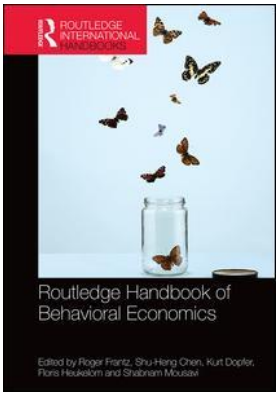

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Roger Frantz, Shu-Heng Chen, Kurt Dopfer, Floris Heukelom, Shabnam Mousavi

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Jason Potts
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BEHAVIORAL INNOVATION ECONOMICS

Jason Potts

Introduction

Viewed from a distance, the concept of a behavioral innovation economics is relatively easy to frame as the application of behavioral economics (heuristics and biases, bounded rationality in human cognition) (Kahneman, 2003) to innovation economics (investment in R&D, entrepreneurial behavior in new ventures, choice over novel goods). The target discipline is innovation economics and so the problems and subject matter of innovation economics shape the research program of behavioral innovation economics. The behavioral in this is simply to study the cognitive processes involved in choice over novelty, as it were, and under uncertainty. So this would seem to be relatively straightforward application of an approach (behavioral economics) to a field of study (economics of innovation).

In several respects, a behavioral innovation economics is already part of the practical arts of government policy that have sought to adopt behavioral insights into innovative thinking in the public sector (Thaler & Sunstein, 2003; Shafir, 2012; Oliver, 2013). Furthermore, behavioral innovation economics, as a kind of strategic-managerial folk wisdom, is already practiced by many firms (and consultants) that seek to design incentives and choice architecture to 'nudge' innovative decision-making and the sorts of knowledge pooling and collaborative activity that lead to successful innovative activities. And something that we might not unreasonably call 'applied behavioral innovation economics' is also widely practiced by many entrepreneurs and venture capitalists that seek to exploit understandings of cognitive processes embodied in heuristics and biases in order to make better and more effective decisions in choice environments with high uncertainty and the need to rely on entrepreneurial judgment (Foss & Klein, 2012), or to induce others to do so (Hwang & Horowitt, 2012). So in many respects behavioral innovation economics already exists in the wild. What we are talking about here is a domesticated and laboratory version of that, and the assembly of it a coherent body of theory that can be formalized and tested, and then further developed for applications. It is this that barely exists, and this chapter is intended as a way to organize what we know, and to suggest a research program for developing that.

Behavioral innovation economics—as the application of behavioral economic theory and principles to the subject matter of innovation economics (also known as Schumpeterian or evolutionary economics)—is not yet a distinct and recognized field of study, but it is one

with much latent potential. Interestingly, this is not because behavioral economics has been neglected from innovation economics, but rather because behavioral assumptions are already deeply embedded in models of the innovating firm. For instance, Nelson and Winter's (1982) 'evolutionary theory of economic change' is constructed atop an explicitly behavioral theory of the firm in which agents are assumed to be boundedly rational (Nelson & Winter, 2002; Nelson, 2008; Cyert & March, 1963; March & Simon, 1958). Furthermore, one can barely shake a stick in the field of entrepreneurial studies without hitting a behavioral explanation for motivations and characteristic features of entrepreneurial actions (Baron, 1998, 2007). Modern Schumpeterian and entrepreneurial economics is built on models with strong and explicit behavioral foundations, yet this is precisely why a distinct field of behavioral innovation economics has not emerged in which behavioral insights are *applied to* innovation economics.

Viewed in this way, an explicitly behavioral innovation economics would have domains of producer and consumer applications. On the supply side, behavioral models would apply to the production of innovation and the coordination necessary to achieve that—that is, to entrepreneurship, the origination and growth of firms, competitive rivalry, and so on. There are applications of behavioral insights to perceptions of opportunities, decisions to invest, and to decisions about cooperative behavior and competitive response. There are also applications to the design of innovation policy and strategy, which is about setting up systems of incentives to induce people to act in ways that are in the group's or society's best interests, even when they are individually risky and uncertain propositions (Greve, 2003; Blinder, 2014).

On the consumer side, a behavioral innovation economics would naturally focus on problems associated with choice over novel goods, the acquisition of new preferences and the adaptation of a consumer lifestyle to innovation (Witt, 2001; Lades, 2013). Innovation means thinking and doing new things, both on the producer and consumer side, and innovation also means pooling and sharing ideas and knowledge, and forming new organizations and institutions. Both aspects of creating and dealing with novelty pose cognitive and behavioral challenges that can be the focus of a behavioral innovation economics.

The challenge here is more than the application of bounded rationality to these problems, as is the standard model in Schumpeterian economics, for instance, and in much modern work on the theory of the firm, starting with Cyert and March (1963). Rather, the focus is to be on the mind and behaviors of the evolutionary adapted human being and the world view that presents and the characteristic decisions that such an agent makes, and why. A behavioral innovation economics will seek to address such basic questions as why innovation is so hard to organize, and why public policy, while often advancing platitudes in its support, often constrains more than it supports. It will focus on why organizations, particularly large organizations, whether public or private, find it so hard to be innovative. It focuses on the question of the reasons why consumers adopt novelty, and the seemingly crucial importance of social context in those decisions. The economic theory of innovation is remarkably straightforward as an application of compound interest: namely, we should invest more, and do so sooner rather than later (*à la* Thaler & Benartzi, 2004). Yet this is nevertheless something that human economic agents find hard to do. Behavioral innovation economics seeks to understand why that is, and to focus on ways to understand how we might improve those situations, both individually and collectively, whether in firms, industries or entire societies.

The starting point in this is to squarely recognize that our minds (and our bodies) were not designed by evolutionary selection forces to live in the current environment that we do. Specifically, we struggle with particular things, and innovation, which I will characterize here as decisions to do new things in uncertain environments, and therefore of choice 'over novelty under uncertainty', is a focus that evolution has not prepared us well for. We are not well adapted

to live in a world of rapidly changing knowledge. This problem I suggest is the core subject matter of behavioral innovation economics.

We proceed as follows. In the second section of this chapter we will outline the heuristics and biases approach to behavioral innovation economics. This in effect gathers behavioral innovation economics as it currently exists, and pivots on the work of Dan Kahneman, Richard Thaler, George Loewenstein, Cass Sunstein, and others. In the third section, we set out the case for an 'evolutionary micro-foundations' view of behavioral innovation economics. This is not inconsistent with the 'heuristics and biases' approach, but seeks to go much deeper; it pivots on the work of Herbert Simon, Gerd Gigerenzer, and others. The fourth section concludes.

The heuristics and biases approach to behavioral innovation economics

Innovation economics as choice over novelty under uncertainty

Innovation economics itself has several distinct meanings: these distinguish between the classic Schumpeterian/evolutionary approach and the neoclassical information economics approach. The classic model comes from the work of Joseph Schumpeter who placed the process of innovation in firms at the centre of an economic model of growth and development (Nelson & Winter, 1982). The microeconomic agent responsible for innovation is the entrepreneur, and the macroeconomic consequence is what he called 'creative destruction'. Innovation is in this sense an evolutionary process characterized by a 'meso trajectory' (Dopfer, 2012) that can be arrayed over three phases: (1) entrepreneurial *origination* of the novel idea; (2) *adoption* of the idea through firms and markets; and (3) *retention* of the innovation into economic institutions, including cognitive and behavioral habits and routines.

The neoclassical model of innovation economics is somewhat different, building out of information economics and the problem of the production of new information in a competitive market. The classic statement of this problem is Arrow's (1962) diagnosis of the market failure problem at the heart of the production of new knowledge, due to fixed costs, approriability, and uncertainty. The innovation problem here is focused about the strategic behavior of firms in competitive markets in the production of new information as an investment under uncertainty problem.

The Schumpeterian and neoclassical approaches contain a lot of overlap and at a microeconomic level arrive at a similar diagnosis of the underlying economic problem, namely as the problem of investment under uncertainty in the production of new information—which is the characterization of the problem of a firm in Schumpeterian competition. On the consumer side, the microeconomic problem is choice over novel goods, about which the consumer may not have sufficient information to form well-behaved preferences. Both contexts can be represented as uncertain learning environments in which rational choice is difficult. So there are ample opportunities—as both a producer problem and a consumer problem—to insert behavioral economics into this domain. We characterize the economic choice problem in the context of innovation as the problem of *choice over novelty under uncertainty*.

Using heuristics and biases to decompose the innovation problem

The context of *choice over novelty under uncertainty* can induce systematic behavioral choice implications that can be assembled in the heuristics and biases tradition as set forth by the like of Dan Kahneman, Richard Thaler, et al. We need not elaborate these here, but they run through the full gamut of heuristics and biases such as loss aversion, risk aversion, hyperbolic discounting,

status quo bias, sunk cost effects, endowment effects, availability bias, framing bias, optimism bias, confirmation bias, and so on (Gilovich et al., 2002). Behavioral innovation economics then examines the effects of the use of decision heuristics, and the biases they introduce, on the various agents involved in innovation choice, including entrepreneurs, investors, regulators and consumers. There are multiple points at which the innovation process is intersected by problems that are identified by behavioral economics. Potts (2010) identifies ten characteristic such behavioral failures, all associated with the problem of choice over novelty under uncertainty.

Potts' approach was to outline a set of particular choice contexts 'over novelty under uncertainty' (i.e. the producer or consumer context of innovation) that while not necessarily difficult for what Richard Thaler (2000) calls 'Econs' seem to be predictably difficult for humans. These then become likely points of failure in the innovation process that can be analyzed from a heuristics and biases approach to behavioral innovation economics. I will outline these ten forms of failure that affect decision-making in innovation as summarized in Table 27.1 below. Choice over novelty under uncertainty presents many opportunities for systematic behavioral error to manifest in maladaptive heuristics and characteristic biases that cause the innovation process to undershoot some rational benchmark.[1] The implication is that innovation failure may occur for reasons extending beyond standard technology failure, market failure, management failure, or even policy failure arguments that occupy the Schumpeterian and neoclassical approaches to innovation economics, but through a further class of behavioral innovation failure. What this does, then, is to add a further layer reasons why innovation is hard and why we might expect to observe systematic failure (i.e. for cognitive behavioral reasons). The subject matter of behavioral innovation economics in this view would be a way to study the way in which this happens and,

Table 27.1 Ten ways that choice under novelty is hard, leading to innovation failure

Dimension of difficulty	*Mechanism*	*Example*
Awareness of novelty	Human brain routinely filters novelty	Novelty with a smaller 'cognitive distance' is easier to notice
How novelty affects you	Some ideas *sui generis*: no existing routines process them	Novelty that creates new categories is hard to process
Selecting new ideas	Selection over novelty difficult to allocate	Criteria to select people *de facto* mechanism for selecting new ideas
Open innovation	Overvaluing endogenous and undervaluing exogenous novelty	'Not invented here' ideas routinely overlooked
Rational innovation	Identity constructs displace rational choice	Personal, social, political factors enter into choice over novelty
Incentivizing innovation	Status quo bias, conformity bias, loss aversion	Behaviour over novelty must overcome costs to any action at all
Innovation portfolios	Portfolios not a natural cognitive category	Difficulty thinking about multiple novelties simultaneously
Investing in innovation	Myopia, imagination failures	Underinvestment in new ideas & undervaluation of cooperation
Space for innovation	Mental accounts	Tendency to infect novelty with extant context
Innovation failure	Accounting for experimental failure	Failure difficult to rationalize, causing avoidance of experiments

Source: Table copied from Potts (2010: 145).

as with the behavioral policy models (e.g. Oliver, 2013), to suggest possible remedies (call this libertarian innovation paternalism? cf. Loewenstein & Haisley, 2007).

Awareness of novelty is hard

The human mind is not adapted to a world of rapid and continual change; it requires effort to notice such changes and register their actual pace (Paquet, 1998). Human perceptual and cognitive apparatuses are mostly filtering mechanisms. Yet in a world of rapid continual change this mechanism will tend to work too well, causing novelty to be overlooked. Noticing novelty requires cognitive effort. The implication is that behavioral failure can occur due to a bias against seeing novelty. Novelty is easier to notice when it has a small 'cognitive distance' from something familiar. The larger this cognitive distance grows, the more effort is required to see the novelty. This can lead to a systematic underestimation of the amount of change in the environment. This can render radical novelty effectively invisible, which may in part explain how disruptive innovations can actually be so disruptive. Failure to notice novelty can constrain the development of raw ideas into entrepreneurial potential, and can limit adoption when businesses or consumers overlook the value of a novel idea. Furthermore, it can lead to firms systematically underestimating the competitive threat posed by a rival product and inappropriately low innovative response.

Knowing how novelty affects you is hard

Even when noticed, because new ideas are often *sui generis*, and thus in effect 'category creating' or changing the extant categories presently used to partition markets, niches, technologies, etc, this may lead to the use of inappropriate heuristics to evaluate the novelty, leading to an appropriate behavioral response. This causes what I will call 'competition blindness' through failure to see how a novel idea changes the substitution possibilities of producers or consumers, or how the new connections the novel idea makes affect which market a firm is actually in (Earl, 2003).

Selecting among many new ideas is hard

Within a firm, the innovation process can be generically characterized as beginning with the search for opportunities, among those, and development. The selection phase is the most behaviorally difficult because it is never possible to be entirely rational; there always remain significant uncertainties. Selection invariably requires champions: someone must get behind an idea for it to succeed. Because of this, the selection process becomes functionally dependent upon who that is, and why. Mechanisms that select people will thus often function *de facto* to select among new ideas.

Open innovation and learning from outsiders is hard

Novel ideas occurring within a group are often treated differently to novel ideas arising from outside. This asymmetry tends to over-value endogenous novelty and under-value or heavily discount exogenous novelty (Salge, 2011). Cooperation in respect of experimenting with new ideas and sharing knowledge is easy within the boundaries of an organization, but often very difficult across such boundaries with 'outsiders' (Hartley & Potts, 2014). This is why 'open innovation' seems unnatural (Chesbrough, 2003) and large firms, which create a larger population of insiders, can be effective.

Being rational about innovation is hard

Choice under novelty can be as much about the person or organization making the choice as about the substantiative material aspects of the new idea itself. Attitudes with respect to new ideas can serve as important and distinct personality and identity markers, thus overlaying all manner of social identity effects into choice with respect to novelty that can be difficult to decompose. New ideas also present clear opportunities for displays of leadership, adventure and even aggression, or of submission and cooperation, all of which have values and functions that may have little to do with the rational undertaking of innovation. Innovation is by definition a social process, as the value and use of new ideas is 'socially constructed' through continual feedback between users, producers and other parties. It is easy to allow social and behavioral factors to dominate decision-making. Evidence of the difficulties of rational choice can be seen in the extent to which largely 'ceremonial' factors regularly intrude into the innovation process. One example is revenue forecasts made in the context of start-up pitches. These are essentially random numbers (Douglas & Shepherd, 2002). Yet they do nevertheless function as a ritualistic signal of willingness to cooperate. Innovation failure can thus occur for reasons that may have nothing to do with the idea itself but rather with respect to improper observance of the socio-cultural customs associated with the introduction of novelty.

Incentivizing novelty creation and innovation is hard

Incentives to novelty and innovation have to be sufficient to overcome risk and loss aversion that may carry into multiple dimensions. The power of conformity bias makes incentivizing innovative thinking hard, in that the incentive is not that of a marginal substitution, but must fully compensate for potential 'ex-communication' from the tribe. Few people have a high tolerance for this, and most require compensation to be considerable. Even when income and material risks are carried by the organization or by financiers, there still remains the prospect of loss in status or identity if a new idea fails. Expectations will differ and no incentive system will work in all contexts. The costs of discovery of what motivations are at work and in what dimensions losses are salient makes design of incentives for novelty and innovation difficult.

Thinking about innovation portfolios is hard

Portfolio approaches to risk are economically rational because the sum of a bundle of *uncorrelated risks* has lower variance than each individually. Serial entrepreneurship is an effective strategy, as is gathering multiple innovation directions under one organization. Many new ideas pursued at once can be a lower risk strategy than just a single new idea if—and only if—those many ideas are uncorrelated. However, human minds evolved under conditions of social payoffs to being right about risks one at a time. This draws upon instinctive capabilities to lead a journey, to organize a project, to champion an idea, to become a hero, and so on. Single ideas—projects—seem a 'natural unit' for choice under novelty, but they are not: they are a behavioral bias. It is hard to think about innovation from a portfolio perspective—call this bias 'portfolio aversion.'

Investing in innovation is hard; getting cooperation for a new idea is hard

Firms (and people) systematically under-invest in the development of innovation competences and capabilities as well as under-invest in particular innovation projects and portfolios. Two

distinct behavioral reasons explain this: first, expectations are hard to form; and second, investment requires persuading others to cooperate. Innovation, by definition, requires cooperation in order to gather and coordinate resources and to induce experimental adoption and learning with respect to the new idea. Yet failure to secure early cooperation is perhaps the most common form of innovation failure. In a network, collaborative or open innovation projects failure commonly arises when cooperative connections fail to form. Yet the opportunity cost of the loss of 'real options' is often difficult to evaluate, especially if others have also not yet signaled their commitment. Risk aversion may thus have a particular manifestation in the form of 'early cooperation aversion' in the often difficult and path-dependent emergence of coalitions about novelty.

Creating space for innovation is hard

Successful innovation requires creating an appropriate 'space' for experimentation to occur. This includes physical space (e.g. a laboratory, an experimental market) and mental space. The creation of mental space for experimentation with novelty can be difficult because it requires letting go or disconnecting from past decisions and knowledge. Endowment effects and sunk cost biases both contribute to this difficulty. A common behavioral bias is the tendency of people to form *mental accounts*, violating the rational principle of fungibility (Thaler, 1985). However, to experiment with novelty often requires a separate mental account (as well as physical and organizational) within which much greater tolerance of failure and heightened attention to feedback occur. The failure to effectively create such an account can result in inappropriate behaviors and heuristics applied to the experimental situation.

Coping with innovation failure is hard

New ideas require experimental learning to ascertain their value and the opportunities they harbor. Yet experimental learning by definition involves failure. This can lead to two often contiguous behavioral failures in the context of experimental learning: (1) the failure to recognize failure when it occurs (either by ignoring it, or reconstructing narratives in which it was not a failure, such as cognitive dissonance); and (2) the failure to learn from failure, in the sense of failing to absorb the feedback information it provided, and thus failing to go on to reconstruct hypotheses and conjectures with that new information. Holding on too long before product release (fear of realizing failure), and staying too long in a failing market (fear of admitting failure, or holding to a belief that a corner will soon be turned) are common behavioral biases that slow the innovation process.

Behavioral innovation economics as evolutionary micro-foundations

Why behavioral innovation economics should be an evolutionary science

The title of this subsection is a reworking of a seminal article of evolutionary economics, by Thorstein Veblen called 'Why is economics not an evolutionary science?' The same point can be argued about behavioral economics in general, not just behavioral innovation economics (Haselton & Nettle, 2006; McDermott et al., 2008). The heuristics and biases approach to behavioral innovation economics in the second section sought to identify characteristic failures in innovation process that could be traced back to characteristic behavioral biases (e.g. loss aversion, sunk cost affects, endowment effects, and so on). That is an effective starting point for a behavioral innovation economics in serving to map out the domain. But simply mapping and labeling is not

yet a science (Jones, 2015). What is further required is an endeavor to understand why dealing with choice over novelty under uncertainty is difficult, what aspects of the environment (whether physical or social) makes it so, and how this presents in particular contexts of entrepreneurial action and judgment, carrying risk, forming groups, adopting new ideas and technologies. As indicated in the first section, this is more than simply constructing micro-foundations along the lines of 'we assume agents are boundedly rational, etc' but with an endeavor to understand how evolved cognition is entrained into the task of innovation. Berg and Gigerenzer (2010) call this a program of 'ecological rationality' (a point made in a different context by Vernon Smith (2003), who distinguished between constructivist and ecological rationality) emphasizing that the behavioral departures from perfect rationality identified in the heuristics and biases program may have their own 'ecological' rationality that can be understood from an evolutionary perspective (Witt, 2006).

An evolutionary micro-foundations approach to behavioral innovation economics seeks to get behind the diagnostic approach of the cognitive heuristics and biases approach toward seeking to understand the why and how aspects of human decision-making in the context of innovation. In essence, this seeks to apply evolutionary sciences (evolutionary biology, evolutionary psychology, evolutionary linguistics, evolutionary anthropology) to underpin why and how questions about human choice over novelty under uncertainty. Toward this, I want to outline two particular instances (both involving my own work, not because it is the leading edge, but simply because I know it best) that illustrate what such an approach looks like. The first is a theory of 'universal nomadism' (Potts, 2003), as an evolutionary explanation of the search and discovery mechanism. The second is a model called 'demic concentration' based on the cultural science model of group formation (Hartley & Potts, 2014).

Universal nomadism

Evolutionary economics in both the Veblenian variant and the Schumpeterian variant have both carried some aspiration, and often maintained an ambition to found the model of the economic agent on explicit evolutionary foundations (Nelson & Winter, 2002; Witt, 2006). For example, Kurt Dopfer (2004) develops a theory of the evolutionary economic agent as a 'rule maker and rule user' (see also Dopfer & Potts, 2008). But these approaches tend to be rather abstract at the level of an evolutionary account of bounded rationality, rather than of particular cognitive modules or mechanisms. The model of universal nomadism, however, seeks to account for a particular aspect of choice over novelty under uncertainty.

Universal nomadism (Potts, 2003) is a theory that seeks to explain the origin of novelty (and therefore the well-spring of innovation) in economic systems as a consequence of an adapted instinct in the human mind—the 'nomadic instinct'. In evolutionary psychology (Cosmides & Tooby, 1994; Plotkin, 1997) the human brain is modeled as a suite of cognitive modules, or instincts, evolutionary adapted to the ancestral environment (the Pleistocene). My claim for the existence of a nomadic instinct is that there were particular features of the 'environment of evolutionary adaptedness' (the EEA) that made nomadic behavior, and the cognitive routines that supported it, a successful adaptation. Evidence for this can clearly be seen in the physical adaptations of the human body (upright walking posture, sprung arches, and so on) but the nomadic instinct argues that this is also a neurocognitive adaption too.

Why might this exist? The reason to suspect the existence of such a nomadic instinct is because the EEA was one in which ancestral humans evolved in a complex environment of semi-desert and savannah, where resources were only semi-stable in time and space. There was a complex distribution of the resources that the human population required to survive. We adapted to this

complex distribution of resources by ourselves becoming complex in our geographical behavior. We became nomadic. For hundreds of thousands of years, a major force of evolutionary selection (plausibly both natural and sexual selection) over the human and pre-human population, mind and body, was adaptation to climactic variation and shifting and migrating resources.

Universal nomadism is the idea that this nomadic behavior may have levered itself into a new domain of language and ideas, an abstract space (rather than a geographical space) where knowledge itself is the resource that must be constantly tracked and settled. The argument is that the very mechanisms adapted to solve the problem of a complex distribution of physical resources in geographic space (i.e. nomadism) were capitalized as the growth of knowledge process in which knowledge itself is the complex and shifting resource.

In Potts (2003) I make various speculative claims about how the nomadic instinct manifests and the distribution over the human population, and its relation to the long run growth of knowledge processes that have driven modern economic growth. I speculate about its neural correlates associated with language processing rather than visual processing because of the connection to maps of knowledge and the geometry of such maps, and also about the subroutines that such an instinct might comprise: a set of triggers; search heuristics; and a halting function. And I point out the predicted claims that the theory makes. For instance, that the motivation to introduce novelty is only weakly related to price incentives and more strongly related to maps of possible journeys. I suggest that the origin of ideas in the economic system, like the origins of novelty, are explicable in part as a story about the construction of maps of the environment (these are those of technologies and their market opportunities) and nomadic behavior in the presence of these maps.

The point of the thesis of universal nomadism was to furnish an evolutionary consistent story about the nature of human cognitive processing and decision-making (over novelty under uncertainty) by connecting it to an environment of evolutionary selection—which in this case was a complex distribution of resources, which selected for cognitive 'modules' (i.e. the instinct of nomadism) that were adapted to such a complex environment. Universal nomadism is the further claim that this nomadic instinct has been co-opted into the realm of a complex distribution of ideas, and that this behavior now manifests as entrepreneurship and innovation, as opposed to nomadic behavior in the savannah.

The point of this example is not to suggest that this is true—it is a speculative theory, and an untested one at that. The point rather is that it is illustrative of what is meant by an endeavor to go beyond a heuristics and biases approach to behavioral innovation economics in order to assemble an evolutionary consistent account of why and how (Jones, 2015) human decision-making in the context of innovation—that is, over novelty under uncertainty—might have the characteristic features that it does.

Demic concentration

Another key aspect of the behavioral economics of innovation comes from an aspect of entrepreneurship and innovation that is traditionally not well treated in economics, namely the fact that it is generally a highly social process. This occurs at several different levels, from the discovery and assembly of the entrepreneurial opportunity, to the creation of the team that becomes the firm, to the building of the market and community of investors and customers, and so on. In essence, doing new things is not done by an individual—even if there is a somewhat romantic tendency to believe that—but is a highly social, highly cooperative process (Hwang & Horowitt, 2012). It is competitive, intensely so, in that it is groups competing with other groups. The success or failure of innovation often comes down to the effectiveness of these social processes—in effect,

we innovate in groups, and for complex group reasons, some of which involves finding solutions to actual problems, but much of which involves complex social signaling. A behavioral innovation economics seeks to understand the evolutionary forces that shape the behaviors that make such groups of knowledge creating agents possible.

A way of approaching this comes from my own more recent work, this time in conjunction with John Hartley, which consists of the development of a general model of what we call 'cultural science'—which is a new approach to the study of culture using evolutionary biology, evolutionary linguistics, evolutionary economics, and semiotics—into a specific model of what we call 'demic concentration' (Hartley & Potts, 2014; Hartley & Potts, 2015), which is based on modern evolutionary theory in which the selective value of culture is that it makes groups, and the selective value of groups is that they make knowledge. Culture acts as the 'survival vehicle' (Pagel, 2012: 12–13) for knowledge and technologies, and thus the group, hence solving the problem of inheritance of knowledge by securing it at group-historical rather than individual-behavioral level. Culture is not something that groups do; rather groups are something that culture does. In this view *Homo sapiens* are a language-using, high-trusting, instinctively cooperative, pro-social groupish animal (Bowles & Gintis, 2011; Nowak, 2011).

A culture-made group is a deme (in biology, a deme refers to an inter-breeding group that shares genes). Ideas and knowledge are 'culturally situated' in the sense that we acquire ideas preferentially from our deme: from within our language, our social references, our (extended) family or trusted non-kin 'honorary relatives' (Pagel, 2012), from within our 'we-group' and against 'they groups'. Innovation occurs as a cultural process when ideas are integrated into the 'we'-group as its boundaries are redrawn to include ideas previously or otherwise part of a 'they-group'. Newness and innovation occur by an evolutionary semiotic process of group-dynamics we call '*demic concentration*'. Demic concentration is the formation of such a bounded group; cf. *demic diffusion* (Cavalli-Sforza, 2000) where the knowledge moves across groups through individual migration. With demic diffusion, knowledge flows out (e.g. farming practices across Neolithic Eurasia, carried by individuals, not by mere copying). With demic concentration, conversely, knowledge flows in: but because of low-trust settings for 'they'-group originated knowledge, it cannot simply be copied but must be *translated* into 'we'-group terms. With demic concentration, the boundaries of a 'knowledge-group' change: this boundary change is innovation.

This 'cultural science' approach derives from a theme arising out of cultural studies—the study of ordinary culture in the Raymond Williams (1958) sense—of culture as productive, and specifically, as productive of novelty. Culture makes groups, groups make knowledge, and new ideas (contributions to knowledge) occur as the tensioned and conflicted boundary of a group changes. Newness and novelty are not the production of an idea, using factor inputs (the production function for ideas), but the reformation of a group boundary such that an idea becomes meaningful. This is the evolutionary model of cultural dynamics through the mechanisms of demic concentration.

Conclusion: toward a research program and policy

Behavioral innovation economics is the application of the approach of behavioral economics to the subject domain of innovation economics, which I have presented here as the problem of choice over novelty under uncertainty. In neoclassical economics, the innovation problem is that of private underinvestment in the research and development that drives innovation from the social welfare perspective. Innovation policy seeks to correct that market failure through a variety of institutions (intellectual property, R&D tax credits, public funding of science, and so forth).

And the research program of innovation economics focuses on understanding these incentive problems, on modeling the process of an innovation trajectory, and on the design of optimal innovation policy.

A behavioral innovation economics looks somewhat different. A mainstream approach that hews to the heuristics and biases behavioral research program will seek to use the various biases and cognitive heuristics identified from the stable of behavioral anomalies and to map these to characteristic points of failure in the innovation process (Potts, 2010). This will explain difficulties and failures in the innovation process by locating the cause of the innovation problem not in the market, as in neoclassical innovation economics, but rather as a decision failure. This different diagnosis would then suggest a different policy approach, based around seeking to correct these decision failures, perhaps through redesign of the choice architecture of the innovation context. At this stage the field is at the phase of beginning to identify possible points of choice failure, and the heuristics and biases that might apply.

A different approach follows more in the manner of Herbert Simon's conception of bounded rationality (and Vernon Smith's conception of ecological rationality) that would seek to furnish explanations of human decision-making in innovation contexts in such a way that these would be consistent with, or even better built upon, foundations in evolutionary theory or neuroscience. This consilience approach was illustrated with two examples (from my own previous work) on an evolutionary theory of novelty generation called 'universal nomadism' (Potts, 2003) and an evolutionary theory of group formation to produce new knowledge called 'demic concentration' (Hartley & Potts, 2014). In this version of behavioral innovation economics the research program seeks to understand human decision-making, both individually and in groups in the context of innovation by drawing on a range of related fields (not just psychology). The policy implications of this approach are also different in that these theories would yield testable predictions about the types of incentive systems and institutional environments that would support endogenous innovation.

Note

1 Potts (2010: 134–5) calls this rational benchmark the 'efficient innovation hypothesis'.

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