportunities, etc.) adequately cover all patterns observed in simulation of all 35 possible combinations. With the only exception being patterns observed regarding bargaining power which we have consciously decided to exclude from the scope of this chapter.