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TOWARD A THEORY OF ENTREPRENEURIAL RENTS: A SIMULATION OF THE MARKET PROCESS

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While strategy theory relies heavily on equilibrium theories of economic rents such as Ricardian and monopoly rents, we do not yet have a comprehensive theory of disequilibrium or entrepreneurial rents. We use cooperative game theory to structure computer simulations of the market process in which acts of creation and discovery disequilibrate and equilibrate the market over time. Using simulation experiments, entrepreneurial rents can be isolated from structural rents by keeping initial structural advantages constant. We impute entrepreneurial rents to underlying actions of creation and discovery under various combinations. Our results have relevant implications for entrepreneurship strategy, particularly for firm boundaries and resource allocation decisions.

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, 2006). 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 and Papenhausen, 2003; Priem and 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, Glosten, and Muller, 1993).

Our paper takes some steps toward answering these questions. 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 and Rumelt, 2003b; Winter, 1987). Accordingly, we define a theory of entrepreneurial rents as a description of the economic mechanisms by

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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 and Bower, 1996).

Since existing theories of rents are based on underlying formal models, our approach in this paper 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 and Stuart, 1996, 2007; Chatain and Zemsky, 2007; Lippman and Rumelt, 2003a; MacDonald and 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, and 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: 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 and 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 and Shane, 2003: 334–335). If there were 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 nonzero profits to be possible, either competition must 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 nonzero 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, 2006). 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

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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 and Shane, 2003; Priem and 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 and 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 and Papenhausen, 2003; D'Aveni, Dagnino, and Smith, 2010; Foss and 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 and Miller, 2012), resource management (Sirmon, Gove, and Hitt, 2008; Sirmon, Hitt, and Ireland, 2007), dynamic capabilities, and asset orchestration (Helfat, 2007; Sirmon *et al.*, 2011), and entrepreneurship (Alvarez and Barney, 2007; Klein, 2008; Shane and 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: 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 and Stuart, 2007; Lippman and Rumelt, 2003a; MacDonald and 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 noncompetitive. It is just a label used to refer to a less constrained and more free-form method of modeling games (Brandenburger and 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; price competition among the producers 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 $0 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 Table 1a, b in million dollar amounts. The game in Table 1b is a variation of the "three-cornered market" in Shubik (1982: 151; adapted from von Neumann and 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 and 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

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Table 1. The characteristic functions used in this paper

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	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	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	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)

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.

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 and 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 and 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 toward equilibrium. This type of entrepreneurship—the discovery and exploitation of existing opportunities—is referred to as *discovery entrepreneurship* (discovery for short) in this paper. 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 of 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 paper, 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 c) and the new value

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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 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 nonentrepreneurial rents. It is also difficult, if not impossible, to empirically distinguish equilibrating versus disequilibrating processes. In this paper 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 and Stuart, 2007; Lippman and Rumelt, 2003a; MacDonald and 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 and Sotomayor, 1990: 11). But despite some early efforts (Littlechild, 1979a,b) and some suggestions (Foss, 2000; 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, 2000; 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 and Schwalbe, 2002; Hart and Kurz, 1983; Konishi and Ray, 2003) to model Kirznerian discovery and the process of moving toward equilibrium within a given characteristic function. We also take inspiration from dynamic cooperative game theory (Filar and 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 and Kimbrough, 2004; Dworman, 1994; Klusch and 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 information requirements on players and to incorporate a higher level of complexity and indeterminateness than purely analytical models would allow (Harrison *et al.*, 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 nonchanging set $N = \{1,2, \ldots ,n\}$ 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

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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 nonempty 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* $v : \Omega \to \mathbb{R}_+$ where $\Omega = \{T_1, T_2, \ldots, T_{2^n}\}$ 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* $CS = \{S_1, S_2, \ldots, S_m\}$ where $\cup_{k=1}^{m} S_k = N$ and $S_k \cap S_l = \phi,\ \forall k \neq l$, i.e., CS is a partition of N into nonempty 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 $x = (x_1, \ldots, x_n) \in \mathbb{R}_+^n$. 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. The first aspect concerns 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. The second aspect concerns 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 paper 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 paper 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,b) 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

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cooperative games have traditionally been used to model economic transactions between buyers and sellers (Debreu and 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 from it a player i; 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: 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 a 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 the paper are produced with some variables kept at default values. As we report throughout the paper, 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 and 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

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capabilities, we have 35 possible combinations. Among these, we explore some combinations in more depth but since many produce similar patterns (see the 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 1,000 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 (MathWorks headquartered in Natick, Massachusetts, USA).

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 (Figure 1a, b). 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).

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

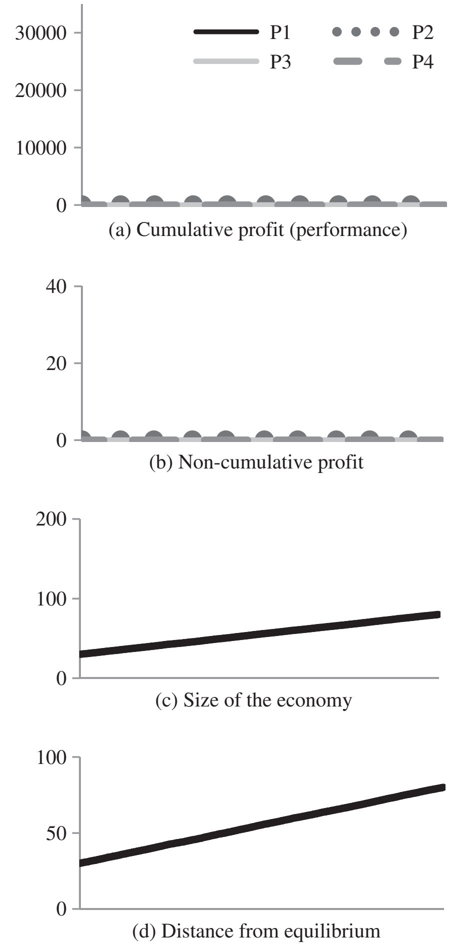

Figure 1. Base case of one creator. The characteristic function for all figures is Table 1e. The horizontal axis represents 1,000 time periods. For each time period the figures show average quantities over 200 runs

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

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

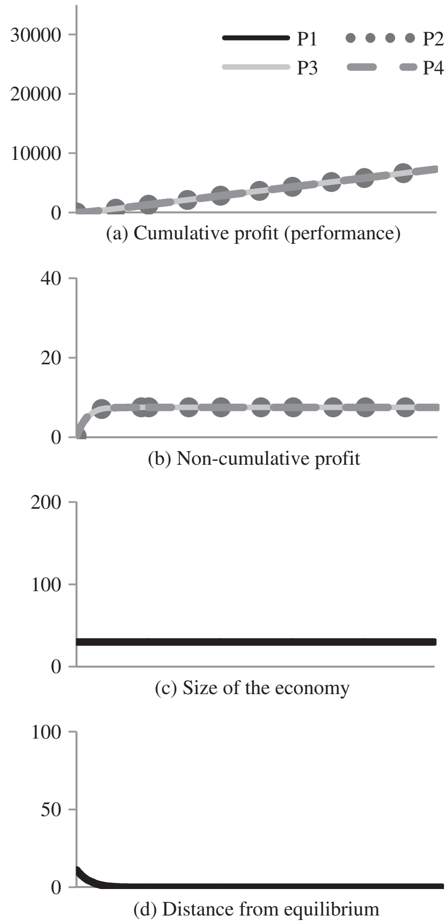

Figure 2. Base case of one discoverer. The characteristic function for all figures is Table 1e. The horizontal axis represents 1,000 time periods. For each time period the figures show average quantities over 200 runs

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, and 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.

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 without 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 destabilize substantially (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,

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

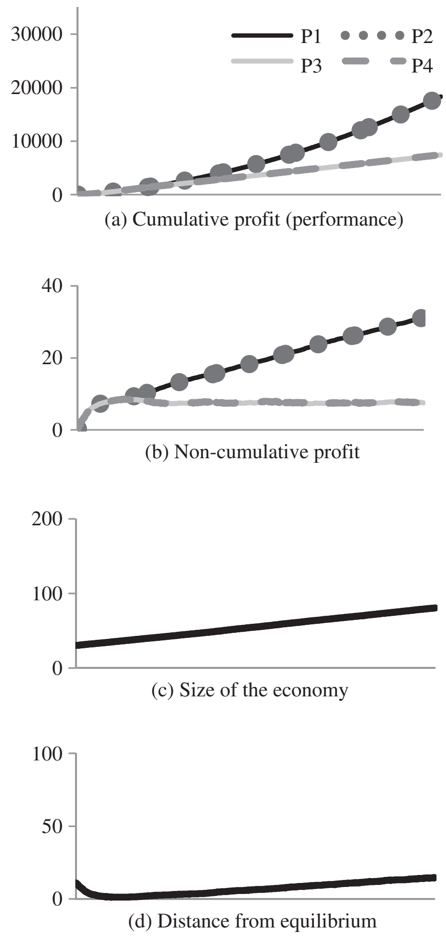

Figure 3. Base case of one creation and one discoverer. The characteristic function for all figures is Table 1e. The horizontal axis represents 1,000 time periods. For each time period the figures show average quantities over 200 runs

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 and 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, reaches a payoff of 7.5 on average in equilibrium and a cumulative performance of approximately 7,300 over 1,000 time periods (a bit less than 7,500 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 1,000) against a changing level of discovery capability for player 2. The results are shown in Figure 4a, b.

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 Figure 4a and b 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

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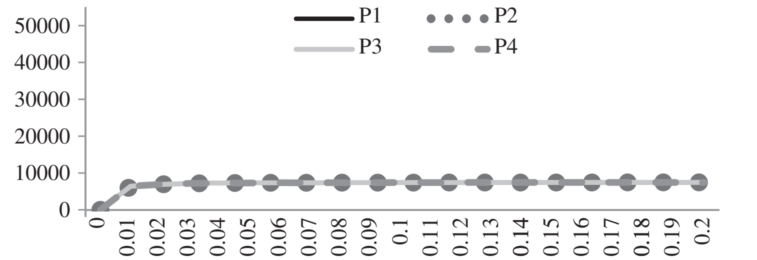
Inputs:

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

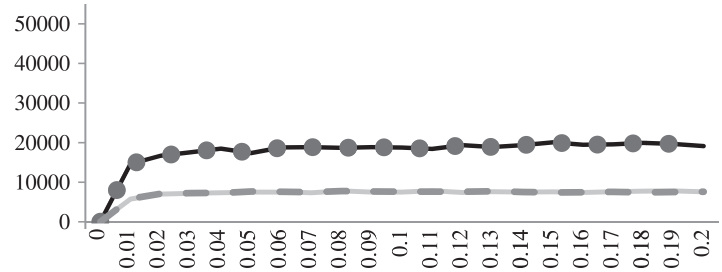
(a) Returns to improving discovery while keeping creation level fixed at 0



Inputs:

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

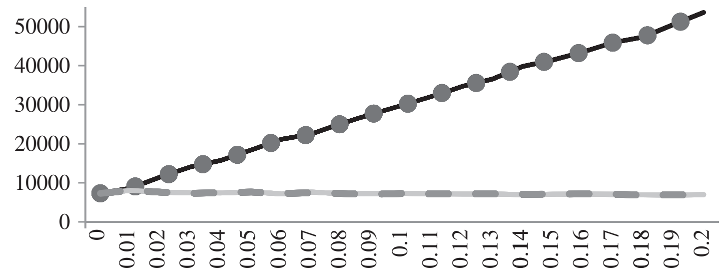
(b) Returns to improving discovery while keeping creation level fixed at 0.05



Inputs:

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

(c) 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

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

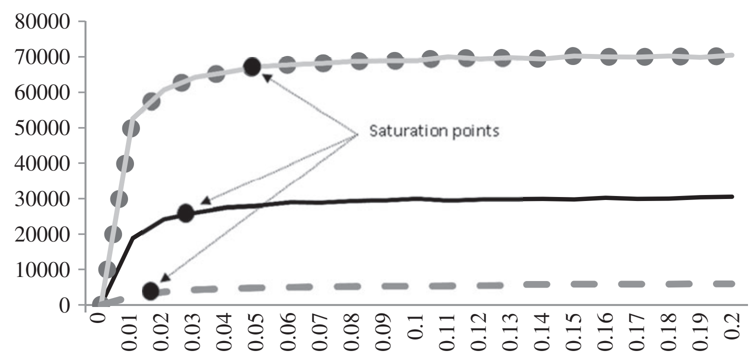


Figure 4. Returns to improving creation and discovery capability. The characteristic function for is Table 1e. The vertical axis represents performance (cumulated profit) at time period 1,000, while the horizontal axis represents levels of x in the input tables. For each data point the figures show average quantities over 200 runs

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 (1979) 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

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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.

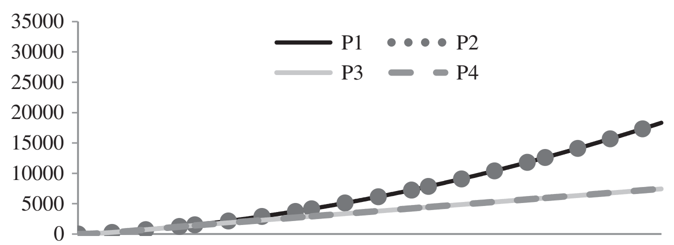
Returns to discovery and creation under competition

Although the characteristic function has been employed to model the structure of competition in an imperfectly competitive equilibrium setting (Lippman and Rumelt, 2003a; MacDonald and 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 bargain only 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 paper.

Moving on to competition among creators, suppose we have only one discoverer but two

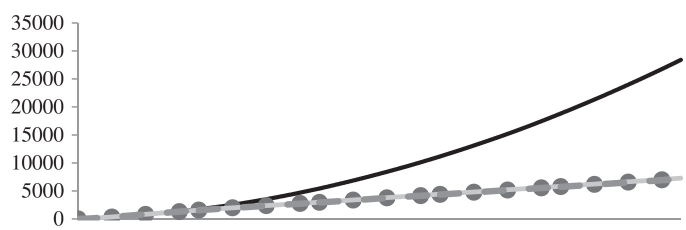
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0	0.05	0	0

(a) 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

(b) 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

(c) One discoverer with two creators

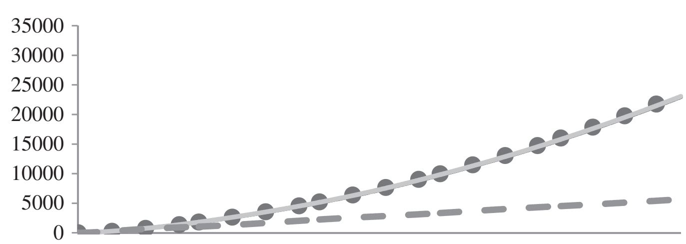


Figure 5. Returns to creation and discovery under competition. The characteristic function for is Table 1e. The vertical axis represents performance (cumulative profit) and the horizontal axis represents 1,000 time periods. For each period the figures show average quantities over 200 runs

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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 and 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 surpass clearly 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 five- and six-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 versus a wide shallow one (i.e., a market with only one creator with 0.15 creation capability versus 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.

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 were 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 (Figure 4a, b, d), 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

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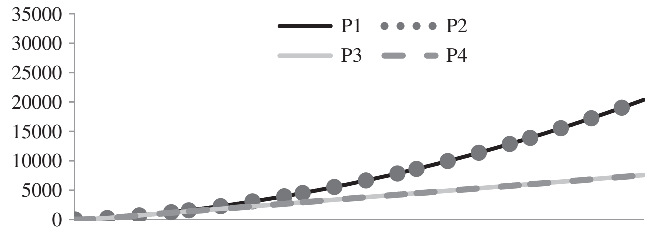
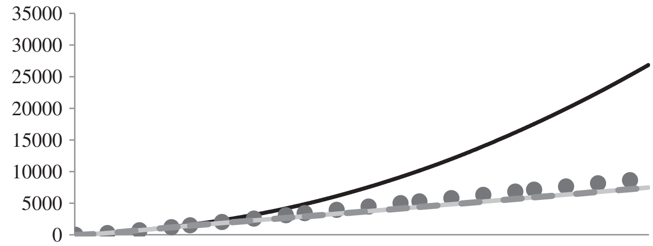
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0.01	0	0
Discovery	0	0.05	0	0

(a) One creator and one dually capable entrepreneur



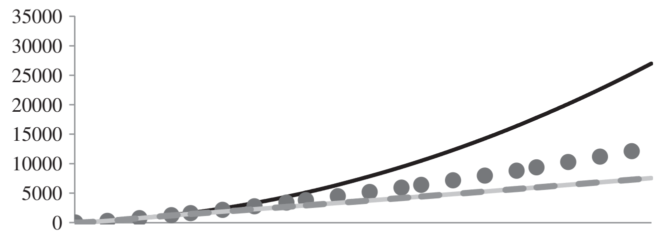
Inputs:	Players' Prob. of Action			
	P1	P2	P3	P4
Creation	0.05	0	0	0
Discovery	0.01	0.05	0	0

(b) 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

(c) 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

(d) Two dually capable entrepreneurs in a larger economy

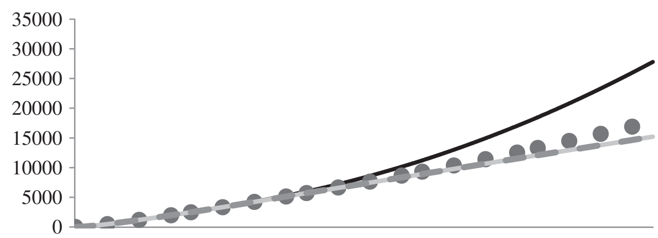


Figure 6. Returns to simultaneous creation and discovery. The characteristic function for a–c is Table 1e and the characteristic function for d is Table 1f. The vertical axis represents performance (cumulative profit) and the horizontal axis represents 1,000 time periods. For each period the figures show average quantities over 200 runs. The inputs for d are identical to c with the difference that the size of the economy has been increased from 30 to 50

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).

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, 2a), which supports theoretical arguments by previous authors (Darroch

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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 (Figure 4a, b, d). 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, 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): (1) 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; (2) 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 (3) 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 and Sjölander, 1990; Lehmann, Braun, and Krispin, 2011; Lehto and Lehtoranta, 2006; Mayer and 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, 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 and 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 and Milgrom, 1994; Jensen and 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 and Prahalad, 1996; Kogut and 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 paper 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 paper 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

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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 paper'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.

Additional 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 paper, and perhaps utilizing other software tools for agent-based simulations. We have merely taken the first steps.

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