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Entrepreneurial round-tripping: The benefits of newness and smallness in multi-directional value creation

Richard Hunt, Lauren Ortiz-Hunt,

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Richard Hunt
Colorado School of Mines, Golden, Colorado, USA, and
Lauren Ortiz-Hunt
Center for Innovation and Entrepreneurship, Blacksburg, Virginia, USA

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Abstract

Purpose – The purpose of this paper is to develop and empirically test the theory that new industry entrants hold advantages over incumbents in the shift from unidirectional to multi-directional revenue streams.
Design/methodology/approach – Using a Cobb-Douglas production function, modified to isolate returns to innovation, the authors examine data from three separate contexts: steamships on Western US rivers (1810-1860), satellite-based internet services (1962-2010) and food waste recycling (1995-2015).
Findings – The results reveal that while incumbents often attempt to stretch existing technologies to fit emerging circumstances, entrepreneurial innovators achieve greater success by approaching multi-directional value creation as a distinct challenge, one requiring new technologies, organizational forms and business models. Existing theories have primarily attributed incumb ent inertia to a firm's inability perceive and pursue radical innovations, the results also suggest that existing firms are unwilling to pursue innovations that are likely to erode the marginal profitability of their respective business models. Ironically, rather than protecting incumbents' financial interests, the authors find that "marginal reasoning" can lead to diminished performance and even extinction.
Research limitations/implications – The proposed framework and empirical findings have implications for numerous multi-directional frontiers, including: social networking, commercial space travel, distance education and medical treatments using nanoscale technologies.
Practical implications – While incumbents often lament the destabilizing effects of multi-directionality, new and small firms enjoy a compelling array of entry points and opportunities.
Originality/value – Scholars, incumbent firms and start-ups both benefit from insights stemming from the novel formulation of multi-directionality challenges and opportunities.

Keywords Innovation, History, Start-ups, Strategic choices, Entrepreneurship, Incumbents

Paper type Research paper

1. Introduction

Multi-directional value creation has emerged as one of the defining characteristics of novel activity systems (Porter, 2002), profitable business models (Zott *et al.*, 2011) and key sources of sustainable competitive advantage (Dierickx and Cool, 1989). Sometimes called "round-tripping" in supply-chain research (Carter and Rogers, 2008; Chen and Paulraj, 2004; Ketchen and Hult, 2007), multi-directionality occurs when revenues are generated through the development of solution sets that allow commercializable goods and services to flow in more than one direction (Beamon, 1999; Ortiz-Hunt, 2015), such as: transportation and communication networks, distance education, cloud computing, multi-party licensing arrangements, proprietary knowledge exchange and even nanoscale therapies using the human circulatory system. Despite its growing prominence, multi-directionality remains ill-defined and underexplored. As such, the phenomenon falls outside the explanatory range of existing frameworks. This study aims to address this notable gap.

With few exceptions, multi-directionality is typically preceded by and evolves from simpler unidirectional business models (Sendall and Küster, 2004), which involves the

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creation and capture of value from transactions that transfer the benefits of goods and services from a producer to a consumer. For example, early personal computers consisted of discrete hardware produced and sold by PC manufacturers for purchase and use by individuals who wanted computers for basic desktop applications such as word processing and spread sheeting. The purchase of a PC thus constituted a unidirectional creation and capture of value. Conversely, an individual buying a web-enabled personal computing device today harvests value from the hardware, software and cloud capabilities while also creating value for friends, family members and countless companies that track his or her "footprints" across the internet through big data analysis and micro-marketing. Access to hardware has become simply one facet of what is now a vast, inter-related network of multi-directional value creation. Like other forms of industry evolution, multi-directionality stems from a cumulative causal sequence of endogenous and exogenous changes that drive dynamic interactions between actors and the environment (Anderson *et al.*, 2012; Cohen and Hodgson, 1997). Over time, these interactions alter the variation, retention and selection (Hodgson, 2007; Hodgson and Knudsen, 2010) of capabilities, routines, business models and competitive advantages (Nelson and Winter, 2009).

From the perspective of both incumbent firms and new ventures, a pressing challenge is how to best capitalize on the shift from unidirectionality to multi-directionality (Ortiz-Hunt, 2015). Extant theory offers conflicting predictions about how these transformations are likely to play out. On the one hand, existing theories related to incremental innovation suggest that large-scale incumbents hold an advantage over smaller, newer firms in extracting value from dominant designs (Tushman and Murmann, 1998) through efficient scale replication of existing technologies, particularly when extant solution sets can be extended into new profit opportunities with minimal modification. (Abernathy and Utterback, 1978; Baumol, 2004; Utterback, 1994). Accordingly, it may seem logical that incumbents would take note of the "emergent, collective, inexorable forces" of evolutionary drift (Ridley, 2015, p. 5) by making the necessary technological and organizational adjustments to dominate the migration from unidirectional to multi-directional value creation.

On the other hand, despite the proven ability of incumbent firms to draw considerable value from existing technologies through incremental innovation (Utterback, 1994), their dominance is far from a foregone conclusion (Hunt, 2013b; Tushman and Murmann, 1998). Existing literature has taken ample note of how ascendant start-ups may challenge incumbents through the rollout of destabilizing technological alternatives (e.g. Dosi, 1982; Teece, 1986; Schumpeter, 1934). For example, Tripsas and Gavetti (2000) examined how digitization fundamentally altered the landscape of the imaging industry, hastening the demise of selected incumbents who failed to embrace emerging technologies. The failure of established firms due to technological disruptions (Christensen, 1997) often occurs when the central design logics of a technology's core architecture are reconfigured (Henderson and Clark, 1990) in ways that change how value is created and captured (Hunt, 2013b; Tushman and Murmann, 1998). Accordingly, technological change appears to be both a driver of industry evolution and a key determinant of firm survival (e.g. Agarwal and Gort, 2002; Audretsch, 1995, 2012; Klepper, 1997).

Thus, the focal point of our investigation centers on the paradox of incumbency in multi-directionality that despite possessing insider knowledge, efficient scale and superior resources, incumbents often fail to develop the leading solution sets for multi-directional flows. In this regard, we pose the following question: under what conditions would new firms outperform existing firms in developing and monetizing multi-directional solution sets? We address this question using novel data sets drawn from three contexts: steamships designed for the US western waterways (1810-1860), which allowed bi-directional portage from New Orleans to Pittsburgh; two-way, satellite-based internet services (1965-2010), which allowed bi-directional flow of broadband content; food waste recycling from

restaurants and stores (1995-2015), which is collected for compost to grow local produce that is delivered for sale by the disposal customers.

Our framework and findings contribute important insights to the ongoing efforts to understand value creation and appropriation within complex, environmentally dynamic, multi-directional systems. Prior scholarship has noted the problems incumbents face in ambidextrously achieving profitable efficient scale at the same time as they seek to develop novel breakthroughs and innovations (e.g. Benner and Tushman, 2003; Christensen, 1997; Hodgson, 1997; Tushman and O'Reilly, 1996); however, the underlying cause of incumbents' inability or unwillingness to capitalize upon near-certain profits has remained largely unanswered. By combining studies in economics, strategic management, innovation, entrepreneurship and history, we have developed a novel and potent concept of "the tyranny of marginal reasoning" to explain why and how incumbents are eventually supplanted by newcomers even when incumbents appear well-positioned to dominate.

In the following section, we provide additional context regarding extant theory while developing two hypotheses. After detailing the three novel contexts, our data sets and the methods used in this study, we present the results and conclude by reflecting on the implications for practitioners and the many opportunities our findings hold for future research.

2. Theoretical development

The theoretical perspective that we develop in this study has roots extending to the work of Schumpeter (1934), Penrose (1959) and Baumol (1968), who variously noted that although the improvements derived from innovation are indispensable to economic growth, innovation is not the same as entrepreneurship, nor does innovation in and of itself generate profits (Anderson *et al.*, 2012; Audretsch, 2012). Rather, profitability arises through efficient returns to increasing scale for firms that have ascended an experience curve. Incumbents safeguard extant technologies because it is generally profitable to do so. However, this protective orientation makes incumbents susceptible to two forces that are relevant to round-tripping: business model disruptions and the errant use of marginal reasoning. Through these, a cumulative, generative model of evolutionary processes emerges (Hodgson, 1993; Boyd and Richerson, 1988) in which the movement by new entrants to exploit adjacent market niches (Hannan and Freeman, 1984) instigates discontinuous change, thereby triggering selection pressures that undermine the outdated solution sets and marginal reasoning of incumbents.

The disruptiveness of multi-directional value creation

An extensive body of scholarship has examined the tendency of incumbent firms to focus on incremental improvements to existing technology once they have achieved high profitability through efficient returns to scale (e.g. Abernathy and Utterback, 1978; Baumol, 2004). Over short periods of time, this approach can be highly effective in harvesting profits from existing innovations (Benner and Tushman, 2003). Over longer spans of time, as competing technologies arise, the adverse consequence of incrementalism is that incumbents may be rendered ill-equipped to survive the emergence of disruptive technologies (e.g. Christensen, 1997). As Danneels (2004) noted, disruptive technologies are often associated with the replacement of incumbents by new entrants. Nonetheless, firms are often unwilling to risk near-term profitability by investing in disruptive activities (Benner and Tushman, 2003; Christensen, 1997). "The short-term certainty of exploitation crowds out exploratory learning and innovation," noted Levinthal and March (1993, p. 682).

The reluctance of incumbents to depart from profitable existing technologies and business models also impacts how they frame their respective responses to multi-directional value creation. Under circumstances in which multi-directionality is merely additive – for example, bus, train and airline passenger travel – then incumbents should thrive because

environmental dynamism is low, extant solution sets remain viable and selection-based survivability conditions (Hannan and Freeman, 1984; Hodgson and Knudsen, 2010; Nelson and Winter, 2009) are largely undisturbed. These forms of round-tripping enable incumbents to leverage existing technologies and gain greater economies of scale. The exact same technology, and approximately the same cost structure, can transport passengers by bus from Chicago to Los Angeles, and from Los Angeles to Chicago. New entrants would be hard-pressed to change the basic calculus of the competitive dynamics other than attempting to compete on cost.

However, multi-directionality is seldom merely additive (Hunt, 2013a). Fundamental changes to key aspects of the competitive dynamics require the development of technologies, organizations and business models that may differ markedly from those used to exploit unidirectional revenue flows. For example, prior to the advent of river-faring steamships, trading companies would use simple barges to drift downstream with the current. Upon arriving at the destination, barges were often disassembled for lumber or burned since porting an empty craft upstream required up to 40 men and six months of arduous labor (Hunter, 1949). This is a clear example of a unidirectional business model with no future in a multi-directional world since the floatable asset was destroyed after a single use. Companies that excelled in traveling with the current faced entirely new technological and organizational demands in order to profit by moving both with the current and against it (Kane, 2004).

Regardless of whether the inability of incumbent firms to thrive or even survive stems from underinvestment and incompetence (Henderson and Clark, 1990) or novel breakthroughs in the governing technology's dominant design through architectural innovation (Henderson and Clark, 1990; Rogers, 2010), it is common for extant business models to suffer or even fail when confronted with radical changes in how value is created and captured (Zott *et al.*, 2011). For example, the business model underlying the downstream barge industry bore little resemblance to the technologies and organizations that would eventually supplant it through entrepreneurial innovations that exploited multi-directional value creation.

The Henderson and Clark (1990) model of architectural innovation attributes the inability of incumbents to heed the warnings of an impending shift in the core technology to "information filters and communication channels that embody old architectural knowledge" (p. 28). In numerous contexts, such as photo imaging (Tripsas and Gavetti, 2000), photolithography (Henderson, 1993), automobiles (Klepper, 1997) and televisions (Klepper and Simons, 2000), the central premise of Henderson and Clark (1990) appears to be sound: in each case, incumbent firms screened out vital indicators of a fundamental shift. However, this is not a robust explanation for the behavior of incumbents facing the migration from unidirectional to multi-directional value creation, wherein the multi-directional opportunity is well-understood and publicly acknowledged by both existing firms and emerging new ventures (Hunter, 1943; Kane, 2004). The Henderson-Clark formulation appears to be most relevant when emerging alternatives to a dominant design are unknown, unclear, ambiguous or equivocal. The existence of multi-directional opportunities, however, is rarely a matter of debate. Rather, the commercial potential is typically well-understood, even while there may be considerable disagreement about whether profitably scaled, unidirectional incumbent solution sets will be viable in addressing the multi-directional context (Benner and Tushman, 2003; Dosi, 1982; Hunt, 2013a).

Therefore, even when incumbent firms clearly understand the commercial potential of multi-directional value creation, they may be reluctant to act if the opportunity requires incumbents to change technologies or organizational forms. This is not the case for small and new firms (Christensen, 1997; Hunt, 2013b), who are able to address the multi-directional opportunities with few, if any, pre-existing commitments to the dominant design. The classic view of new ventures is that they suffer from two inherent liabilities: smallness and newness (Hannan and Freeman, 1984; Stinchcombe and March, 1965). The liability of

smallness refers to the fact that small firms are resource-poor actors, lacking financial (capital), technological (e.g. research and development (R & D) knowledge), physical (e.g. products, components), and intangible (e.g. market information, new inventions) resources (Hoang and Antoncic, 2003). The liability of newness refers to the lack of reputation, network ties (O'Donnell *et al.*, 2001) and legitimacy of the firm (Stinchcombe and March, 1965). Early-stage firms often struggle to attain and maintain credibility in the marketplace (Hunt, 2015; Starr and Macmillan, 1990). These liabilities constitute a significant handicap when multi-directional value creation is largely replicative; that is, circumstances in which the migration from unidirectionality does not require changes in the core technologies. For example, a newcomer would face formidable barriers in industries geared toward the scaled exploitation of massive infrastructure, such as railroads. In addition to the significant capital investment required, new entrants offer no revenue enhancements or cost savings that cannot be exploited more ably by incumbent firms (Benner and Tushman, 2003).

Conversely, small and new firms may find themselves on equal, or even preferential footing when the migration from unidirectionality favors significant changes, because they are comparatively unencumbered by allegiances to existing technologies, organizational forms and business models (Christensen, 1997; Henderson and Clark, 1990). When multi-directionality requires changes in both the dominant technological design and the dominant organizational form, newness and smallness may become assets rather than liabilities because new entrants are better positioned to develop and market solution sets that embrace new approaches to the evolving competitive dynamics rather than aiming to forestall organizational and technological changes (Benner and Tushman, 2003; Christensen, 1997; Danneels, 2004). In this vein, we predict:

H1. Entrepreneurial innovators will outperform incumbent firms in multi-directional value creation when new technologies and organizational forms are required to exploit the multi-directional opportunity.

The tyranny of marginal reasoning

Round-tripping that requires incumbents to invest in novel technologies and organizations runs aground when firms encounter marginal profits stemming from multi-directionality that are lower than the existing marginal productivity of unidirectionality (Sendall and Küster, 2004). Margin erosion of this nature can be extremely problematic for incumbent firms. Optimal returns to a production process are most frequently derived using marginal analysis (Baumol and Hall, 1977; Beamon, 1999; Machlup, 1946). Once a firm has achieved efficient returns to scale, diminishing margins typically signify erosion in the efficiency of productive processes (Coelli *et al.*, 2005). Therefore, scaling is a critical facet of shareholder return maximization (Machlup, 1946), but more fundamentally, it is also the goal of innovation and R&D investments. Without the prospect of efficient returns to scale, outlays to support innovation are non-rational because it is only through the scaled production of new products and services that innovation serves any profitable purpose (Dosi, 1982). Innovative firms are only rewarded for novel breakthroughs to the extent that they can achieve efficient scale production at prices the market will ultimately assign (Coelli *et al.*, 2005).

It is both understandable and problematic that large-scale incumbents focus on robust margins (Benner and Tushman, 2003; Levinthal and March, 1993). It is understandable because, *ceteris paribus*, a margin-based focus is consistent with profitability aims. However, technology and organizational forms rarely persist in an unadulterated, unchallenged state for an extended period of time, especially when multi-directionality changes the value-creation, value-capture calculus (Benner and Tushman, 2003; Danneels, 2004). Applying marginal reasoning frameworks (e.g. Guilding *et al.*, 2000), incumbent firms that are faced with the challenges of multi-directional value creation will often seek to implement some

permutation of the existing solution sets, rather than venturing into novel alternatives. We call this margin-focused strategic direction-setting "the tyranny of marginal reasoning." Even though aggregate returns may be enhanced through multi-directional models, it is not uncommon for business processes that are optimized for unidirectionality to exhibit lower marginal returns in a multi-directional context. That is, even though aggregate welfare may be greatly enhanced, incremental returns to scale are diminished relative to the rates of return derived from unidirectional models. For this reason, incumbent may be unwilling or unable to develop and implement innovative solution sets for multi-directional value capture. Instead, innovating entrepreneurs may be the key to facilitating this important source of sustainable development:

H2. Entrepreneurial innovators will outperform incumbent firms in multi-directional value creation when the marginal returns to multi-directionality are lower than the existing marginal returns to unidirectionality.

3. Multi-directional value opportunities

Up to this point, we have large discussed unidirectionality and multi-directionality in the abstract. We have asserted that newness and smallness may be assets rather than liability when the migration from unidirectionality involves significant changes to the dominant technological design, organizational forms or governing business model. Small changes should favor incumbents, while large changes should favor newcomers, but this begs the question: what constitutes small and large changes? Based on the theory we have advanced above, large changes necessitate both technological and organizational changes. Smaller changes should involve either technological change or organizational change or neither. Since some multi-directional conditions may require new technologies but not new organizational forms, while other conditions may require new organizational forms but not new technologies, it is necessary to examine all the possible permutations of technological and organizational disruption. Table I provides a roadmap for our proposed rubric.

Scenario 1 involves unidirectional migrations that do not necessitate changes in either the dominant technology or organizational form. This scenario is included for control purposes represented by use of the inter-state railway freight industry. Scenarios 2-4, each change one or both of these dimensions. Consistent with *H1* and *H2*, our proposed theory posits circumstances in which greater change is associated with an increasing presence and success of new ventures. To illustrate the spectrum of changes associated with the evolution to multi-directionality, we have gathered data for three distinct contexts: steamships on Western US rivers (1810-1860), satellite-based internet services (1962-2010) and food waste recycling (1995-2015). As indicated in Table I, each of these three involved different degrees of change.

Table I. Predictive framework for migration from unidirectional to multi-directional value creation

Scenario	Technology for multi-directional value creation	Organizational form for multi-directional value creation	Impact on marginal returns vs unidirectionality	Prediction	Context in this study
1	=	=	Better margins	Incumbent firm domination	Control industry. Inter-state railway freight
2	Δ	=	Mixed margins	Mixed. No clear winners	Satellite-based internet service
3	=	Δ	Worse margins	New and small firm domination	Food waste recycling
4	Δ	Δ	Worse margins	New and small firm domination	River-faring steamships

Steamships on the western waterways

Prior to the invention of the steamship, only about 5 percent of the American population lived west of the Appalachian Mountains, and the Western rivers remained an under-utilized resource. Keelboats and flatboats could easily carry goods downstream, but could only travel upstream by tedious, burdensome and costly methods. The low-grade lumber from flatboats was often simply burned. Keelboats were pulled back upstream, with slaves and immigrants performing this backbreaking work through poling, bushwhacking, cordelling or warping (Hunter, 1943; Kane, 2004). A good rate of progress was 12 miles per day. Fulton and other ocean-faring steamship operators realized the potential commercial opportunity in river-based commerce. However, incumbents were apprehensive of any design that would reduce the compartment space for goods (Haites and Mak, 1971; Mak and Walton, 1972), despite facing dramatically different conditions on the rivers. Ocean steamers were substantial crafts that carried large, immensely profitable loads, but they were perilously underpowered and over-sized for the requirements of river navigation. Instead, new investors and firms emerged that sought to address the round-tripping problem from a fresh perspective.

Two-way satellite internet service

Early pioneers in communications satellites, who made spectacular profits broadcasting a fixed array of content, labored for decades to find ways to stretch the existing business model to incorporate high-speed internet access (Hu and Li, 2001). Unidirectional delivery of content optimizes a satellite's marginal revenue generation (Metz, 2000). In comparison, the economics of multi-directionality appear at the margin to be unattractive since it involves individual users tying up satellite capacity for idiosyncratic purposes (McKinion *et al.*, 2004). There are also critical issues pertaining to contention and traffic monitoring, for which bi-directionality creates exponentially greater technical challenges as well as far higher costs (Obata *et al.*, 2005). Similar to bi-directional river travel, new firms produced novel technologies that were instrumental in making satellite-based broadband financially viable, such as Ka-band spot beams, "bent-pipe" signal reflection architecture, signal amplifiers, attenuation and latency remediators, and ultra-light atmospheric aircraft with onboard solar-charged batteries (Hu and Li, 2001; Kuran and Tugcu, 2007).

Food waste recycling

On average, Americans each annually generate 475 lbs of food waste. In aggregate, this is 70 MM tons, nearly one-third of the weight-volume in landfills (Ghosh *et al.*, 2015). Many states, and most municipalities, favor steps taken to turn food waste into productive compost. Doing so would alleviate landfill space constraints and reduce vermin concerns. The problem is that for firms that have invested heavily in optimizing the collection and disposal of unsorted residential and commercial waste, bi-directional value creation looks unattractive. Instead, start-up firms have developed novel process flows that involve collecting food waste, transforming into compost, using that compost to grow local produce, and then selling the produce back to the waste disposal customers (Fehr *et al.*, 2002; Refsgaard and Magnussen, 2009). The model has required new organizational structures and the use of aggregate rather than marginal reasoning (Parfitt *et al.*, 2010). New firms have sought to make recycled food waste services the primary service offering, to which the disposal of other refuse has been added, vs the existing model that treated food waste as a disruptive inconvenience.

Control industry: inter-state railway freight

Freight hauling via inter-state railway systems began in the 1830s, primarily as a supplement to inexpensive hauling via the country's extensive system of canals and by-ways. In unidirectional

fashion, downstream shipping via canals was paired with upstream shipping via railroads. Typically, the hauling was supported by separate companies, one for canal portage and other for railroad service. By the 1850s, railway systems were multi-directional, hauling finished goods to the west and returning with raw materials to the east. The multi-directionality was a boon to incumbent railroads, which enjoyed vastly more effective and efficient use of the fixed assets in the migration from unidirectionality. This context, in which neither the technologies nor the organizational forms significantly changed in the migration from unidirectionality, is an ideal industry to use as a control in this study.

4. Data, method and model

The centerpiece of our inquiry involves a head-to-head comparison between incumbent firms and new entrants across varying degrees of technological and organizational disruption, asking: when and how do new and small firms hold an advantage in the migration from unidirectional to multi-directional value creation? Addressing this question required the use of multiple data sets from contrasting time periods and industry contexts, comprised of technical, operational and financial data. This allowed us to avoid the risk that the social-contextual factors predominating at any given point in time may themselves be the primary driver of observed effects and outcomes, vs environmental forces (Hodgson, 1993). An historical research design enabled us to be responsive to the challenges of witnessing the forces of variation and selection that are central to evolutionary economics (e.g. Hodgson, 1997) and population ecology (e.g. Hannan and Freeman, 1984).

For each of the three contexts, we followed established conventions for differentiating between incumbent firms and new entrants (Evans, 1987; Reynolds, 1987; Reynolds and Curtin, 2010) by stipulating that new firms needed to be less than five years old and must not have had a major market presence in any other industry prior to commencement of operations in each focal industry. Since our investigation examines antecedents and outcomes surrounding the transformation of unidirectional to multi-directional value streams, the pool of incumbents is generally comprised of firms that were actively engaged in a unidirectional business model.

Data

For steamboat data (1810-1860), we drew upon government documents and privately sourced records (Haites and Mak, 1971; Hunter, 1949; Kane, 2004; Mak and Walton, 1972) for 510 steamships, owned and operated by 203 different companies. Comprehensive compilations of steamboat economics for the period 1807-1868 provide a remarkably detailed accounting of both revenue and costs (Haites and Mak, 1971; Hunter, 1949). Costs include craft size, average running time per year, price of wood, daily fuel consumption, labor costs, repairs, wharfage charges and insurance. Revenue data are equally detailed as a consequence of state and federal reporting requirements; these include: shipment manifests, total tonnage, passenger fares and the value of transported cargo. Wages and fuel constituted approximately 70 percent of the operating costs, with provisions and administrative outlays making up the remainder. Importantly, detailed estimates have been developed separately for both upstream and downstream travel (e.g. Haites and Mak, 1971; Kane, 2004), particularly for companies operating between New Orleans and Louisville.

For two-way satellite interconnectivity (1962-2010), we used data from internet service providers (ISP) and satellite operators, obtained through USPTO, SEC and Dun & Bradstreet databases. The first commercial broadcast satellite was Telstar, developed by AT&T, which went live in 1962. The first residential ISP, The World, was launched in 1989, using wired telephony. From 1962 to 2010 various combinations of satellite technologies and internet service were patented (Hu and Li, 2001; Kuran and Tugcu, 2007; Metz, 2000),

involving primarily 168 firms, which were using industry directories and incorporation documents, consistent with prior examinations of market entry and case histories of firm survival (e.g. Baum and Singh, 1994; Carroll and Hannan, 2000). Financial and operational data for 64 publicly traded firms were obtained through mandatory periodic filings through the SEC. Data for 104 private ISPs were obtained through D&B. Exhaustive documentation on patents granted for military and civilian satellite technologies was extracted through USPTO search engines. From an initial pool of 26,440 patents, 3,418 were identified that are relevant to the confluence of satellite and internet technologies.

The most recent context, involving food waste recycling (1995-2015), we gathered data using a survey that was sent to 155 firms operating in the food waste disposal/recycling segment, since only seven of the firms are publicly traded and there is no effective way to disaggregate food waste costs and revenues from the overall waste handling financials. Definitions and descriptions included in the survey used taxonomies for food waste and food waste recycling developed through recent studies on environmental management and policy (Fehr *et al.*, 2002; Ghosh *et al.*, 2015; Refsgaard and Magnussen, 2009). Of the 155 firms that were contacted, 117 responded with data that were utilizable in our study. In total, 83 of the firms were classified as incumbents, having participated in waste hauling for an average of 35 years. Only three of these incumbents engaged in food waste recycling. Of the remaining 34 firms, 24 engaged exclusively in food waste recycling, eight handled conventional waste as well as food waste recycling and two disposed of food waste in landfills along with all other refuse. Each firm provided detailed revenue and cost models for food and non-food waste disposal and recycling, where applicable.

The data for our control industry, inter-state railway freight, were drawn from extensive online databases maintained by the US Department of Transportation, Department of Commerce and Department of Agriculture. In total, 134 firms, covering the period from 1835 to 2015, were included in the sample.

Analytical design

Our analytical design employs a Cobb-Douglas aggregate production function (CDF), modified to take into account returns to innovation (RTI) (e.g. Dixit and Stiglitz, 1977; Kortum, 1997; Solow, 1957). Through this function, we fully derived the component sources of long-term economic gains, which were regressed in an econometric model that was structured as a head-to-head comparison between entrepreneurs and incumbents. The basic form of CDF is: $Q = AL^{\alpha}K^{\beta}$, where Q is total output, L is the quantity of labor, K is the quantity of capital, and α and β are output elasticities, such that $0 < \alpha, \beta < 1$ and $\alpha + \beta = 1$. While retaining the core CDF structure, we decomposed the capital service function, consistent with Dixit-Stiglitz, to account for the component contribution of innovations to the productive process. This was done because conventional CDF treats technologies as perfect substitutes, but we placed no bounds on the variety or incremental productive capacity of new innovations in our analysis (Peeters and de la Potterie, 2006). The final form of our model (for which the detailed derivation can be provided) is:

$$(1-I_i) = a + b(k_i - l_i) + cl_i + dT_i + fD_i + gC + e_i \quad (1)$$

In our model $(1 - I)$ is the log of incremental production attributable to firm-level innovation; $(k - l)$ is the log of physical capital per unit of labor; l is the log of labor units; T is an orthogonal set of codes representing industry-level technological variety across unidirectional and multi-directional contexts; D is an orthogonal set of codes representing the market opportunities for unidirectional and multi-directional value creation; C is a dummy coded variable for firm type (incumbents: 0; new entrants: 1) i represents the ith company for each of the three data sets; e_i represents error terms; and a, b, c, d, f and g are

parameter estimates. Since the sum of the output elasticities always equals 1 in CDF, our model captures the residual component of production (I) that is attributable to innovations that may or may not be operationalized at the firm level.

Predictors

As indicated above, the dependent variable in our investigation is RTI, which is a continuous value for firm-specific productivity calculated as the logged partial derivative of the innovation component from the decomposed capital service function of our CDF. The two focal predictors are: firm type, a discrete dichotomous variable for incumbents and new entrants; and firm vs industry margins, a continuous variable represented by the difference of firm margins less average industry margins.

Controls

As indicated in Equation (1), the model also estimates values for labor, industry technology, unidirectional and multi-directional market opportunities. Additionally, we control for known covariates of productivity: time-series data for macro-economic factors (GDP growth), demographics (aggregate population and income per capita); industry population, industry size and industry cohort controls drawn from population ecology (Hannan and Freeman, 1984); and firm-specific effects related to age, size, intellectual capital (patents and citations), executive management experience (years).

5. Results

Table II reports the descriptive statistics and correlations among the model variables. Small-to-moderate correlations among the main independent variables in the study suggest that multicollinearity might be an issue in the empirical models. To address these concerns, before estimating the statistical models, we centered all continuous, independent variables. We then calculated the variance inflation factors (VIFs) with the full model reported in Model 6 and all VIFs were below the standard threshold of 10 suggesting that any concerns multicollinearity are resolved. Without exception, the correlation coefficients are consistent with the relationships we have predicted through our theoretical conception of the migration from unidirectional to multi-directional value creation.

The central proposition of our framework is that under certain conditions newness and smallness are assets rather than liabilities in multi-directional value creation. When environmental forces generate stronger, more viable variations (Hannan and Freeman, 1984; Hodgson, 1993) that fundamentally change the competitive dynamics of an industry, then

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. Returns to innovation											
2. Existing margins	*−0.36*										
3. Firm type	*0.21*	*−0.24*									
4. Tech embeddedness	−0.03	0.03	0.08								
5. Org. embeddedness	0.02	−0.02	0.10	0.13							
6. Firm size	0.11	0.11	0.11	*0.17*	*0.13*						
7. Firm age	−0.09	−0.06	−0.05	−0.02	0.10	0.40					
8. Macro-economic matrix	*−0.18*	*−0.17*	−0.07	0.01	0.06	0.09	0.02				
9. Socio-educational matrix	*−0.16*	*−0.17*	−0.03	0.00	0.04	−0.10	0.01	*0.22*			
10. Industry pop at entry	*0.19*	*0.15*	*0.24*	0.09	0.06	0.03	−0.03	−0.10	−0.04		
11. Cohort population	*−0.17*	*−0.19*	*−0.15*	0.08	0.12	0.11	0.12	*0.14*	*0.22*	−0.09	
12. Policy environment	*0.15*	0.11	0.08	0.04	−0.07	0.08	*−0.16*	0.02	0.07	*0.17*	0.05

Note: Italics indicate correlation with $p < 0.01$

Table II.
Correlation coefficients

large-scale, more inertial incumbents face a greater likelihood of extinction. To test the theory, we predicted that new firms would outperform incumbents under two conditions: when the shift from unidirectional to multi-directional revenue requires new technologies, organizations or business models; and when analysis suggests that the marginal rates of return for multi-directional profits were less than unidirectional rates of return. The rationale for each prediction is derived from the theory-based assertion that greater levels of technological and organizational change will improve the prospects of small and new ventures *vis-à-vis* incumbents. This is expected to occur because incumbents will tend to apply solution sets that leverage existing capabilities, routines and business models (Benner and Tushman, 2003; Danneels, 2004; Zott *et al.*, 2011). When the changes required to create and capture value from multi-directionality is relatively modest, then incumbents will possess the capacity to make small, incremental tweaks to existing systems (Hunt, 2013b) and thereby stretch existing solution sets to maintain efficient returns to scale. Conversely, substantial changes to the technological and organizational paradigms will make tweaking ineffective and stretching impossible. A summary of the regression results provides strong confirmation of these core assertions (Table III).

For each of the three historical contexts and the control scenario both firm type and marginal returns were significant predictors of the dependent variable, RTI. The results provide strong support for *H1* and *H2*, as well as the degree of change predicted by the four scenarios in Table I. The positive coefficients for steamships, satellite internet and food waste each indicate that new and small firms are situated more favorably within the industry as the greater and greater changes befall a given industry in the migration from unidirectionality to multi-directionality. Importantly, the control scenario using the inter-state railroad freight industry is a negative coefficient. This is precisely as the proposed framework predicts. When incumbents are not required to materially alter technologies and organizational forms to capture multi-directional value, then newness and smallness become significant liabilities and the extant selection-survival conditions remain intact for incumbent firms. Hence, the negative coefficients. The complete regression results are displayed in Table IV.

As the regression results indicate for each of the industry contexts, firm type and margin effects are both significant predictors of RTI. Over and above well-established macro, industry and firm-level controls, new market entrants enjoy increasing RTI. Moreover, these returns become more pronounced when the evolution to multi-directional value creation is technologically and organizationally disruptive. The comparative ability to harvest returns from multi-directionality is presented in Figure 1.

Figure 1 demonstrates two stark realities: incumbents will prevail when they can adapt existing solution sets to new circumstances; and incumbents will, to varying degrees, capitulate when multi-directionality requires significant change. For all except the railroad freight context, RTI – calculated as the partial derivative attributable to firm-level innovation in a multi-directional context – is, on average, significantly negative for incumbents, indicating existing sources of capital resources are favored to the extent that

	H1: new tech. and org. required				*H2*: unfavorable margins			
Context	Correlation coeff. for "firm type"	*p*-value	Model *F*-test	Adj. R^2	Correlation coeff. for "margin Δ"	*p*-value	Model *F*-test	Adj. R^2
Western rivers	0.84	< 0.001	87.4	0.71	1.07	< 0.001	64.1	0.55
2-way satellites	0.25	< 0.01	49.3	0.50	0.58	< 0.01	38.8	0.41
Food waste recycling	0.43	< 0.01	56.0	0.55	1.01	< 0.001	69.2	0.62
R.R. freight (control)	−0.77	< 0.01	61.2	0.64	−0.98	< 0.001	74.1	0.67

Table III. Summary regression results

DV (returns to innovation)	Hypotheses	Model 1: controls	Model 2: R.R.	Model 3: steam	Model 4: waste	Model 5: satellite	Model 6: all
Independent variables							
Firm type (1 = new venture)	*H1*		−0.77**	0.84***	0.43**	0.25**	0.47***
SD			0.4	0.31	0.28	0.16	0.22
Firm vs industry margins	*H2*		−0.98***	1.07***	1.01***	0.58**	0.56***
SD			0.45	0.42	0.63	0.32	0.29
Firm – intellectual capital (patent cit.)		0.38**	0.31**	0.35**	0.27**	0.20*	0.27**
SD		0.2	0.11	0.19	0.16	0.11	0.12
Firm – key officer experience (years)		0.12*	0.09*	−0.11*	−0.09	−0.09	−0.03
SD		0.07	0.04	0.07	0.05	0.05	0.01
Firm age (years)		0.26*	0.33*	−0.23**	−0.15*	−0.13*	−0.17*
SD		0.16	0.17	0.16	0.08	0.07	0.11
Firm size (% of industry presence)		−0.18	0.15*	−0.32**	−0.19*	−0.14**	−0.19**
SD		0.09	0.05	0.22	0.12	0.11	0.13
Entry cohort (avg. lifespan)		−0.09	−0.03	−0.05	0.07	−0.13*	0.03
SD		0.06	0.02	0.03	0.04	0.07	0.01
Industry growth rate (%)		0.11	0.10*	−0.21**	0.19*	0.23**	0.17*
SD		0.07	0.05	0.08	0.06	0.12	0.12
Industry size/industry population (avg. presence)		−0.17*	−0.22**	−0.17*	−0.15*	−0.27	−0.2
SD		0.12	0.08	0.13	0.09	0.18	0.13
Indus population at entry (no.)		0.15	−0.22**	0.25	0.28**	0.22	0.23
SD		0.08	0.12	0.08	0.14	0.16	0.18
Industry size ($ revenue)		−0.14*	−0.18*	0.13*	0.09	−0.03	−0.04
SD		0.09	0.12	0.08	0.04	0.01	0.01
GDP growth rate (%)		0.13*	0.11	0.24**	0.16*	0.18*	0.19*
SD		0.03	0.03	0.09	0.04	0.04	0.05
Year dummies		Incl	Incl	Incl	Incl	Incl	Incl
(Constant)		Incl	Incl	Incl	Incl	Incl	Incl
Adjusted R^2		0.35	0.64	0.71	0.55	0.50	0.64
ΔR^2 (vs controls only)		-*-	0.29	0.36	0.20	0.15	0.29
F*-value – full model		128.7	149.1	137.5	158.8	161.0	146.3

Notes: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table IV.
Complete regression results for four migrations to multi-directionality

they extend the marginal returns captured under unidirectional conditions. Meanwhile, new firms derive significant incremental benefit from the technological and organizational innovations they have developed to exploit multi-directional value creation.

It is also evident from Figure 1 that the greater the change, the greater favorable impact on new ventures. Steamships on the western waterways (indicated by the red dotted line) represented the most disruptive scenario, fundamentally impacting core business model elements involving the dominant technologies and organizational forms. Consistent with our theory, new firms in this industry held a massive advantage over incumbents in harvesting RTI. More modest disruptions to the food waste and satellite industries favored new ventures but in a less pronounced fashion than witnessed in the steam ship context. This "laddered" effect arises as a function of the magnitude of disruption experienced in each industry as a consequence of the migration from unidirectionality.

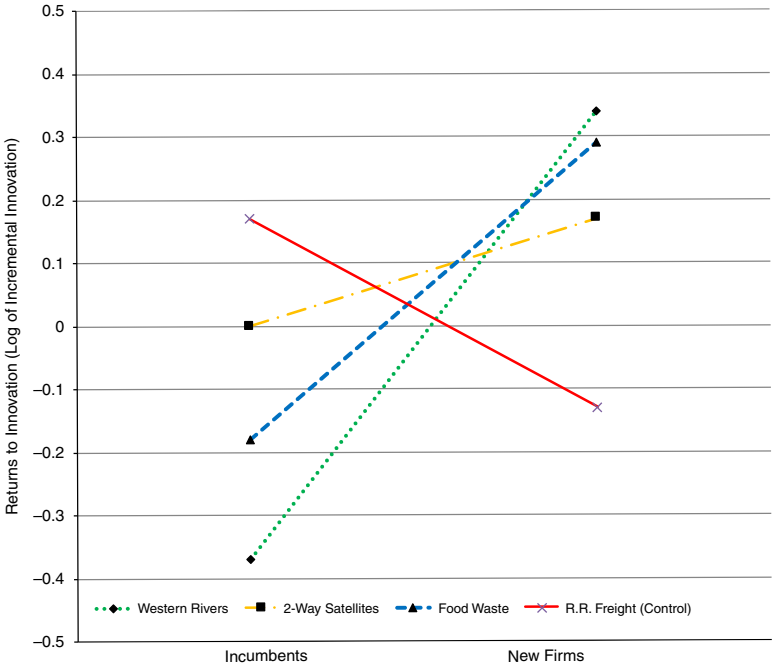

Figure 1.
Comparative returns to innovation – new firms vs incumbents

Meanwhile, in the railroad freight context, where the conditions allowed large, efficient scale incumbents to migrate seamlessly to multi-directionality, there is – as the proposed model predicted – a substantial liability to being a small or new venture.

6. Discussion

The essence of strategy, noted Porter (1996, p. 68), is "the creation of a unique and valuable position, involving a different set of activities." This is certainly true in the migration from unidirectional to multi-directional value creation. As each the three contexts for our study demonstrate, round-tripping rarely involves simple mirroring or uncomplicated replication of one-way flows. Rather, it appears that multi-directionality requires the creation of "a different set of activities," many of which lie beyond the interest or reach of existing firms. The fact that so many incumbents face difficulty successfully migrating to multi-directional technologies, organizations and business models reminds us that, in many respects, strategy is also a perspective (e.g. Drucker, 1994). Firms that fail to survive industry evolutions toward multi-directionality are rarely selected out due to ignorance. Instead, their demise stems from the perspective that they possess the tools necessary to be successful, when in fact they do not.

As the foregoing results suggest, when confronted with disruptive challenges, incumbents will often attempt to stretch existing technologies, organizational forms and business models from unidirectional to multi-directional contexts. In each of the three contexts examined in this study, incumbent firms run the risk of rendering themselves extinct by failing to adapt to the technological and organizational demands associated with the migration from unidirectional to multi-directional value creation Consistent with evolutionary conceptions of industry change and firm survival (Hodgson, 1993, 2007; Nelson and Winter, 2009), the collision of environmental dynamism and organizational

rigidity creates the conditions wherein existing firms are driven to extinction. In the first two contexts – steamships and satellite-based internet services – large-scale, well-resourced incumbents gave way to new and small firms that chose to approach multi-directional value creation as a unique challenge, one requiring novel solution sets that were quite distinct form the systems and capabilities used to derive unidirectional profits. In the third case – food waste recycling – we examined an emerging context in which it is still to be determined whether incumbents will adapt the challenges of multi-directionality.

What makes these three instances illuminating is that in each case the multi-directional opportunities were well known to the incumbents. However, existing firms attempted to repurpose, retrofit and force-fit extant technologies and organizational forms to the evolving set of circumstances. This was not done out of ignorance of the opportunity. Rather, incumbents relied upon well-proven solution sets in an attempt to preserve the attractive margins that are accrued through efficient returns to scale. Ironically, the marginal reasoning that discourages incumbents from leading multi-directional value creation is a key element in their eventual demise. This is the essence of what we have coined the "tyranny of marginal reasoning." Despite enjoying a significant head start, incumbent firms appear to eschew the enhanced aggregate profitability that accrues to multi-directional value creators. Meanwhile, entrepreneurs, who are comparatively unencumbered by such biases, develop viable solution sets that endow them with a leadership position in the generation of multi-directional revenue streams.

Implications for scholars

To an accelerating degree, multi-directional value creation has become a defining feature of profitable activity systems across service and manufacturing sectors (Porter, 1996, 2002). Mega-trend developments, such as those related to globalization, big data analytics, social networking and the monetization of knowledge assets, are continually spawning opportunities for existing firms and new entrants (Agarwal and Gort, 2002; Christensen, 1997; Hunt and Lerner, 2012; Klepper, 1997). Strategic management scholars have sought to anticipate these developments through frameworks that describe and predict the role of dynamic capabilities (e.g. Helfat *et al.*, 2009; Teece *et al.*, 1997), competitive positioning (Porter, 2002), ambidexterity (e.g. Tushman and O'Reilly, 1996) and technological paradigms (e.g. Henderson and Clark, 1990). What is conspicuously missing from extant models, however, are the tools needed to differentiate and explicate two key elements: capital assets, including knowledge and innovation; and the specific sources of environmental disruption.

Responding to these gaps, the predictive framework advanced in this study presents two vital disaggregations that clear the path for deeper analysis of multi-directionality and the fate of incumbent firms. First, we have disaggregated the capital function, specifically knowledge stocks, by isolating the RTI through our modified formulation of Cobb-Douglas. Applications of this approach to existing and emerging industries will allow scholars in economics, strategic management, innovation and entrepreneurship to build and test new theories related to specific forms of innovation, including firm-level effectiveness in responding to changes in environmental conditions and competitive dynamics. Second, we have disaggregated the sources of disruptiveness through a taxonomy that categorizes and characterizes each disruption permutation of the technological, organizational and business model changes that each disruption elicits (Table I). This work extends and enhances extant frameworks (e.g. Henderson and Clark, 1990) by building theoretical support for the consideration of organizational and business model disruptions as a supplement to the technologically oriented conceptions that dominate existing frameworks. Future research can apply these disaggregations to the establishment of clearer boundary conditions regarding when, how and why firm characteristics, such as size, age and access to resources, play a role in determining the heterogeneity of firm-level outcomes.

Our multi-directional value framework, built in part from Schumpeter's (1934) model of discontinuous change, reinvigorates efforts to articulate the boundaries and interactions between innovative actors and the operating environment. Historically, evolutionary models of industry change (Agarwal and Gort, 2002; Penrose, 1959) have spotlighted the uneasy, somewhat awkward co-existence between environmental conditions and the ramifications of intentionality and action by innovative new entrants. Hodgson (1997) addressed these tensions, noting that both endogenous and exogenous sources of change can exist in an evolutionary interpretation of Schumpeterian innovation. In particular, his positive acknowledgment of Boyd and Richerson (1988, p. 137) offers the perspective that evolution is guided by the interaction between relevant information and the local environment in which the actor operates. The approach we have mapped out through this line of analysis continues this sensible, less contentious middle path. In Schumpeterian fashion, we do not view the innovations and resulting difficulties faced by incumbents in stretching their current business models to try to accommodate multi-directionality as an act of long-term omniscience. Rather, we see these events as a model of generative evolutionary processes whereby the moves into adjacent market niches instigate discontinuous change and create the very selection pressures that undermine the marginal reasoning of incumbents. In fact, what is so interesting about the results of the evolutionary forces we have discovered is the fact that small variations (multi-directional vs unidirectional value creation) sometimes create such enormous selection pressures. By failing to identify and respond to highly relevant forces in which the environment itself is the "central actor" driving multi-directional dynamics, incumbent firms are "selected out." Going forward, exciting research opportunities exist to apply this more accommodative stance toward the mutualistic role of entrepreneurs and environments by assessing variation and selection as a consequence of both endogenous and exogenous forces.

Implications for practitioners

The findings from this study have potent implications for a wide spectrum of firms and competitive contexts, ranging from small, nascent-stage ventures to large-scale incumbents, and from localized, service-sector concerns to globally operating manufacturers. For existing firms, our findings pose a cautionary tale. In the past, classical conceptions of corporate strategy and competitive positioning have counseled that incumbents are best served by "leading from strength" while "giving up the crumbs" (e.g. Katz, 1970). The problem with this mindset in a multi-directional world is that it exposes large firms to the worst facets of organizational inertia. Often, it is difficult to discern the importance of looming disruptions until their influence is imminent. That which may initially seem to be "crumbs" may turn out to be the entire meal. In each of the three contexts investigated in this study, extremely profitable incumbents perceived round-tripping to be an uncomplicated extension of existing business, or a limited opportunity of mere "crumbs." Both perspectives proved to be incorrect, with severe consequences for non-adaptive firms. The challenge for incumbents is to accept and even embrace the fact that multi-directional value creation will be noisy and disruptive to existing technologies, organizations and business models. Firms that instead choose to employ strict marginal reasoning in assessing the strategic pathways are likely to encounter difficulty in adapting their respective business models to the shifting competitive dynamics, causing such firms to become less and less relevant.

Instead, the results suggest that survivability depends upon a fundamental rethinking of the competitive dynamics that accompany multi-directionality. A difficult, undesirable facet of this shift often involves an erosion in marginal profitability. However, the corresponding shift to aggregate network profitability is a more realistic and sustainable approach to multi-directional value creation and capture. For example, the ecosystem-wide perspectives of Google, Amazon and Facebook, have resulted in the promulgation of "freemiums"

(i.e. desirable features and functionality that are given to consumers for free) that confound traditional attempts to conceptualize economic value (Niculescu and Wu, 2014). In one telling instance, Facebook spent $19 billion to acquire the cross-platform messaging application, WhatsApp, only to subsequently discontinue any plans for the acquired unit to generate revenue, hoping instead to create and capture new sources of ecosystem-wide customer value by leveraging a free WhatsApp service. For many incumbents, this shift to margin-eroding, aggregate measures of system-wide, multi-directional profit is simply beyond their capacity to adapt to radically new business models.

While incumbents often lament the destabilizing effects of multi-directionality, new and small firms enjoy a compelling array of entry points and opportunities. The complacency of incumbents in the face of potent disruptions makes multi-directional business models uniquely attractive to firms that are neither encumbered by lower margins, nor biased against network-level and ecosystem-wide conceptions of profit generation. New firms, entering nascent sectors that are characterized by novel technologies, organizations and business models may find it attractive to develop market entry approaches that are "born multi-directional." This is, in some sense, analogous to firms that are "born global" (e.g. Knight and Cavusgil, 2004), which refers to newcomers that immediately aim to capitalize upon environmental conditions that favor an international orientation. Similarly, new ventures that are specifically designed to capitalize on emerging opportunities stemming from multi-directionality may discover a selective advantage in developing this orientation from inception.

Limitations and opportunities

As with all retrospective analyses, this study involves design elements that require careful assessment with respect to robustness. While the three contexts that were selected as the focus of our inquiry are temporally and spatially varied, we knew when we undertook the analysis that each of the three had a rich mixture of incumbents and newcomers. With the benefit of history, we also knew that each involved unidirectional to multi-directional migrations that were turbulent technological transformations, involving expensive decisions that would dictate the long-term fate of each industry. Not all migrations to multi-directionality will be as colorful as theses three, nor will they always favor new, small firms. There are many instances in which incumbents dominated both unidirectionality and multi-directionality. Without apparent exception, these instances involve migrations in which the underlying technology and governing solution sets remain intact, such as inter-state shipping, bus and train travel, and the dissemination of traditional print media. In each of these cases, incumbents were well-served by simply stretching extant solutions to ne circumstances and opportunities. Opportunities abound for follow-on empirical studies that delve into new industries, sectors and technologies to develop increasingly nuanced tests of our theory of multi-directional creation and the strategic impact of marginal reasoning.

From the stand-point of statistical robustness, studies such as the one we have conducted in this paper are susceptible to the effects of endogeneity. As a safeguard, tests were performed to ensure that the results were not subject to the potentially confounding effects of endogeneity and right-side truncation. As with most studies in which both the strategies and the outcomes of those strategies are included in the analysis, our research design is susceptible to endogeneity on three fronts: omitted variables, reverse causality and errors-in-variables bias. To assess the possible presence of omitted variables, we used the two-step procedure (Heckman, 1979). Applying Heckman, we generated an inverse Mills ratio, which was found to be not statistically significant. As for reverse causality, we used lagged time-series variables to confirm the directionality of the focal effects (Davidson and MacKinnon, 1992). We also performed a Hausman (1978) test, which confirmed that the model predictors are not subject to a simultaneity bias.

7. Conclusion

An unending assortment of sectors and technologies continue to emerge that are typified by multi-directionality: social networking, commercial space travel, distance education and medical treatments using nanoscale technologies. Although it often seems logical that incumbent will dominate these domains, the odds seem to be against them doing so. As Henderson and Clark (1990) noted, "An architectural innovation's effect depends in a direct way on the nature of organizational learning." It is not uncommon for new opportunities to emerge from reconfiguring technologies within the framework of existing architectures. When this can be accomplished, incumbents will realize a handsome payoff. However, when this is not tenable, incumbents who stretch existing solution sets to meet the demands of multi-directional conditions will find themselves ill-equipped to survive entrepreneurial round-tripping, while new and small firms appear likely to flourish.

References

Abernathy, W.J. and Utterback, J.M. (1978), "Patterns of industrial innovation", *Technology Review*, Vol. 80 No. 7, pp. 40-47.

Agarwal, R. and Gort, M. (2002), "Firm and product life cycles and firm survival", *The American Economic Review*, Vol. 92 No. 2, pp. 184-190.

Anderson, A.R., Drakopoulou Dodd, S. and Jack, S.L. (2012), "Entrepreneurship as connecting: some implications for theorising and practice", *Management Decision*, Vol. 50 No. 5, pp. 958-971.

Audretsch, D. (2012), "Entrepreneurship research", *Management Decision*, Vol. 50 No. 5, pp. 755-764.

Audretsch, D.B. (1995), *Innovation and Industry Evolution*, MIT Press, Cambridge, MA.

Baum, J. and Singh, J. (1994), "Organizational niches and the dynamics of organizational mortality", *American Journal of Sociology*, Vol. 100 No. 2, pp. 346-380.

Baumol, W. (1968), "Entrepreneurship in economic theory", *The American Economic Review*, Vol. 58 No. 2, pp. 64-71.

Baumol, W. (2004), "Education for innovation: entrepreneurial breakthroughs vs corporate incremental improvements", No. w10578, National Bureau of Economic Research, Cambridge, MA.

Baumol, W. and Hall, P. (1977), *Economic Theory and Operations Analysis*, Prentice Hall, New York, NY.

Beamon, B. (1999), "Measuring supply chain performance", *International Journal of Operations & Production Management*, Vol. 19 No. 3, pp. 275-292.

Benner, M. and Tushman, M. (2003), "Exploitation, exploration, and process management: the productivity dilemma revisited", *Academy of Management Review*, Vol. 28 No. 2, pp. 238-256.

Boyd, R. and Richerson, P.J. (1988), *Culture and the Evolutionary Process*, University of Chicago Press, Chicago, IL.

Carroll, G. and Hannan, M. (2000), *The Demography of Corporations and Industries*, Princeton University Press, Princeton, NJ.

Carter, C. and Rogers, D. (2008), "A framework of sustainable supply chain management", *International Journal of Physical Distribution & Logistics Management*, Vol. 38 No. 5, pp. 360-387.

Chen, I.J. and Paulraj, A. (2004), "Towards a theory of supply chain management: the constructs and measurements", *Journal of Operations Management*, Vol. 22 No. 2, pp. 119-150.

Christensen, C.M. (1997), *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press, Boston, MA.

Coelli, T., Rao, D., O'Donnell, C. and Battese, G. (2005), *An Introduction to Efficiency and Productivity Analysis*, Springer Science & Business Media, Berlin.

Danneels, E. (2004), "Disruptive technology reconsidered: a critique and research agenda", *Journal of Product Innovation Management*, Vol. 21 No. 4, pp. 246-258.

Davidson, R. and MacKinnon, J. (1992), "A new form of the information matrix test", *Econometrica: Journal of the Econometric Society*, Vol. 60 No. 1, pp. 145-157.

Dierickx, I. and Cool, K. (1989), "Asset stock accumulation and sustainability of competitive advantage", *Management Science*, Vol. 35 No. 12, pp. 1504-1511.

Dixit, A.K. and Stiglitz, J.E. (1977), "Monopolistic competition and optimum product diversity", *The American Economic Review*, Vol. 67 No. 3, pp. 297-308.

Dosi, G. (1982), "Technological paradigms and technological trajectories", *Research Policy*, Vol. 11 No. 3, pp. 147-162.

Drucker, P. (1994), "The theory of the business", *Harvard Business Review*, Vol. 72 No. 5, pp. 95-104.

Evans, D. (1987), "The relationship between firm growth, size, and age: estimates for 100 manufacturing industries", *The Journal of Industrial Economics*, Vol. 35 No. 4, pp. 567-581.

Fehr, M., Calcado, M.D.R. and Romao, D.C. (2002), "The basis of a policy for minimizing and recycling food waste", *Environmental Science & Policy*, Vol. 5 No. 3, pp. 247-253.

Ghosh, P., Sharma, S., Haigh, Y., Evers, A. and Ho, G. (2015), "An overview of food loss and waste: why does it matter?", *Cosmos*, Vol. 11 No. 1, pp. 89-103.

Guilding, C., Cravens, K.S. and Tayles, M. (2000), "An international comparison of strategic management accounting practices", *Management Accounting Research*, Vol. 11 No. 1, pp. 113-135.

Haites, E.F. and Mak, J. (1971), "Steamboating on the mississippi, 1810-1860: a purely competitive industry", *Business History Review*, Vol. 45 No. 1, pp. 52-78.

Hannan, M.T. and Freeman, J. (1984), "Structural inertia and organizational change", *American Sociological Review*, Vol. 49 No. 2, pp. 149-164.

Heckman, J. (1979), "Sample selection bias as a specification error", *Econometrica*, Vol. 47 No. l, pp. 53-161.

Helfat, C., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D. and Winter, S. (2009), *Dynamic Capabilities: Understanding Strategic Change in Organizations*, Wiley & Sons, Hoboken, NJ.

Henderson, R. (1993), "Underinvestment and incompetence as responses to radical innovation", *RAND Journal of Economics*, Vol. 24 No. 2, pp. 248-270.

Henderson, R. and Clark, K. (1990), "Architectural innovation: reconfiguration of existing product technologies and failure of established firms", *Administrative Science Quarterly*, Vol. 35 No. 1, pp. 9-30.

Hoang, H. and Antoncic, B. (2003), "Network-based research in entrepreneurship: a critical review", *Journal of Business Venturing*, Vol. 18 No. 2, pp. 165-187.

Hodgson, G.M. (1993), *Economics and Evolution: Bringing Life Back into Economics*, University of Michigan Press, Ann Arbor, MI.

Hodgson, G.M. (1997), "The evolutionary and non-darwinian economics of Joseph Schumpeter", *Journal of Evolutionary Economics*, Vol. 7 No. 2, pp. 131-145.

Hodgson, G.M. (2007), "Evolutionary and institutional economics as the new mainstream?", *Evolutionary and Institutional Economics Review*, Vol. 4 No. 1, pp. 7-25.

Hodgson, G.M. and Knudsen, T. (2010), *Darwin's Conjecture: The Search for General Principles of Social and Economic Evolution*, University of Chicago Press, Chicago, IL.

Hu, Y. and Li, V. (2001), "Satellite-based internet", *IEEE Communications*, Vol. 39 No. 3, pp. 154-162.

Hunt, R. (2013a), "Priming the pump: demand-side drivers of entrepreneurial activity", *Frontiers of Entrepreneurship Research*, Vol. 33 No. 14, p. 2.

Hunt, R. (2013b), "Entrepreneurial tweaking: an empirical study of technology diffusion through secondary inventions and design modifications", *European Journal of Innovation Management*, Vol. 16 No. 2, pp. 148-170.

Hunt, R. (2015), "Contagion entrepreneurship: institutional support, strategic incoherence, and the social costs of over-entry", *Journal of Small Business Management*, Vol. 53 No. S1, pp. 5-29.

Hunt, R. and Lerner, D. (2012), "Reassessing the entrepreneurial spin-off performance advantage: a natural experiment involving a complete population", *Frontiers of Entrepreneurship Research*, Vol. 32 No. 12, p. 2.

Hunter, L. (1943), "Invention of the western steamboat", *The Journal of Economic History*, Vol. 3 No. 2, pp. 201-220.

Hunter, L. (1949), *Steamboats on the Western Rivers: An Economic and Technological History*, Courier Corporation, North Chelmsford, MA.

Kane, A.I. (2004), *The Western River Steamboat*, Texas A&M Press, College Station, TX.

Katz, R.L. (1970), *Cases and Concepts in Corporate Strategy*, Prentice Hall, New York, NY.

Ketchen, D. and Hult, G. (2007), "Bridging organization theory and supply chain management: the case of best value supply chains", *Journal of Operations Management*, Vol. 25 No. 2, pp. 573-580.

Klepper, S. (1997), "Industry life cycles", *Industrial and Corporate Change*, Vol. 6 No. 1, pp. 145-182.

Klepper, S. and Simons, K.L. (2000), "Dominance by birthright: entry of radio producers and ramifications in the television receiver industry", *Strategic Management Journal*, Vol. 21 Nos 10/11, pp. 997-1016.

Knight, G.A. and Cavusgil, S.T. (2004), "Innovation, organizational capabilities, and the born-global firm", *Journal of International Business Studies*, Vol. 35 No. 2, pp. 124-141.

Kortum, S.S. (1997), "Research, patenting, and technological change", *Econometrica: Journal of the Econometric Society*, Vol. 65 No. 6, pp. 1389-1419.

Kuran, M.S. and Tugcu, T. (2007), "A survey on emerging broadband wireless access technologies", *Computer Networks*, Vol. 51 No. 11, pp. 3013-3046.

Levinthal, D. and March, J. (1993), "The myopia of learning", *Strategic Management Journal*, Vol. 14 No. S2, pp. 95-112.

McKinion, J., Turner, S., Willers, J., Read, J., Jenkins, J. and McDade, J. (2004), "Wireless technology and satellite internet access for high-speed whole farm connectivity in precision agriculture", *Agricultural Systems*, Vol. 81 No. 3, pp. 201-212.

Machlup, F. (1946), "Marginal analysis and empirical research", *The American Economic Review*, Vol. 36 No. 4, pp. 519-554.

Mak, J. and Walton, G. (1972), "Steamboats and the productivity surge in river transportation", *The Journal of Economic History*, Vol. 32 No. 3, pp. 619-640.

Metz, C. (2000), "IP-over-satellite: internet connectivity blasts off", *IEEE Internet Computing*, Vol. 4 No. 4, pp. 84-89.

Nelson, R.R. and Winter, S.G. (2009), *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge, MA.

Niculescu, M.F. and Wu, D.J. (2014), "Economics of free under perpetual licensing: implications for the software industry", *Information Systems Research*, Vol. 25 No. 1, pp. 173-199.

Obata, H., Takeuchi, S. and Ishida, K. (2005), "A new TCP congestion control method considering adaptability over satellite internet", *25th IEEE International Conference on Distributed Computing Systems Workshops, June*, pp. 75-81.

O'Donnell, A., Gilmore, A., Cummins, D. and Carson, D. (2001), "The network construct in entrepreneurship research: a review and critique", *Management Decision*, Vol. 39 No. 9, pp. 749-760.

Ortiz-Hunt, L. (2015), "Entrepreneurial round tripping: the benefits of newness and smallness in multi-directional value creation", *Frontiers of Entrepreneurship Research*, Vol. 35 No. 11, p. 3.

Parfitt, J., Barthel, M. and Macnaughton, S. (2010), "Food waste within food supply chains: quantification and potential for change to 2050", *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol. 365 No. 1554, pp. 3065-3081.

Peeters, C. and de la Potterie, B.V.P. (2006), "Innovation strategy and the patenting behavior of firms", *Journal of Evolutionary Economics*, Vol. 16 Nos 1-2, pp. 109-135.

Penrose, E. (1959), *The Theory of the Growth of the Firm*, Blackwell & Mott Ltd, London.

Porter, M. (1996), "What is strategy?", *Harvard Business Review*, Vol. 74 No. 6, pp. 61-78.

Porter, M. (2002), "What is strategy?", in Mazzucato, M. (Ed.), *Strategy for Business: A Reader*, Sage Publishing, London, pp. 3-28.

Refsgaard, K. and Magnussen, K. (2009), "Household behaviour and attitudes with respect to recycling food waste", *Journal of Environmental Management*, Vol. 90 No. 2, pp. 760-771.

Reynolds, P. (1987), "New firms: societal contribution versus survival potential", *Journal of Business Venturing*, Vol. 2 No. 3, pp. 231-246.

Reynolds, P. and Curtin, R. (2010), *New Business Creation: An International Overview*, Vol. 27, Springer Science & Business Media, Berlin, Germany.

Ridley, M. (2015), *The Evolution of Everything: How New Ideas Emerge*, HarperCollins, New York City, NY.

Rogers, E.M. (2010), *Diffusion of Innovations*, Simon and Schuster, New York, NY.

Schumpeter, J.A. (1934), *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle* (Vol. 55), Transaction Publishers, Piscataway, NJ.

Sendall, S. and Küster, J. (2004), "Taming model round-trip engineering", *Proceedings of Workshop on Best Practices for Model-Driven Software Development*, 10, pp. 1-23.

Solow, R.M. (1957), "Technical change and the aggregate production function", *The Review of Economics and Statistics*, Vol. 39 No. 3, pp. 312-320.

Starr, J. and MacMillan, I. C. (1990), "Resource cooptation via social contracting: resource acquisition strategies for new ventures", *Strategic Management Journal*, Vol. 11 No. S1, pp. 79-92.

Stinchcombe, A. and March, J. (1965), "Social structure and organizations", *Handbook of Organizations*, pp. 142-193.

Teece, D. (1986), "Profiting from technological innovation – implications for integration, collaboration, licensing and public-policy", *Research Policy*, Vol. 15 No. 6, pp. 285-305.

Teece, D.J., Pisano, G. and Shuen, A. (1997), "Dynamic capabilities and strategic management", *Strategic Management Journal*, Vol. 18 No. 7, pp. 509-533.

Tripsas, M. and Gavetti, G. (2000), "Capabilities, cognition, and inertia: evidence from digital imaging", *Strategic Management Journal*, Vol. 21 Nos 10-11, pp. 1147-1161.

Tushman, M. and Murmann, J. (1998), "Dominant designs, technology cycles, and organization outcomes", *Academy of Management Proceedings*, Vol. 1998 No. 1, pp. A1-A33.

Tushman, M.L. and O'Reilly, C. (1996), "The ambidextrous organizations: managing evolutionary and revolutionary change", *California management review*, Vol. 38 No. 4, pp. 8-30.

Utterback, J. (1994), "Radical innovation and corporate regeneration", *Research-Technology Management*, Vol. 37 No. 4, pp. 10-20.

Zott, C., Amit, R. and Massa, L. (2011), "The business model: recent developments and future research", *Journal of Management*, Vol. 37 No. 4, pp. 1019-1042.

Further reading

Mintzberg, H., Ahlstrand, B. and Lampel, J. (2005), *Strategy Safari*, Simon and Schuster, New York, NY.

Utterback, J.M. (1996), *Mastering the Dynamics of Innovation*, Harvard Business Press, Cambridge, MA.

About the authors

Richard A. Hunt (PhD, University of Colorado at Boulder) is an Assistant Professor of Strategy and Entrepreneurship at the Colorado School of Mines. His research examines the intersection of entrepreneurship, innovation and strategy, including entrepreneurial environments, advantageous knowledge, new sector formation, modes of market entry, and early-stage operational behavior. His work has received more than a dozen awards including recognition as the outstanding doctoral dissertation of 2014 by the Academy of Management. In addition to his PhD, Dr Hunt holds degrees from Rice (BA), Harvard (MA) and Stanford (MBA). Richard Hunt is the corresponding author and can be contacted at: rahunt@mines.edu

Lauren Ortiz-Hunt studies Economics and Mathematics at the Smith College in Northampton, MA, USA. In her capacity as a Research Associate at the Center for Innovation and Entrepreneurship at Virginia Tech, Ortiz-Hunt investigated entrepreneurship and innovation in the broader context of USA and world history, including the advent of steamships on western US rivers and the development of novel business models by women entrepreneurs in the Middle East and North Africa.