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REGULAR ARTICLE

On the entrepreneurial genesis of new markets: effectual transformations versus causal search and selection

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Abstract The generation of new markets is an emerging area of interest among researchers working in the traditions of evolutionary economics. And true to those traditions, the current study incorporates empirical evidence from psychology and cognitive science to develop micro-foundations for evolutionary theories of new market generation. In this paper we present an in-depth analysis of how expert entrepreneurs use effectual logic to conceptualize the creation of new markets. Our results challenge received wisdom based on search and selection processes and move beyond combinatorial ideas to develop instead a "transformational" view of market genesis.

Keywords Entrepreneurship · Transformation · Industrial dynamics · New market creation

JEL Classification D4 · D52 · D71 · D72 · L1 · L2 · M13 · M31 · P42

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1 Introduction

Where do new markets come from? Conventional wisdom in the Schumpeterian tradition is that the entrepreneur—like the stork—delivers them, i.e. that most new markets are pushed up from the supply side (Metcalfe 2004; Mowery and Rosenberg 1979). In an elegant summary of this wisdom, the late Paul Geroski suggested that there is one very strong implication of this supply-push process for the generation of new markets: the goods and services that entrepreneurs bring to new markets are no more than guesses about what might appeal to consumers (Geroski 2002:48). Geroski argued that even when it is clear that there is potentially a large market for an innovation, the precise nature of customer demands for the innovation tend to be "inchoate" rather than specific because customers initially have little practical knowledge or experience of the innovation. Without a precise target to shoot at, entrepreneurs launch a variety of different products that embody different ideas about what consumers might really want. Therefore there is an explosion of product and service variants early in the development of a new market (Abernathy and Utterback 1978; Geroski 2002:61). Later in the evolution of a new market, as customer demand becomes more "articulate" and the market takes a more definitive form, competitive pressures lead entrepreneurs who guessed wrong to be selected out of the market; as in Darwin's coral reef, these entrepreneurial corpses provide the foundations upon which later entrants build (Klepper and Simons 1997; Metcalfe 1998).

What models of agent behavior might underpin these new market processes Geroski and others have so eruditely described? Might there be a way of incorporating empirical evidence from psychology and cognitive science into evolutionary theories of new market generation? Dosi and his colleagues have suggested that evolutionary economists renew their focus on possible micro processes that might help explain observed macro patterns (Fagiolo and Dosi 2003; Winter et al. 2003). Summarizing existing models of micro-behavior, Dosi and Winter (2000:31) conclude:

> The challenge ahead, as we see it, involves a painstaking reassessment of the microfoundations characterizing what agents do, how they learn, their interactions and the ways all that is embedded into institutional structures and "habits of thought" that shape the possible worlds achievable at any point in time. Certainly, for economists, that reassessment requires more attention to the wealth of evidence from other disciplines, from psychology to political science. The upside of such inquiry might be that the descriptive analysis of observed courses of individual and collective behavior is freed (at last) from the conceptual prison of a deductive, prescriptive theory of action.

This paper represents one step in the process of such a "painstaking reassessment of microfoundations." We bring to evolutionary economics evidence from a cognitive-scientific study of how expert entrepreneurs conceptualize the creation of new markets. Our design challenges received wisdom

based on agent search and selection processes (embodied in current theories of market creation) and moves beyond combinatorial ideas (such as those based on replicator dynamics and recombinant processes), to develop instead a "transformational" view of market genesis at the micro level.

The paper proceeds as follows. We start, in the next section, with a brief overview of different conceptual frameworks that underlie the genesis of new markets. Here we compare "causal search and selection" concepts with the concept of "effectual transformation" processes by delineating the essential features of each one. In the third section of the paper we report on an empirical test of these two approaches using the well established method of protocol analysis from the literature on cognitive expertise. Results show that the transformation approach systematically results in more variety and is strongly preferred by expert entrepreneurs as compared to MBA students trained in search and selection processes. Section 4 builds on this result and inductively elaborates on a variety of transformation processes through an in-depth analysis of the qualitative data in the study. Implications are laid out in the concluding section.

2 Contrasting views on new market creation: "search and selection" and "transformation"

In general, individuals do not act randomly, even if such actions may appear as random variations at the macro level from the point of view of selection processes. They try to do their best, one way or another. At least four approaches to "doing one's best" can be culled from existing theory:

2.1 Rational search and selection (formal decision theory)

Readers of this journal are probably familiar with the informal concepts and formal models of rational search theory, categorically outlined first in the work of Stigler (1961). Here we merely highlight certain features of that model as they pertain to the realm of new market creation. The predominant answer today to the problem of how an entrepreneur or manager might act on the problem of new market creation consists of conceptualizing the problem as some form of search and selection among a universe of exogenously given market opportunities. The key idea is that search is optimizing, based on the goals of the agent. At least in principle, search is unconstrained and encompasses a vast number of possibilities. For instance, in "The Birth of a New Market," Bala and Goyal (1994) postulate that new markets open up due to technological, political or regulatory changes, and that the actual emergence of any particular new market then depends on the subsequent "exploratory" attempts entrepreneurs make to "enter" and capture niches within it. In "Option value and entry timing" Miller and Folta (2002) underline the concept of search among exogenously given possibilities by modeling a firm's decision

to enter a new market as purchasing an option on being involved in that market.

2.2 Heuristic search and selection (behavioral theories)

One of the outcomes of Simon's introduction of the idea of bounded rationality (Simon 1955) is the notion that the assumptions of rational search theory vastly overstated the capabilities of normal human beings to search and select among possibilities. The result is a theory of heuristic search, based on the assumption of cognitive limitations. The simplest form of heuristic search is the idea that agents search locally, i.e. among possibilities that are close to their starting point. Another way to say this is that they search based on their local knowledge (Hayek 1945; Shane 2001).

A classic example of the application of heuristic search in the innovation literature is Nelson and Winter's model of firm behavior, which posits local search (Nelson and Winter 1982). For example, in the search for better production methods, firms are modeled as searching incrementally in the space of possible improvements to their existing production processes. Empirical evidence suggests that this captures some aspects of the reality of innovation quite well as it explains the pattern of gradually accumulating improvements along technology trajectories (Dosi 1997).

However, the key issue in both models of rational and heuristic search is the notion of an exogenously given possibility set. This notion flies in the face of the basic Schumpeterian insight that the deep economic significance of innovative processes is that they transform an economy from within (Metcalfe 2004:164), i.e. that growth is better conceptualized as an endogenous process. Weitzman (1998:332) describes this contrast as follows:

> Is the production of knowledge a process that can be modeled by analogy to fishing new ponds or discovering new oil reserves? It seems to me that something fundamentally different is involved here. When research effort is applied, new ideas arise out of some kind of cumulative interactive process that intuitively seems somewhat different from prospecting for petroleum.

2.3 New combinations (Schumpeter and Weitzman)

Long ago Schumpeter came to the same conclusion, stating that innovations take the form of "new combinations" (Schumpeter 1934) that involve employing existing things in new ways. This may result in new markets, new production processes, new products, and new ways of organizing and new methods of distribution. Schumpeter theorized that new combinations lay at the root of his macro-level conceptualization of the evolutionary nature of economic change, and defined "the carrying out of new combinations" as the essence of entrepreneurship. Schumpeter's conceptualization of innovation as a recombinatorial process is supported by both technology historians and

studies of creativity in science and elsewhere, i.e. Poincare (1908), Usher (1929), Koestler (1964) and Basalla (1988). So empirical data support the view that many innovations do emerge through recombination of preexisting elements.

Just as importantly, at an abstract level it is possible to conceptualize *all* innovations as new combinations. Recently, Weitzman (1998) set out to provide microfoundations for economic models of endogenous growth by viewing all innovation as recombination. The Weitzman model shows an important result. The bottom-line of recombinatorial innovation is that the number of innovative possibilities arising from new combinations quickly becomes astronomical, vastly outstripping the capacity of the economic system to process all the seed ideas into workable innovations. This leads Weitzman to conclude that, "In such a world the core of economic life could appear increasingly to be centered on the more and more intensive processing of ever-greater numbers of new seed ideas into workable innovations…" (Weitzman 1998:356) and that "[T]he ultimate limits to growth lie not so much in our ability to *generate* new ideas, so much as in our ability to *process* an abundance of potentially new seed ideas into usable form." (p. 333, italics per original).

2.4 Transformations

Given this framing of economic growth based on recombinatorial innovation, the Weitzman model leaves us with the question of what an empirically robust conceptualization of the *process* of producing *workable* innovations might look like. In a recently published paper, Sarasvathy and Dew (2005) build on the view of endogenous growth offered by the likes of Schumpeter, Weitzman, evolutionary and "New Growth" (Romer 1994) scholars by considering the idea that entrepreneurs might have developed processes of turning an abundance of potentially new ideas into usable forms (Endres and Woods 2010). Specifically, they develop two themes:

1. Ways to create new markets go beyond combinatorial methods: they involve transformations, particularly stakeholder-dependent transformations.
2. A good place to look for new microfoundations for the results found in studies of new technologies and new markets is in studies of the methods used by expert entrepreneurs.

The Sarasvathy and Dew (2005) framework shows a way to get beyond Schumpeter, Weitzman and other articulations of combinatorial innovation per se, and suggests *how* entrepreneurs might develop *usable* innovations without either having to make ad hoc combinations or having to search and select among exploding sets of possible new combinations. Instead, working within the bounds of human cognition, entrepreneurs are theorized to use an internally consistent set of heuristics called "effectual logic" to generate usable innovations, contingent on interactions with particular stakeholders who

self-select into the new market creation process.[1] The heuristics result in a series of transformations of the particular stakeholders' means-at-hand into new goods and services that are often *unanticipated residual artifacts* of the effectual process and not pre-selected effects or goals to be reached through search and selection among possible causes. These artifacts, therefore, embody a variety of ingredients from interactions among self-selected stakeholders including partially or fully formed preferences, ambiguous aspirations or clear values, error-prone judgment as well as prescient imagination.

All we have to do to appreciate the general thrust of this conceptual framework is to drop the idea of exogenously given goods altogether and replace it with the notion of "the market as a game without goods" (Buchanan and Vanberg 1990:182), i.e. a view of the market as a process which involves inventing goods based on interactions between individuals. The focus then shifts to looking at how these individuals produce new goods and services by transforming existing artifacts already in hand into new ones, rather than searching and selecting among a preconceived and exogenously given "space" of all possible goods. Or, as the epistemologist and philosopher of mind, Goodman (1978) puts it: "We have come to think of the actual as one among many possible worlds. We need to repaint that picture. All possible worlds lie within the actual one." The content, structure and process of these transformations is the central theme of the rest of this paper.

2.4.1 Differentiating transformation from search and selection

There are three principal factors that differentiate the transformation concept from search and selection. The first is that search and selection normally assumes, either explicitly or implicitly, a conscious intent to capture a new or latent market. In the literature on entrepreneurship this normally takes the form of prescient or visionary individuals searching for and selecting among market opportunities. Because search and selection takes place under uncertain circumstances this process, though deliberate, is often described as involving novel conjectures (Harper 1996) and, as articulated by Metcalfe (2004:159):

> The point about these conjectures is that, while they may have a partial basis is knowledge of the present and prior circumstances, they rest in large part on beliefs that are yet to be tested, or be confirmed or falsified.

In contrast, in the concept of transformation, the creation of a new market need not be intentional or even the result of foresight or imagination of possible new markets. It could simply be one way to fulfill an individual's motivations and/or an unanticipated consequence of people just doing things

[1] For a detailed exposition of the logic and its connections to economics and social philosophy, see Sarasvathy (2007).

they think are possible and worth doing. This is closer to Hayek's view of how markets work than it is to Schumpeter's, i.e. to the idea that markets are socially complex entities that usually go beyond the organizing conception of any one or few individuals (Hayek 1960, 1978). In the concept of effectual transformation, markets are viewed as an occasional residual of lots of different people going around doing things they think are worthwhile who, in the process, produce a new market even though none of them may have consciously intended that in the beginning, let alone articulated it, or explicitly adopted it as a goal. The goals and articulations about the market are just as likely to be "discovered" and created in the process of doing, as they are to be preconceived or envisioned a priori. The new market that gets created, therefore, may just as likely be a *consequence* of the transformations undertaken by the participants to the process as it may be an *antecedent* goal driving the process.

Second, given bounded cognition, search is generally theorized to be limited to a finite set of very local possibilities. Very little can be/has been said theoretically about how such search is actually conducted, although some empirical studies of entrepreneurship are consistent with this view (Shane 2001). In general, theorists simply take the local search assumption for granted as leading to a given set of possibilities and expend their energies on analyzing processes of selection (for instance, Metcalfe 1998).

Transformation is also very consistent with bounded cognition and begins with very local possibilities. However, rather than looking to select between these, it conceptualizes entrepreneurial action as involving the transformation of those possibilities into new ones. Here all the important details are about methods/processes of transformation rather than about selection criteria, either at the micro or macro levels.

Third, search and selection is largely static and theoretically prior to most market creation activities and the selection of partners or stakeholders. In contrast, transformation is conceptualized as being intrinsically dynamic and interactive—it is the actions and interactions with stakeholders who self-select into the entrepreneurial process that lead to particular transformations that may or may not lead to new markets. This stakeholder-dependent process is consistent with Weitzman's result from the recombinatorial innovation model—that the model shows a lack of technological determinateness—which paves the way for considering how usable innovations emerge from a stakeholder-dependent process (Sarasvathy and Dew 2005).

It is important to note that the extreme dichotomy described above is meant to create a powerful theoretical separation between transformation and search and selection processes. Empirically speaking, of course, we expect both search/selection and transformational processes would be at work concurrently or iteratively. In this connection, we could go to field data including case studies and histories to look for evidence one way or another. This has been and is continuing to be done (Sarasvathy and Kotha 2001; Dew 2003; Harting 2004; Harmeling et al. 2004). These preliminary investigations indicate that strong patterns of one or the other can indeed be isolated and evidenced.

In the current study we decided to look for micro-foundational evidence in a more controlled setting, by contrasting the behavior of expert entrepreneurs (who are hypothesized to use transformation processes) with MBA students (taken to be schooled in search and selection processes). In particular, we look to test the following central hypothesis:

- Expert entrepreneurs will use more transformational approaches and consequently, generate more new markets than MBA students, who will use more search and selection processes.

The logic for this hypothesis is that transformational processes are contingent upon particular stakeholders and their idiosyncratic endowments and capabilities. This results in the generation of a wider variety of viable market opportunities. By contrast, MBA managers' use of search and optimal selection results in a narrowing of new market options, i.e. squeezing variance out. Moreover, the stakeholder-dependence of transformation processes results in the increased variance being along the lines of more usable products than pure combinatorial approach would predict.

In the next section of the paper we explain a study we conducted that tests this hypothesis. After explaining the study and reviewing the results, we develop a conceptual framework of a variety of transformation types, many of which were evidenced in qualitative data drawn from the study. The essential point we show is that conceptually, the process for the genesis of new markets involves transformational as well as combinatorial elements.

3 Empirical study

In order to test the hypothesis we used data from a protocol study in which subjects were given the task of discovering and/or creating a market for a new product. We proceeded with the study as follows. First, we selected a sample of expert entrepreneurs and MBA students. Second, we developed a research instrument that reflected key tasks involved in discovering and/or creating a market for a new product. Third, the subjects completed the problem-solving tasks during which time their concurrent verbal "think aloud" protocols were collected. Finally, we transcribed, coded and analyzed the protocol data. In the following sections of the paper, we describe the study in more detail.

3.1 Research method: concurrent verbal "think aloud" protocol

Concurrent verbal "think aloud" protocol analysis is a widely used empirical research method in cognitive psychology. Ericsson and Simon (1993) reviewed over 200 empirical studies that use this method of investigation, principally to study decision making processes used by experts. Examples include the study of expertise in chess (Charness 1989), scientific discovery (Qin and Simon 1990), mathematics (Webb 1975) and medical diagnosis (Johnson 1988). Several prior studies relate to business topics, such as how entrepreneurs and

bankers manage risks (Sarasvathy et al. 1998), cost estimation (Mukhopadhyay et al. 1992), argumentation in management consulting (Young 1988), accounting expertise (Riahi-Belkaoui 1989) and decision making (Montgomery and Svenson 1989).

The advantage of concurrent verbal "think aloud" protocol over other methods of investigation is that it allows researchers to get more direct insights into the cognitive processing of subjects. This is because of the nature of short term memory in the human brain, which holds a very limited amount of information (Ericsson and Simon 1980). The think aloud protocol involves subjects concurrently verbalizing their thoughts as they solve a decision problem. Their tape-recorded transcriptions provide the data that is then analyzed. This procedure has certain advantages over other methods of investigation (Ericsson and Simon 1993) such as retrospective recall (which allows subjects to narrate how they believe they solve problems rather than how they actually solve them) and stimulus-response methods such as questionnaires (which force the researcher to "connect the dots" in subjects' decision processes).

3.2 Subjects

The subjects in our study were 27 expert entrepreneurs ("experts") and 37 MBA students ("novices"). The experts in the study were individuals who had founded three or more new ventures, remained with at least one venture for more than 10 years, and taken that venture public with an IPO (initial public offering) of its stock. The comparison group of novices were graduate students in business (Isenberg 1986). MBA students were chosen for the study because they would have enough general business acumen to understand and tackle the problem set used in the study, and because they represent the output of conventional management education based on a "rational choice" logic embracing search and selection principles. Comparing the novices with the experts indicated that the groups were dichotomous with 87% of the novices having never founded a new venture. The novices were 97% American, aged between 26 and 46, with between 0 and 21 years of work experience in large and complex organizations. By comparison the experts were 90% American, aged between 40 and 82, with two thirds having graduate degrees. On average, the experts had founded seven new ventures and had 22 years experience as entrepreneurs. Table 1 provides basic descriptive data about the two samples.[2]

[2]Two sources were utilized to identify possible expert entrepreneurs for the study: (1) A list of the one hundred most successful entrepreneurs from 1960 to 1985, compiled by the venture capitalist, David Silver (Silver 1985); and, (2) The list of national winners of the Entrepreneurs of the Year awards, compiled by Ernst & Young. Together, the two sources drew their members from a pool that included virtually every major new company created by an entrepreneur in the U.S. from 1960 till 1996. Both publications used several evaluation procedures and qualification criteria to select their lists from the complete populations of entrepreneurial companies in their respective times. Thus the sample of expert entrepreneurs used in this study was drawn from a population of entrepreneurs who were independently verified as having a track record that suggests a high level of entrepreneurial competence and expertise.

Table 1 Descriptive statistics of expert and novice samples

Variable	Mean	SD	Minimum	Maximum
Experts: subjects ($N = 27$)				
Year of birth	1943	8.8	1918	1953
Ventures started	7.3	7.4	3	40
Years worked for those	21.6	9.3	12	43
Novices: subjects ($N = 37$)				
Year of birth	1970	4.9	1959	1979
Ventures started	0.2	0.4	0	2
Years worked for those	0.46	1.3	0	5

3.3 Procedures

The decision problem used in this study was an imaginary game of entrepreneurship called *Venturing*. A detailed description this product was given to each subject (a copy of the entire problem is attached in the Appendix to this paper, including the set of questions used). We chose to make entrepreneurship itself the product for which the subjects had to identify/create a market in order to be as unbiased as possible, i.e. the decision problem used in the study was chosen so as not to technologically or otherwise bias some subjects against others. Subjects were asked to read aloud the Venturing decision problem, and then answer several questions about the development of a market for this product. Throughout the task each subject was instructed to continuously "think aloud".

The coding scheme we used to extract relevant data from the transcribed protocols of subjects had three general categories of codings.[3] First, we looked at expert-novice information processing differences in general, such as how often the subjects theorized from prior experience, their use of analogies, and the total number of words spoken, etc. Second, we looked at domain-specific differences related to new market creation. This data was used in the present study, and included variables such as stakeholder partnering and the number of unexpected new market opportunities produced. Third, we collected data on domain-specific differences in new venture creation. This included data on variables such as the amount of attention paid to resource constraints, etc.

In order to ensure robustness of the coded results, we had an independent coder code all the protocols (this coder was blind to the hypotheses of the

[3]We used the helix process described in Ericsson and Simon (1993:280) to generate the coding scheme. This process calls for repeated circles of coding scheme items generated along a particular axis, such as the three axes of general expertise, market creation, and new venture creation in our study. One member of the research team began listing specific items of the coding scheme from four randomly selected protocols, two from experts and two from novices. Thereafter, the same researcher added items to the list from other protocols and refined the list in an iterative fashion until the coding scheme converged into a complete and coherent instrument for analyzing all the protocols. Two other members of the research team then used the coding scheme to independently code the protocols.

study and not involved in the study in any other way). The codings of the research team and the independent coder were then compared to examine the inter-coder agreement (James et al. 1993). The results showed a strong mean agreement of .82 across the variables used in this study, and no specific variable scored lower than .67. We then used ANOVA to analyze the codings that consisted of frequency counts, and chi-squared tests to analyze the codings that consisted of dichotomous variables.

4 Results

We found several important differences between the experts and the novices in the study. In terms of the *process* of building new markets, the concept of transformation suggests that the genesis of new markets will involve entrepreneur–stakeholder relationships. Consistent with this we found that the experts were significantly more likely than novices ($p = .001$) to suggest building a market for *Venturing* by stitching together a network of stakeholder partnerships. In total, 55% of the experts mentioned 21 partnering opportunities while only 10% of the novices mentioned partnering (a total of 5 mentions). Consistent with the transformation perspective, converting initial customers into strategic partners was a popular method of developing the market. Another method that was preferred by the experts was attempting to sell *Venturing* to customers/strategic partners even before the product was fully developed or produced. Consistent with this approach, we found that the experts were significantly more likely to engage in personally selling to initial customers. Although the experts did not significantly differ from novices ($p = .755$) in whether they selected direct sales or not, those experts that did select direct sales were more likely ($p = .024$) to sell personally than the novices (the novices instead suggested that they would recruit a sales force). This emphasis on personal selling again suggests that the experts think in terms of building integrative partnering relationships with initial customers.

We found significant support for the central hypothesis of the study. The experts consistently went beyond the data specified in the research instrument as they worked through the problems. We coded and counted all mentions of possible market segments in the transcripts from problems 1 and 2 of the research instrument. Because the *Venturing* product given in the problems was an educational game, we first counted the number of times subjects mentioned selling Venturing in some kind of educational or gaming market. The experts made 28 mentions of these expected market opportunities compared with 30 by the novices, so there were no significant differences. However, when we turned to the number of mentions of *unexpected* market opportunities (i.e. beyond the educational or gaming market specifically mentioned in the research instrument) the two groups performed quite differently: the experts mentioned 63 alternatives whereas the novices mentioned 28 ($p = .000$). This result supports the central hypothesis of the paper. The details of the codings and counts are summarized in Table 2 below:

Table 2 Summary of variable descriptions and analysis results

Variable description	Descriptive statistics	Significance between experts and novices	Summary of findings
Times subject mentioned partnership activities	Max: 3 Min: 0 SD: 0.73	$F = 13.24$ $p = 0.001$	Compared with novices, experts prefer to build new ventures with partners
Subject choice of direct sales as a channel	Expert: 6Y, 21N Novice: 8Y, 29N	ChiSq[a] = .003 $p = 0.954$	No significant difference in the choice of a direct sales channel between experts and novices
Subjects choosing direct channel and personally approaching customers	Expert: 3Y, 3N Novice: 0Y, 8N	ChiSq = 5.09 $p = 0.024$	Experts that chose direct sales were more likely than novices sell personally
Number of new markets articulated by subject during the experiment	Max: 7 Min: 0 SD: 1.38	$F = 18.235$ $p = 0.000$[b]	Expert entrepreneurs articulated more new markets than novices

[a]ChiSquared tests are two-tailed
[b]Significance test based on random sample of 27 out of 37 novices

5 Varieties of transformation

In this section we turn to conceptually categorizing the variety of transformation procedures performed by the expert entrepreneurs as evidenced in qualitative data in the protocols. In essence the transcripts showed that the experts were much more likely to transform the initial *Venturing* product concept they were given in the problem set into a diverse range of market opportunities, whereas the novices searched and selected from the data about markets that was given to them in the problem set, i.e. novices accepted the product as given and looked to optimize within given alternative segments. Several of the transformation types we highlight here have been discussed in an abstract way in the philosophy literature (for example in Goodman 1978). The essential point we make here is that the process for the genesis of new markets involves transformational concepts, as well as combinatorial elements. Our view is that the term "new combinations" is widely used in the innovation literature to cover a variety of different processes, often with the result that it obliterates the concept of transformation which is, in fact, quite germane to the genesis of new markets (a theme we will return to in our concluding comments). We found evidence of several different transformation processes in our data. The list of transformation concepts we describe here is not meant to be exhaustive; it is just meant to illustrate some of the different kinds of transformation / types of transformational operations that we found were used by the experts in our study. We expect other types also exist (for other alternatives see Goldenberg et al. 2001). Here we briefly articulate the transformation types we found evidence for using anecdotal and historical examples as well as examples from the protocols of the experts.

5.1 Deletion and supplementation

This is the closest to the process of recombination. Goodman describes it as "weeding out" and "filling in", i.e. deleting things and supplementing the artifact with new elements (Goodman 1978). The mathematical equivalent is, of course, adding and subtracting. The excision of old material, i.e. weeding out, is not much studied in the literature as compared to combinatorial processes. For example, entrepreneur Henry Ford weeded out everything that was not essential in order to come up with a cheap design of automobile—the Model T—though the literature only emphasizes his creative recombination of technologies to create the production line. Ruth Owades created *Calyx and Corolla* by weeding out florists from the fresh flower delivery business, though it is tempting to focus instead on her new combination of fresh flowers with Fedex delivery methods. One example of supplementation from our study was E18 (expert #18), who added other functional areas of business to transform Venturing into a product for education in marketing and operations management, etc., resulting in "a family of products for different functional areas of business".

5.2 Composition and decomposition

The central idea here is reorganizing material that is already there. This involves disassembly, reorganization and re-composition into new arrangements, and then putting everything back together again. This process transforms the artifact. One recent anecdotal example is "Atkins-friendly" foods, i.e. marketers' attempts to recompose many markets for high fat but low carbohydrate foods around the idea of the Atkins Diet. These markets have been recomposed around their nutritional value. Among our transcripts of experts, E5's transcript is especially interesting for the way the subject imaginatively redescribes Venturing in several different ways, eventually finishing with a whole new market he imagined for: "any learning in an interactive situation where simulation is a benefit."

5.3 Exaptation

According to Mokyr, "The basic idea is that a technique that was originally selected for one trait owes its later success and survival to another trait which it happens to possess." (Mokyr 1998). Exaptation transforms resources by converting them from established uses (things they were designed for) to new uses (things they weren't designed for). Aspirin is a well-known example of exaptation (Dew et al. 2004). Another example is Riverdale Mills "Aquamesh" lobster traps, made from plastic-dipped galvanized wire mesh. Aquamesh has such tiny openings that it is virtually impossible to scale or cut through, which has made it perfect for security fencing after the September 11 terrorist attacks in New York. So now Riverdale sells "Wirewall" (Crowley 2002). A key exaptation in the *Venturing* study was that the product might make an

attractive evaluation tool instead of training device. This led four different experts to suggest transforming the market for Venturing into some kind of evaluation tool, including self-evaluation.

5.4 Manipulation

Manipulation involves market or product transformations analogous to physically inverting, mirroring, twisting and turning something inside out. There are several different flavors of manipulation, all of which involve seeing the market or an artifact as a manipulable object. The Economist recently described an interesting example of inversion: the market for violent video games has been studied for its disruptive psychological effects on minors; now a market is emerging for the same violent games, this time in treating war veterans with post traumatic stress disorders (Economist 2005). In our study one example of manipulation of Venturing occurred when E26 transformed the market for Venturing into the "pretendsters" market. Instead of marketing Venturing to people who want to become entrepreneurs (would-be entrepreneurs, or into student populations) E26 stood that idea on its head by defining a market of individuals who *don't* want to become entrepreneurs but would like to pretend instead, i.e. just simulate the experience—the "pretendsters" market. This inverted the market creation approach typically used in the study.

5.5 Deformation

Goodman (1978) describes deformation as akin to smoothing out a rough curve or caricaturing artifacts or people. Improvised jazz is an example: artists "deform" the melody in various ways with different notes, rhythm and tempo. Entrepreneurs engage in deformation, both metaphorically and literally in products and services. For instance, Howard Schultz got the idea for Starbucks coffee bars from Italian coffee bars, i.e. the Starbuck's concept involved deliberately deforming the "original" into an American retail setting. In the think-aloud experiment we conducted, E3 deformed the Venturing product market given in the problem set first into a "family of products for the business school market" and a "family of products for the distributor market." Both these market definitions involve treating the originally Venturing idea as an elastic platform from which other business ideas are launched. It involves seeing the original concept as something that can be stretched and deformed to create new options.

5.6 Localization, regionalization, globalization operations

Transforming the scope of the market by narrowing or enlarging it is another mechanism of transformation that we found prevalent among experts. Anecdotally this happens every time an entrepreneur transforms an iconic American product into a global one. In the protocols of experts, there are two instances where the experts suggest taking Venturing to the global market.

There are another two instances where experts suggest taking Venturing to regional development agencies, a variation on the local-regional-global theme. The basic notion is that you transform the market by redefining in terms of either more local, more regional or more global ways.

5.7 Prototypying

Prototyping involves using the original product market—in the case of Venturing it was the educational gaming market—as a prototype and then transforming that instance into a different product that shares the same basic features of the prototype. So, if A (the prototype) is an apple tree, transformations into B might include an orange tree. Both belong to the prototype "tree". Prototyping in some ways is analogous to the phenomenon of copying errors which is so central to the production of random variation in evolutionary biology. However, human beings have an evolved propensity to prototype in particular ways (Lakoff and Johnson 1999) which means prototyping does not yield a pattern of random variation, as in biology. Prototyping was one of the most common transformation operations that the experts performed in our study. Based on the education-related prototype given to them, six experts suggested transforming Venturing into a tool for the government market, non-profit market and management training markets.

5.8 Stereotyping

The idea of stereotyping is that there are certain simplified or standardized transformation processes that lack originality or inventiveness, i.e. are conventional and socially well-known but do not equate to a more fundamental notion, such as a mathematic function like addition, or a psychological one like prototyping. One example discussed by several experts in our study was transforming the product marketing scenario they were given into marketing the whole firm rather than the product. The most popular idea was selling or licensing Venturing to a big game company which would have the distribution arrangements to hand and the financial clout necessary to market the product. E6, E21, E22 and E28 all transformed the problem given to them using this mechanism.

5.9 Free associating

This process covers those transformations that appear to essentially idiosyncratic, i.e. based on the experts' prior knowledge and experience. It includes some of the elements identified as transformational "associations" in psychology (Karniol 1985:933–934) as well as associations derived from the experts local knowledge or knowledge corridor outlined in the work of Kirzner (1979) and empirically studied by Shane (2001). This type of transformation is very much contingent upon the agent undertaking the transformation, examples being personal experiences, memories, reminiscences, etc. Experts accumulate

a large store of prior knowledge which provides them with a portfolio of potentially relevant information to draw from. As an example, in our study E25 suggested that he might cross-license Venturing and develop a set of indirect products based on this cross-licensing process. This response is unique to E25—no other expert suggested anything even close to it. In the informal interview after the completion of the protocol experiment, E25 indicated that he was reusing an approach that he had used in a prior venture.

6 Conclusion

In this paper we have focused on the contrast between viewing new market creation as a result of search/selection processes or viewing it as a result of transformation processes. Although it is possible to model entrepreneurial processes as either, we have presented evidence that show that expert entrepreneurs that use transformation processes produce a larger number of new market ideas than novices schooled in search and selection. We have also conceptualized several varieties of transformation.

The crux of our presentation boils down to the following. Evolutionary economics has for a long time satisfied itself with modeling strategies that derive, by analogy, to evolutionary biology. However, we believe there are strong reasons for thinking that human transformation processes are not the same as biological ones, and that the kinds of variety the economic system produces through human transformation processes is therefore different from the kinds that you get in biological systems. In biology the idea of recombinations is powerful because basically two given genes are recombined into a new organism in sexual reproduction (though that is not the only mode of reproduction in biological systems, of course, it is one that is often used—by analogy—in studies of technology). However, we have shown in this paper that not only are expert entrepreneurs better thought of as using transformational processes rather than simple recombination or more elaborate search and selection, but also that there are a wide variety of transformation processes possible. In our view, this suggests that two important amendments are necessary in order for our modeling strategies to be more appropriate to the task of modeling economic evolution.

First, as useful as recombination is as a modeling strategy, it has led to unwarranted neglect of the economic implications of the many different transformation processes that appear to be routinely used in technology and market evolution by expert entrepreneurs. Transformational processes impact the sorts of variation you expect to see in the economy. For example, a world in which exaptations are admitted changes the pathways of evolution, because exaptations are technologically “free”, i.e. they differ in significant ways in terms of innovative effort, uncertainties and costs compared to adaptive innovation programs that are targeted at preexisting or preconceived markets (Dew et al. 2004). This changes the predictions of models of resources allocated

to innovation. This general point—that the types of variation empirically observed will differ from modeling predictions—is the direct result of the fact that recombination is an excellent abstract modeling assumption (and is to some extent reflected in empirical data on processes of innovation) but at the price of fundamentally reducing the variety of transformation types considered in these kinds of models. Given the present state of our knowledge we cannot rule out the possibility that some of these transformation types actually have a significant impact in the evolving economic system. Future modeling efforts should explore this possibility.

Second, these different sorts of variation impact the macro-level patterns that one would expect to see in an evolving system, i.e. these micro-patterns of heterogeneity matter because they cascade all the way up the system. They are not weeded out by evolutionary selection. An example is path dependence: one would expect less path dependence in a system that admits multiple processes of transformation, compared to a system that admits only new combinations. Since the basic conclusion of a model such as Weitzman (1998) and a basic evolutionary mode of thinking (heuristic) is path dependence (i.e. time only goes one way; one cannot go back and resurrect genes that have been extinguished) admitting non-combinatorial transformations changes one of the basic results of the model. In the case of evolutionary models, this will also alter some of their basic policy prescriptions (Witt 2003; Moreau 2004), i.e. about the trade-offs between exploration and exploitation viz. keeping options open as wide as possible for as long as possible (not foreclosing on options until they are thoroughly explored). The same implications also arise in the organizational literature, where search and selection is the traditional model for exploration and exploitation in organizations (March 1991) but where, for instance, scholars have recently attempted to model the role of strategic analogies, with interesting implications (Gavetti et al. 2004). Thus, replacing the notion of causal search and selection with the notion of effectual transformation leads one to different managerial as well policy prescriptions, not to mention an alternative line of research into the creation of new markets.

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Appendix A: Research instrument

A.1 Introduction

In the following experiment, you will solve two decision problems. These problems arise in the context of building a new company for an imaginary product. A detailed description of the product follows this introduction.

Although the product is imaginary, it is technically feasible and financially viable. The data for the problems have been obtained through realistic market research—the kind of market research used in developing a real world business plan.

Before you start on the product description and the problems, I do need one act of creative imagination on your part. I request you to put yourself in the role of the an entrepreneur building a company—i.e., you have a little money of your own to start this company, and whatever experience you have to date.

Throughout the experiment you should talk aloud the thoughts you are having. Please start by reading aloud the following instructions.

A.2 Description of the product

You have created a computer game of entrepreneurship. You believe you can combine this game with some educational material and profiles of successful entrepreneurs to make an excellent teaching tool for entrepreneurship. Your inspiration for the product came from several reports in the newspapers and magazines about increasing demand for entrepreneurship education; and the fact that a curriculum involving entrepreneurship even at the junior high or high school level induces students to learn not only business-related topics but math and science and communication skills as well.

The game part of the product consists of a simulated environment for starting and running a company. There are separate sub-simulations of markets, competitors, regulators, macroeconomic factors and a random factor for "luck". The game has a sophisticated multi-media interface—for example, a 3D office where phones ring with messages from the market, a TV that will provide macroeconomic information when switched on, and simulated managerial staff with whom the player (CEO) can consult in making decisions. At the beginning of the game, the player can choose from a variety of businesses the type of business he/she wants to start (For example: manufacturing, personal services, software etc.) and has to make decisions such as which market segment to sell to, how many people to hire, what type of financing to go for, etc. During the game, the player has to make production decisions such as how much to produce, whether to build new warehouses or negotiate with trucking companies, etc.; marketing decisions such as which channels of distribution to use, which media to advertise in and so on; management decisions involving hiring, training, promoting and firing of employees, and so on. There is an accounting subroutine that tracks and computes the implications of the various decisions for the bottom line. The simulation's responses to the player's decisions permit a range of possible final outcomes—from bankruptcy to a "hockey stick".

You have taken all possible precautions regarding intellectual property. The name of your company is *Entrepreneurship, Inc.* The name of the product is *Venturing*.

A.2.1 Problem 1: Identifying the market

Before we look at some market research data, please answer the following questions—one at a time: *(Please continue thinking aloud as you arrive at your decisions)*

1. Who could be your potential customers for this product?
2. Who could be your potential competitors for this product?
3. What information would you seek about potential customers and competitors—list questions you would want answered.
4. How will you find out this information—what kind of market research would you do?
5. What do you think are the growth possibilities for this company?

A.2.2. Problem 2: Defining the market

In this problem you have to make some marketing decisions.

Based on *secondary market research* (published sources, etc.), you estimate that there are three major segments who are interested in the product:

Segment	Estimated total size
Young adults between the ages of 15 and 25	20 Million
Adults over 25 who are curious about entrepreneurship	30 Million
Educators	200,000 institutions

The estimated dollar value of the instructional technology market is $1.7 Billion
The estimated dollar value of the interactive simulation game market is $800 Million
Both are expected to grow at a minimum rate of 20% p.a. for the next 5 years

The following are the results of the primary (direct) market research that you have completed.

Survey #1—Internet users were allowed to download a scaled down version (Game stops after 15 min of playing) of the prototype and were asked to fill out a questionnaire

You get 600 hits per day.
300 of them actually download the product.
You have 500 filled out questionnaires so far.

Willing to pay ($)	Young adults (%)	Adults (%)	Educators (%)
50–100	45	26	52
100–150	32	38	30
150–200	15	22	16
200–250	8	9	2
250–300	0	5	0
Total	100	100	100

Survey #2: The prototype was demonstrated at 2 Barnes & Noble and 3 Borders Bookstores

Willing to pay ($)	Young adults (%)	Adults (%)	Educators (%)
50–100	51	21	65
100–150	42	49	18
150–200	7	19	10
200–250	0	8	7
250–300	0	3	0
Total	100	100	100

Survey #3: Focus Group of educators (high school and community college teachers and administrators) The educators who participated in the focus group find the product exciting and useful—but want several additions and modifications made before they would be willing to pay a price of over $150 for it. As it is, they would be willing to pay $50–80 and would demand a discount on that for site licenses or bulk orders.

Both at the bookstore demo and the focus group, participants are very positive and enthusiastic about the product. They provide you good feedback on specific features and also extend suggestions for improvement. But the educators are particularly keen on going beyond the "game" aspect; they make it clear that much more development and support would be required in trying to market the product to them. They also indicate that there are non-profit foundations and other funding sources interested in entrepreneurship that might be willing to promote the product and fund its purchase by educational institutions.

Based on your market research, you arrive at the following *cost estimates for marketing* your product.

Internet	$20,000 upfront + $500 per month thereafter
Retailers	$500,000 to 1 M upfront and support services and follow-up thereafter
Mail order catalogs	Relatively cheap—but ads and demos could cost $50,000 upfront
Direct selling to schools	Involves recruiting and training sales representatives except locally

Competition None of the following four possible competitors combine a simulation game with substantial education materials—you are unique in this respect.

Company	Product	Description	Price per unit	Sales ($)
Maxis	Sim City	Urban planning simulation	29.95	30 M
Microprose	Civilization	Civilization building simulation	50.00	20 M
Sierra on-line	Caesar	City building simulation	59.95	18 M
Future endeavors (New co. < 1 year old)	ScholasticTreetop	CD-ROMs of scholastic books	n/a	1 M

The game companies are making a net return of 25% on sales

At this point, please take your time and make the following decisions: *(Please continue thinking aloud as you arrive at your decisions)*

1. Which market segment/segments will you sell your product to?
2. How will you price your product?
3. How will you sell to your selected market segment/segments?

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