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PRIMING THE PUMP: DEMAND-SIDE DRIVERS OF ENTREPRENEURIAL ACTIVITY

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Abstract

This paper employs qualitative historical artifacts and a cliometric model to analyze data spanning 97 years – from the launch of *Popular Science Monthly* magazine (1872) to the moon landing (1969) – in order to assess the ways in which society signals demand-side preferences for a greater quantity and diversity of entrepreneurship. In one of the first expansive empirical analyses highlighting societal demand for entrepreneurship, I identify demand-side signaling mechanisms that fuel increased entrepreneurial activity. Through this, my study provides compelling evidence that latent demand-side forces serve as a generative mechanism of innovation and entrepreneurship, not simply a selective mechanism.

Introduction

One of the crucial questions of entrepreneurship continues to be: Where do new firms and industries come from? As Schoonhoven and Romanelli noted, the great challenge inherent in this question is that scholars "are trying to examine something before it comes into existence" (2009: 235). How, they asked, is it possible for "researchers to measure the existence of an open environmental space before new or existing firms act to occupy it?" Prior research on entrepreneurship has addressed this issue through two very different lenses: one has focused on supply-side dynamics and the other, on demand-side dynamics (Thornton 1999). While the supply-side perspective emphasizes individual characteristics and the ways in which founders and founding teams access the mechanisms of innovation (Schoonhoven & Romanelli 2001), the demand-side perspective addresses the role of environmental context (Aldrich & Wiedenmayer 1993; Romanelli 1989), societal signals (Meyers & Marquis 1969; Schmookler 1966), and user-provocated breakthroughs (Priem, LI & Carr 2012; von Hippel 1976).

Across multiple industries comprised of well-established incumbent firms, demand-side scholarship has borne witness to the potent effects of explicit demand preferences by generations of user-customers. What is notably missing from demand-side scholarship, however, is a formulation and articulation of latent demand effects as they pertain to new firms and sectors, which I will argue in this paper, are both pervasive and powerful in determining the quantity and diversity of entrepreneurship and innovation supplied to the market. Given the diffuse and shifting nature of demand-side effects, my study employs data that are amenable to the methodological rigor of historical econometrics. The dataset used in this study spans nearly a century of commercialization of scientific knowledge in the United States, from 1872 to 1969; a time period with tectonic social shifts and epic technological changes. Consistent with the long timeframes employed by population ecologists (e.g. Hannan & Freeman 1984), diffusion scholars (e.g. Benner & Tushman 2002; Rogers 2003; Tushman & Murmann 1998), and a select group of scholars in strategy and entrepreneurship (e.g. Casson 1982; Godley & Casson 2010), this study provides a panoramic scale, but with the added benefit of not sacrificing fine-grained empirics.

In addition to offering an innovative methodological roadmap, this study makes a number of contributions to entrepreneurship scholarship. First, my findings demonstrate that latent demand-side effects can be explicitly identified. They are, contrary to extant literature (e.g. Mowery & Rosenberg 1979), readily distinguishable from supply-side effects, even in the context of new technologies. Second, I present compelling evidence that demand-pull effects generate technological innovation and entrepreneurial activity. By showing that in many cases demand-pull effects significantly precede entrepreneurial activity for a given set of emerging technologies, I reveal the ways in which society signals its latent demands for a greater quantity and diversity of entrepreneurship. Finally, my research greatly strengthens the case for considering entrepreneurship as a distinctive domain (Shane 2012; Shane & Venkatraman 2001) Efforts to comprehend and harness latent preferences for new innovations and entrepreneurial activity cannot reasonably be placed comprehensively under the purview of strategic management studies or economics. Rather, demand-pull effects related to entrepreneurship constitute a distinctive phenomenon; one that is not readily subsumed by theories addressing competitive positioning, sustainable resource and knowledge advantages, and ascents to efficient scale. Societal calls for a greater quantity and diversity of entrepreneurial activity, as well as the responses to those calls, uniquely situate the field of entrepreneurship in a distinctive theoretical and empirical domain.

In the following section, I discuss the theoretical gaps caused by the persistent focus on supply-side, technology-push drivers of innovation and entrepreneurship. Within this framework, I advance and then test a set of hypotheses predicting that demand-side forces play a key role in generating innovations, while entrepreneurial suppliers often play a key role in selecting innovations from the opportunities generated by wider market forces. Following a presentation of the results, I discuss notable implications for future research.

Theory Development and Hypotheses

Which comes first: the demand for innovations and entrepreneurship or the supply? The question is more than simply an ontological curiosity. If the supply of innovations invariably precedes demand, then clearly supply shapes and steers demand, allowing it selection privileges but not a generative capacity. If societal demands – regardless of whether they are latent or explicit – invariably precede supply, then entrepreneurs are largely "sifters and sorters," possessing selection privileges, but not generative capabilities. In all likelihood, it is some of each. That is, extant theory has largely settled on the conviction that demand and supply forces exert symbiotic, often indifferentiable influence on one another in an evolutionary process that produces technological advances (Mowery & Rosenberg 1979; Di Stefano, Gambardella & Verona 2012). In this paper I will argue that frameworks propounding a comingling, cross-fertilizing middle ground are actually tilted heavily towards supply-side perspectives. I argue further that these dominant frameworks tend to give short shrift to demand-side forces, if it is addressed at all.

Even a cursory review of entrepreneurship articles produced by scholars for the 59 leading entrepreneurship journals (Stewart & Cotton 2012) in the past twenty-five years, suggests that supply-side articles out-number demand-pull perspectives by nearly 100:1. The supply-side emphasis of most entrepreneurship scholarship occurs for very a practical reason: while it is possible to readily witness, model and analyze the supply of innovation and entrepreneurship, it is often impossible to isolate and quantify situations in which demand for innovation and entrepreneurship precedes supply. Supply-side analyses can take advantage of contemporary settings and recent data, but demand-side perspectives inherently involve highly diffuse populations for which trends may develop over a long period of time. In seeking to gain some foothold in the debate regarding supply-demand primacy, the tendency among demand-side scholars has been to focus on either differential access to resources (Astley 1985; Tushman & Anderson 1986), or the role of institutions (Aldrich & Fiol 1994; Baum & Oliver 1991; Thornton 1999) in creating environmental conditions that are conducive to entrepreneurial activity (Baumol 1990; North 1990). Each of these demand-side approaches has been heavily reliant upon anecdotal evidence, rather than statistically significant samples and longitudinal designs. The primary consequence of this is that the supply-side perspective has exerted significantly more influence in addressing the question of sector and firm origins. A recent renaissance in demand-side studies (e.g. Franke & Shah 2003; Priem et al. 2012; Ye et al. 2011) has reinvigorated the analysis of demand-pull effects; however, recent scholarship has relied upon small populations, limited time-frames and incumbent firms operating within well-established industries, thereby limiting the applicability of the demand-pull findings to contexts involving existing firms interacting with existing customers. Still unanswered is the fundamental question: Do demand–pull forces play a role in generating new innovations, firms and sectors? Given that this question purports to address *conditions that exist before the innovations, firms and sectors themselves exist*, an entirely new methodology is required, relying upon longer historical time-frames that allow for longitudinal designs and frequent, fine-grained sampling of evolving conditions.

These differing perspectives have roots in the long-standing demand-pull versus technology push debate that has occupied scholars of technological change for nearly fifty years (Dosi 1982; Freeman 1974; Mowery & Rosenberg 1979; Pavitt 1984; Rosenberg 1982; Schmookler 1966; von Hippel 1976). The technology-push approach sees innovations emerging "independent of specific customer or market needs," while the demand-pull approach sees innovations emerging as a "direct attempt to satisfy specific market needs" (Li, Priem & Verona 2012: 6). Over time, the debate was substantively resolved by a general consensus that there exists a mutual dependence between demand-pull and technology-push (Di Stefano, Gambardella & Verona 2012). Functionally, however, research emanating from the technology-pull, supply-side perspective has largely overshadowed the demand-side output in both the generation of comprehensive empirical support and the development of a strong theoretical foundation. As Mowery and Rosenberg (1979) asserted, the highly inter-related nature of demand-pull and supply-push makes it extremely difficult identify and parse out the facets of innovation that are patently a result of demand. On the other hand, the supply of innovations by entrepreneurs is readily apparent in the form of patents, product designs, new launches and new sectors. Therefore, even while the push-pull debate has been superficially settled through an acknowledgement of mutuality, the overwhelming tendency has been to side with Dosi (1982: 150), who claimed that scholars propounding the existence of demand-pull effects had failed "to produce sufficient evidence that needs expressed through market signaling" plays a demonstrable role in the generation of innovations.

The central argument of this paper is to assert that the mutual dependence approach to demand-pull and supply-push has largely failed to model and describe latent demand. This has, in turn, resulted in a pointed over-emphasis on supply-side forces of innovation and entrepreneurship, which may, as Schoonhoven and Romanelli have claimed, over-romanticized the role of the lone, swashbuckling entrepreneur (2009). The supply-side emphasis has resulted in a mutual dependence model that is severely skewed towards supply-side effects. In such a model, it has become common to consider demand forces serving as a selection mechanism of innovation and entrepreneurship, but not as a generative mechanism. In an effort to offer a counterpunctal approach that rebalances the mutual dependence model, this study aims to test the following hypotheses. First, consistent with emerging demand-side research that has thus far primarily focused on incumbent firms and existing customers (Priem et. al. 2012a, 2012b):

Hypothesis 1: Latent demand for entrepreneurial innovation often precedes supply.

If it can be demonstrated in at least some material instances that demand-pull effects precede the supply of entrepreneurial activity, then it is conceivable that demand can serve as a generative source of entrepreneurial innovation, as opposed to simply being a selective force for promising innovations developed by entrepreneurs. In these instances, both the quantity and diversity of entrepreneurial activity may be a consequence demand-side signaling:

Hypothesis 2a: Demand-pull forces are positively associated with the quantity of entrepreneurship that is supplied to the market.

Hypothesis 2b: Demand-pull forces are positively associated with the diversity of entrepreneurship that is supplied to the market.

As noted earlier, existing literature has tried to chart a middle course, asserting that supply and demand are interlocked, symbiotic and mutually dependent. Recent perspectives propounding inter-subjective mechanisms take this inter-relatedness to the fullest extent (Davidson 2001; Sarasvathy et al. 2008; York et al. 2012): "The relationships between supply and demand are circular, interactive and contingent rather than linear, unilateral and inevitable" (Sarasvathy 2004:20). Regardless of *ex post* "circular, interactive and contingent" processes, entrepreneurial activity emanating from demand-side signaling should display a validation dividend as a consequence of entrepreneurs "answering the call" of latent societal demands. By adopting a demand-side perspective, this study tests the validity of the assertion that:

Hypothesis 3: Entrepreneurial innovation that follows evidence of demand-pull preferences has a greater chance of commercial success than entrepreneurial innovation preceding evidence of demand-pull preferences.

Data and Methods

As noted from the outset, the study of demand-pull effects, especially those pertaining to new firms and sectors, has suffered for want of a viable methodological approach. While measures related to the analysis of supply-side, technology-push phenomena are plentiful and generally well documented, there are few viable mechanisms for the acquisition and analysis of demand-side effects. Recent research has made credible progress towards defining the ways in which existing companies service the explicit and latent demands of existing customers (Adner 2002; Baldwin & von Hippel 2010; Benner & Tripsas 2012; Li, Priem & Verona 2012; Priem, Li & Carr 2012; von Krough & von Hippel 2006). In this context, scholars have had good success distinguishing between demand-side and supply-side innovations, capturing the ways in which users often serve as innovators (Nambisan & Baron 2010; Priem et al. 2012). However, broadly diffuse societal preferences involving conditions that precede innovations, firms and sectors, are another matter entirely. In this period preceding the emergence of new organizational forms that is so central to the study of entrepreneurship, there has been virtually no empirical research whatsoever.

Cognizant of the many methodological impediments, I devised a study design based on nearly one hundred years of detailed historical artifacts. The study of entrepreneurship does not have a strong tradition of using historical sources, but the validation of historical techniques has significant precedent in other social sciences, including economics, sociology, political science and anthropology (Golder 2000). Using historical artifacts involving nearly a century of societal signaling, I examined the extent to which latent demand-side preferences served as verifiable drivers of innovation and entrepreneurship. To do this, I trace the migration from pure science to applied science to commercialized science. (Table 1)

In order to insure that the findings are not simply a manifestation of the specific historical source material that I employed in the analysis, I used three separate longitudinal sources of historical artifacts: (i.) *Popular Science Monthly* magazine, from 1872 to 1969; (ii.) periodicals, newsletters, club minutes, films and radio transcripts from the Science Society, from 1921 to 1969; and, (iii.) programs and news accounts from the U.S. National High School Science Fair, from 1950 to 1969. By selecting an historical span that stretches from Post-Bellum Reconstruction to the first steps on the moon, these historical artifacts form an in-depth accounting of many of the greatest scientific and technological advances in human history (Mokyr 1998).

Popular Science Monthly was first published in 1872, just seventeen years after the end of the American Civil War, "to disseminate scientific knowledge to the educated layman" (Pop Sci Aug 1872:104). In its early years, the magazine was a frequent outlet for the likes of Darwin, Spencer, Huxley, Pasteur, James, Edison, Dewey, Blackwell, Becquerel, Maxwell, Tesla, and Ramsay. The magazine has been published continuously for 140 years, generating nearly 1,700 issues, and an exhaustive chronicle of science and technology, covering 60% of the history of the United States.

The Science Service was the brainchild of publishing magnate E.W. Scripps, who started the organization in 1921 to present "unsensationalized, accurate and fascinating scientific news to the American public" (Smithsonian 2012). Although Scripps and the Science Service's newswire never fully realized its mission of enjoining editors nationwide in the mass circulation of scientific knowledge, the Service did spawn publications and clubs that left an indelible imprint on American culture (Astell 1930). In so doing, the organization produced tens of thousands of historical artifacts that are pertinent to an assessment of commercializable science. The flagship publication was the *Science Newsletter*. Virtually a complete collection of publications, films, meeting minutes and radio transcripts are available through the Smithsonian Institute Archives.

National Science Fair. Through the influence and support of Scripps, the Science Service and Westinghouse, the first nationwide science competition was held in 1942, with the intent of encouraging talented high school students to pursue a career in science. In 1950, finalists for this competition met in Philadelphia for the first national science fair. Detailed programs, extensive news accounts and data about the background, college plans and career choices are available for each year's event through the Smithsonian and the New York Public Library.

Coding. In total, 2,084 documents containing 33,720 articles and advertisements were coded for content related to pure science, applied science and commercialized science. Ten undergraduate science and engineering students were trained to perform the categorization in accordance with the rubric in Table 1. Inter-rater reliability exceeded 87% for the coding of each source and for any permutation of coders and document sources.

Innovation and Sector Data: Various measures of the quantity and diversity of entrepreneurial activity were captured through data from the U.S. Patent and Trade Office (1872 – 2012) SIC/NAICS classifications (1937 – 2012) and Dun & Bradstreet Classifications (1872 - 2012).

Dependent Variables

Applying a cliometric approach through OLS and logistic regression models, I modeled and tested the four hypotheses using three separate dependent variables: Entrepreneurial Activity – Quantity, Entrepreneurial Activity – Diversity, and Commercialization Events.

Entrepreneurial Activity – Quantity (EAQ). This continuous variable is a blended rate comprised of the total number of new patents and the total number of new business sectors emanating from a scientific discovery. Scientific discoveries were coded from historical artifacts and then traced, wherever applicable, to patenting and commercialization.

Entrepreneurial Activity – Diversity (EAD). This continuous variable is a blended rate comprised of the total number of distinct patent-holders and the numerical distance of new business sector codes (SIC/NAICS) emanating from a scientific discovery. Scientific discoveries were coded from historical artifacts and then traced to patenting and commercialization.

Commercialization Events (CE). This is a dummy variable, with 1 representing the eventual commercialization of each scientific discovery identified in the coding of the historical artifacts. Commercialization is defined as the existence of at least one revenue-generating organization for which it can be demonstrated that technology was marketed to potential customers.

Key Predictors

Sequence is a dummy variable designed to capture the demand-supply sequence. A coded value of 1 indicates that evidence of demand-pull forces in the historical artifacts of this study preceded evidence of the entrepreneurial supply of commercializable opportunities.

Demand-Pull Velocity is a relative measure of the speed with which demand-first scientific discoveries indicated through the historical artifacts of this study move from an engineering conceptualization to an actively marketed product or service (commercialized science - CS). Values ranging between 0 and 1 are calculated through the ratio: 1 / (CS Date – AS Date).

Demand-Pull Mass is a relative measure of the scale with which demand-first scientific discoveries indicated through the historical artifacts of this study. D-P Mass is determined by counting the total number of artifacts mentioning a particular scientific discovery as a conceptual starting point for applied or commercialized science. Values are greater than 0 for AS + CS.

Key Events: Three major historical events were modeled through dummy codes in order to assess and control for their respective effect on demand-side phenomena: the Great Depression, World War II and the Space Race.

Controls and Instrumental Variables. Consistent with cliometric models that aim to express the materiality and directionality of causal agents related to innovation for historical data over extended periods (e.g. Moser 2004), control variables were employed: population, GDP per capita and time sequence. Models such as the ones developed for this analysis are potentially at risk of endogeneity on two fronts: reverse causality and omitted variables. In addressing the former, I used lagged time-series variables to confirm the directionality of focal effects (Davidson & MacKinnon 1992). For the latter, I employed instrumental variables (Angrist, Imbens & Rubin 1993) that are correlated with the focal predictors of demand-side signaling but not the error term.

Models

Specifications. Logistic regression, OLS regression and significant mean differences were employed to derive and explicate the focal effects. Hypothesis 1, predicting that demand-pull effects often precede the supply of entrepreneurship was evaluated by using longitudinal mean differences of coded scientific content form each of the three sources of historical artifacts. Hypotheses 2a and 2b were analyzed using OLS methods represented by the generalized model:

$$\textit{EAQ or EAD} = \textit{Controls} + \textit{Instruments} + \textit{Demand-Pull Velocity} + \textit{Demand-Pull Mass} + \textit{Key Events} + \textit{Demand-Supply Sequence} + \varepsilon \quad (1)$$

Hypothesis 3 predicted that when demand-pull effects precede supply-side technology-push, then there existed a greater likelihood of successful commercialization. In order to test this, the dependent variable for commercialization events was modeled using both a logistic regression and a Cox Proportional Hazard (PH) regression. The logistic regression model is represented by:

$$\textit{CE} = \textit{Controls} + \textit{Instruments} + \textit{Demand-Pull Velocity} + \textit{Demand-Pull Mass} + \textit{Key Events} + \textit{Demand-Supply Sequence} + \varepsilon \quad (2)$$

The survival analysis approach employs the Cox PH regressions, where each variable is exponentiated to provide the hazard ratio for a one-unit increase in the predictor:

$$h(t) = h_0(t)\exp(b_1 X + b_0) \quad (3)$$

The equation states that the hazard of the focal event occurring at a future time t is the derivative of the probability that the event will occur in time *t*.

Results

Analysis of the findings indicates compelling support for all four hypotheses, with the statistical models supporting Hypotheses 2a, 2b and 3, exhibiting significant ($p < 0.01$) and material effects. Importantly, the findings provide significant evidence that latent societal demand for entrepreneurship is a key determinant of supply-side entrepreneurial activity. Each of the correlation coefficients reflects the directionality and materiality of the predicted relationships among the variables (Table 2).

Support for Hypothesis 1 is richly in evidence from each of the three sources of historical artifacts. Figures 1, 2 and 3, display pronounced trend lines indicating an assertive, inextricable migration from content favoring pure science to content that relegates pure science and its theory-focused aims to a subordinated role. The most dramatic change is apparent in Popular Science, where pure science content slipped from nearly 100% to 10%. Meanwhile, content related to commercialized science – articles related to products actively marketed to existing or future customers – rose to more than 50%, from 0% in 1872. Early interest in the writings of Darwin, Curie, and Spenser, evolved to a product orientation as readership demanded more focus on applications stemming from scientific breakthroughs (Table 3). Since *Popular Science* is a profit-seeking publication, it is necessary to examine whether this trend also appears in looking at the not-for-profit *Science Society News* and the National Science Fair. In both instances, the escalation in applied science content is apparent. Each of these three sources is indicative of latent societal preferences. Given the diffuse nature of societal signaling, the use of periodicals and other historical artifacts has been shown to be a valid method for evidence of demand-side effects (Golder 2000). The extent to which each of these well known, broadly representative sources chart a similar course, is evidence that society serves as a generative force as well as a selective force with respect to innovation and entrepreneurial activity.

Hypotheses 2a and 2b predicted that increases in demand-pull effects are associated with an increase in the quantity and diversity of entrepreneurial activity. Even after controlling for a wide array of macro-level effects, time-series factors and key events, the velocity and mass of demand-pull effects are shown to be significant (Table 4) predictors of both the quantity and diversity of entrepreneurial activity. This finding supports Hypotheses 2a and 2b as well as the qualitative assessment performed in regard to Hypothesis 1. Taken in total, these findings underscore the generative role of latent demand-pull forces.

Hypothesis 3 extends the examination of demand-pull and supply-push effects into a comparative context by predicting that when demand-pull forces precede supply-side, technology-push, then innovations have a greater probability of resulting in a commercialized product or service. In essence, this suggests that entrepreneurs who are attentive to contexts I which societal signaling plays a generative role, are more likely to find commercial viability for their innovations than when supply-push innovations are introduced. In order to adduce this comparison, I developed a matched set of 300 scientific discoveries that were randomly selected from two pools of coded data, one pool consisting of situations in which evidence of demand preceded supply, and one pool consisting of situations in which supply preceded demand. As indicated in Table 4 (Model 3a), Hypothesis 3 finds support; that is, primacy of demand is expected to lead to more frequent success. The predictor, *Sequence,* is highly significant ($p < .001$) in predicting the logistic model outcomes for the commercializability of each sequence. To more precisely determine the comparative effects of demand-supply sequencing, I used a hazard rate model, for which the relevant focal end-point consisted of a commercialization event. In further support of Hypothesis 3, the findings show that when demand precedes supply the effect on commercializability is positive, while the effect on commercializability is significantly negative when supply precedes demand (Table 5). The significant difference is evident in the Kaplan-Meier plot (Figure 4).

Discussion

The purpose of this paper is to examine the role of latent demand-side forces in generating entrepreneurial activity. Extant literature has largely settled on the viewpoint that both supply and demand forces are instrumental to the discovery and development of new innovations. However, this balanced framework has not resulted in balanced scholarship. By a wide margin, supply-side forces, meticulously depicting the nature and substance of innovating individuals and groups, have overshadowed demand-side research. Those studies that have elucidated demand are overwhelmingly focused on the processes of incumbent firms responding to the preferences and needs of existing customers. Largely absent from this scholarship are empirical studies that focus attention on the influence of demand forces with respect to new sectors, emerging technologies and nascent-stage firms. As a consequence of supply-side biases, new markets are often defined by the technologies and innovators that initially populate new sectors; thereby presupposing that supply-side forces serve as the primary generative mechanism of entrepreneurship, while demand-side forces serve as the primary selective mechanism. The problems with this approach are numerous, but most conspicuously, the approach errs in failing to account for latent preferences that are presented through societal signals regarding the quantity and diversity of entrepreneurship. Ameliorating this important scholarly gap requires a new set of methods and models. Responding to that need, this study uses heretofore-untapped longitudinal data in order to analyze micro-level changes over a century of market evolution. In so doing, I present important findings: demand often precedes supply; societal signaling plays a key role in determining the quantity and diversity of entrepreneurial activity; and, entrepreneurs responding to demand signals outperform those that attempt to bring to market products and services that have not been generated by society.

Limitations and Opportunities

As with all studies, design-related decisions bear both strengths and weaknesses. For this study, there two potential limitations: generalizability and endogeneity. Regarding the former, it is doubtlessly a worthy debate to assess the degree to which my historical artifacts are representative of latent societal demand. By choosing three different sources, each of which possessed a broad and deep reach into American society, it was obviously my hope to triangulate on material findings, rather than investing hope in the potential effects drawn from a single source. Further study is likely to both enhance and diminish effects discerned from these three substantial bodies of historical record. Regarding the latter concern, the risks of endogeneity are endemic to analyses involving time-series data and causal directionality. Accordingly, I performed robustness checks involving the use of instrumental variables (IV). To test for reverse causality and errors-in-variables I developed IVs for use in a two-stage least squared (TSLS) analysis, which is a preferred approach in dealing with multiple endogenous regressors and in models containing both continuous and categorical dependent variables (Bascle 2008). To test for these potential sources of endogeneity, I regressed the model predictors onto an instrumental vector containing three instruments that included: change in oil consumption, the rate of urbanization, and the change in agricultural labor. Using Staiger and Stock's (1997) procedure for first-stage F-statistics, the correlation strength was well above the Staiger-Stock threshold of 10.83, thereby providing ample support for the IV relevance.

Conclusion

On the strength of the results generated from these qualitative and cliometric analyses, this paper makes several noteworthy contributions to entrepreneurship studies. First, we provide decisive empirical tests of demand-side effects for entrepreneurial activity. This is important because prior research largely relegates demand-side dynamics to merely a contextual role. In stark contrast, our results indicate that societal demand is a key determinant and primary antecedent of entrepreneurial activity. Second, I identify and explicate potent mechanisms used to signal demand preferences related to entrepreneurship. Third, I contribute fresh methodological innovations by using cliometric models and novel historical data to illuminate elusive phenomena that challenge existing theoretical assumptions.

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Table 1: Categorization Rubric for Scientific Content of Historical Artifacts

Category	Summary Definition	Example
Pure Science	A method of inductively or deductively investigating nature through the development and establishment of information to aid understanding—prediction and perhaps explanation of phenomena in the natural world. Scientists working in this type of research don't necessarily have any ideas in mind about applications of their work.	Discovering that fluorophosphonate esters can react with acetylcholinesterase
Applied Science	Applied science is the exact science of applying knowledge from one or more natural scientific fields to practical problems. Many applied sciences can be considered forms of engineering. Applied science is important for technology development. Its use in industrial settings is usually referred to as research and development (R&D).	Developing a nerve agent.
Commercialized Science	Development of a product or service based on applied science that is offered for sale to existing or future customers.	Manufacture, market and sell agent in fulfillment of a government contract.

Table 2: Correlation Coefficients and Descriptive Statistics

	Variable	Mean	Std Dev	1	2	3	4	5	6	7	8	9
1	Commercialization	0.24	0.13									
2	Diversity of Entre	0.33	0.18	*0.19*								
3	Quantity of Entre	0.28	0.13	*0.13*	0.05							
4	Demand-Pull Velocity	0.38	0.14	*0.21*	*0.17*	*0.18*						
5	Demand-Pull Mass	0.31	0.13	*0.15*	*0.14*	*0.17*	0.08					
6	Great Depression	0.07	0.04	0.08	0.04	0.05	0.04	0.05				
7	World War II	0.09	0.06	0.07	0.03	0.04	0.08	0.04	*0.11*			
8	Space Race	0.13	0.06	0.09	*0.11*	*0.10*	*0.14*	*0.12*	-0.02	0.04		
9	Sequence (D before S)	0.50	0.22	*0.23*	*0.19*	*0.18*	*0.21*	*0.16*	0.03	0.06	0.09	
10	Macro-Control Vector	0.27	0.18	0.07	0.05	0.04	0.02	0.04	-0.03	-0.03	0.04	0.05

Italics indicate correlation with $p < .01$

Table 3: *Popular Science Monthly* - Content Examples by Era

1872	1919	1969
• The Study of Sociology • The Recent Eclipse of the Sun • Science and Immortality • The Source of Labor • Quetelet on the Science of Man • Disinfection and Disinfectants • The Unity of Human Species • The Causes of Dyspepsia • Woman and Political Power • Early Superstitions of Medicine • Prehistoric Times • The Nature of Disease • Southern Alaska • Hints on House building • Production of Stupidity in Schools	• Hello Mars, This is Earth! • Our Capital's Public waste Baskets • The Tale of Totem Pole • Insects that Sail on Raindrops • Can You Save a Drowning Man? • Why Does a Curveball Curve? • Money Making Inventions! • Improving the Intake Manifold • Squaring a Board Without a Square • The Trouble with Hooves • On the Trail of the Grizzly Bear • How Fast is Your Brain? • Keeping Paintbrush Handles Clean • A Poultry Roost that Destroys Mites • Substitute for Battery Separators	• What the Apollo 8 Moon Flight Really Did for Us. • Are We Changing Weather by Accident? • New Brakes for Your Car • The Growing Rage for Fun Cars • Canned Movies for Your TV Set • Oil Drilling City Under the Sea • It's Easy Now to Form Your Own Wrought Iron • What's New in Tools • How to Build the Microdorm • New Math Discovery? • Color from Black and White Film? • Facts About Drinking and Driving

Table 4: OLS Regression Models

	Model 2a (OLS)		**Model 2b (OLS)**		**Model 3 (Logistic)**	
Dependent Variable	**Entrepreneurial Activity - Quantity (EAQ)**		**Entrepreneurial Activity - Diversity (EAD)**		**Commercialization Event (1 = CE) (Odds Ratio)**	
Hypotheses	*Base Model*	*Increased Demand-Pull Positively Related to Increased Quantiity*	*Base Model*	*Increased Demand-Pull Positively Related to Increased Diversity*	*Base Model*	*Increased CE when Demand Precedes Supply*
Predictors						
Constant	Incl	Incl	Incl	Incl	Incl	Incl
Macro Control Vector	0.97*	0.88	1.10*	1.03	1.38*	1.29*
s.d.	*(0.19)*	*(0.22)*	*(0.34)*	*(0.30)*	*(0.40)*	*(0.38)*
Demand-Pull Velocity	1.56*	1.22*	1.31	1.2	2.20**	2.13**
s.d.	*(0.48)*	*(0.37)*	*(0.47)*	*(0.43)*	*(1.32)*	*(1.25)*
Demand-Pull - Mass	0.87	0.81	0.68	0.65	1.19*	1.18*
s.d.	*(0.21)*	*(0.20)*	*(0.14)*	*(0.14)*	*(0.56)*	*(0.56)*
Great Depression	3.01**	2.40**	2.12**	1.72*	1.49*	1.22*
s.d.	*(1.77)*	*(1.32)*	*(0.51)*	*(0.41)*	*(1.02)*	*(0.95)*
World War II	2.33**	2.17**	1.80*	1.72*	1.54*	1.36*
s.d.	*(0.82)*	*(0.61)*	*(0.55)*	*(0.52)*	*(.83)*	*(0.79)*
Space Race	1.68*	1.43*	2.04**	1.99*	2.16**	2.12**
s.d.	*(0.70)*	*(0.58)*	*(0.89)*	*(0.82)*	*(1.27)*	*(1.21)*
Demand Precedes Supply		2.85***		2.60**		3.43***
s.d.		*(1.59)*		*(1.88)*		*(2.21)*
Adjusted R^2	0.53	0.66	0.47	,58	--	--
F-value	117.4	131.2	98.8	102.1	--	--
Δ Adjusted R^2		0.13		0.11		
χ^2					342.5	412.6
Predictive Accuracy					77.00%	96.0%
N = 33,720						
Standardized Coefficients.						
*** p < 0.001, ** p < .01, * p < .05						

Table 5: Cox Proportional Hazard Model

	Demand Precedes Supply (n = 150)			Supply Precedes Demand (n = 150)		
	Probability of CE (95% CI)	*Std dev.*	*P Value*	*Probability of CE (95% CI)*	*Std dev.*	*P Value*
Variables						
Controls - Macro	1.13	0.25	< 0.01	1.03	0.15	< 0.01
Demand-Pull Velocity	1.03	0.26	0.06	0.93	0.04	0.03
Demand-Pull - Mass	1.01	0.30	0.14	0.98	0.11	0.18
Great Depression	1.02	0.40	0.11	1.00	0.05	0.01
World War II	1.04	0.32	0.05	1.01	0.02	0.01
Space Race	1.02	0.38	0.14	1.01	0.04	0.12
Demand-Supply Sequence	2.07	0.32	< 0.001	0.88	0.09	<0.001
χ^2	103.8			78.1		
P Value	< 0.001			< 0.001		

Figure 1: ***Popular Science Monthly*** **Article Content (1872 – 1969)**

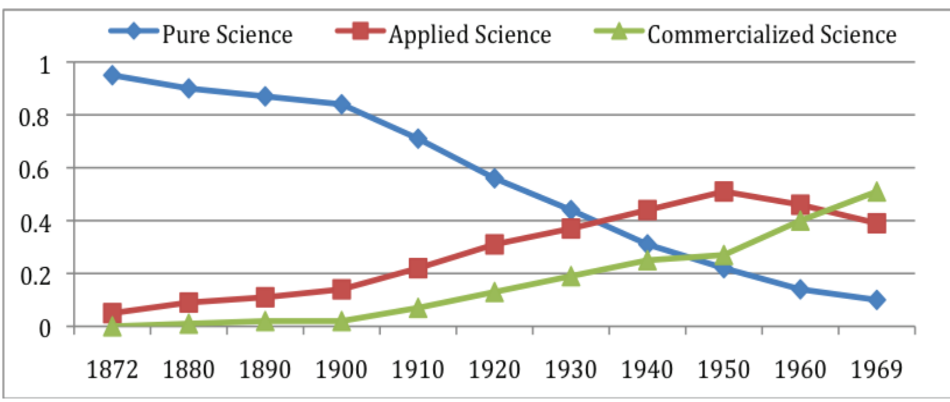

Figure 2: Science Society Newsletter Content (1921 – 1969)

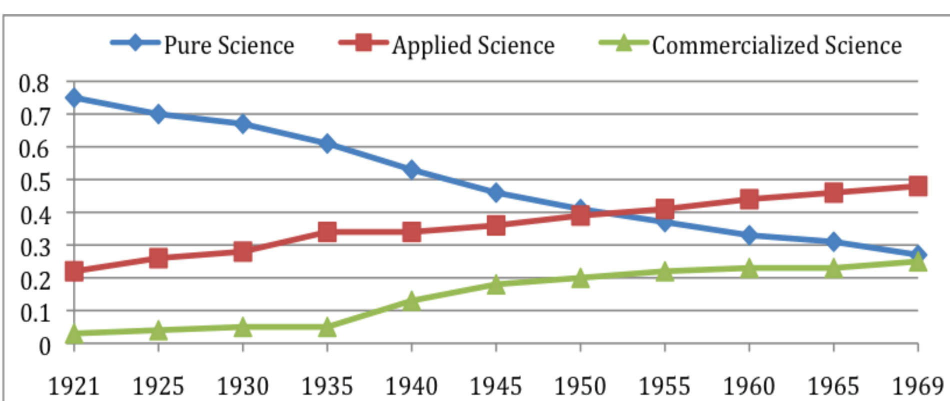

Figure 3: National Science Fair Exhibits (1950 – 1969)

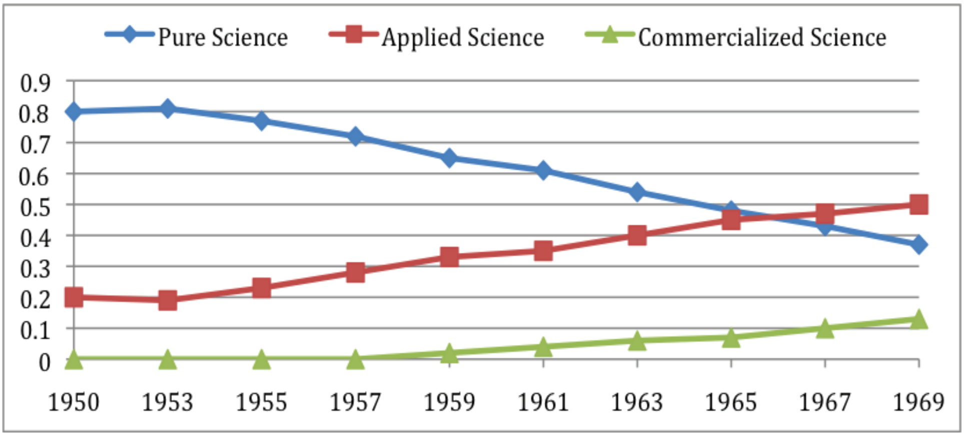

Figure 4: Kaplan-Maier Plot Based on Demand-Supply Sequencing