

12-2011

ACCELERATING INNOVATION VIA INDUSTRY-SCALE OPEN INNOVATION NETWORKS: A CASE STUDY IN THE US AUTOMOTIVE INDUSTRY

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ACCELERATING INNOVATION VIA INDUSTRY-SCALE OPEN INNOVATION
NETWORKS: A CASE STUDY IN THE
US AUTOMOTIVE INDUSTRY

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
For the Requirements for the Degree
Doctor of Philosophy
Policy Studies

by
John Norton Skardon
December 2011

Accepted by:
Dr. David Bodde, Committee Chair
Dr. Holley Ulbrich,
Dr. Adam Warber,
Dr. Robert Becker

ABSTRACT

Innovation is a key driving force of economic growth in the United States and other developed countries. A wide range of public policies seek to stimulate growth while curbing its excesses. As the rate of innovation continues to slow across many industry segments, state and federal policy makers continue to look for new ideas to stimulate growth. Between the extremes of antitrust and industrial policy lies a fertile and mostly unexplored area where government and industry may collaborate.

Industry-government collaboration so far has had mixed success. Innovations in organizational form that utilize networks to link entrepreneurs, publically funded research, and industry firms can provide a new way for policy makers to stimulate innovation. This research describes a new organizational design called an industry-scale open innovation network (OIN) that links the innovations of small firms with the systems integration, scaling, and distribution strengths of larger firms.

The heart of the OIN design is a dynamic two-sided market for innovation with a specialized intermediary called a hub firm orchestrating the deal flow. Over time, the OIN is theorized to accelerate the rate, lower the cost, and improve the effectiveness of innovation in select industries. Clemson University and the American Society of Mechanical Engineers (ASME) designed and demonstrated the anchor service for an open innovation network with the US automotive industry. This demonstration, called the *AutoVenture Forum* (AVF), marks the first time that an open-innovation service has been attempted at the industry level.

The first demonstration of the *AutoVenture Forum* was held near Detroit, Michigan on 22 September, 2010. Key findings for managing open innovation at the industry level include (a) the tiered supply industry forms the essential link between the original equipment makers like GM (OEM) and the entrepreneurs because it solves the scale-up issue; (b) supply chain innovation builds job creation; (c) a high-quality flow of deal-ready entrepreneurs is essential to attract industry participation; and (d) industry leadership will be required to establish the complete innovation network.

DEDICATION

I dedicate this research to my wife and partner of thirty one years, Mariko Skardon. Without her total support and encouragement, this work would not have been possible. I also wish to thank our children, Erin and Jennifer, for their support and encouragement.

Completion of this work would not have been possible without the support from my parents, Ben and Betsy Skardon of Clemson, South Carolina.

ACKNOWLEDGEMENTS

First, I want to acknowledge the financial support I received during this research from the Policy Studies department at Clemson University, and especially Ms Carolyn Benson and Dr. Bruce Ransom, chair of Policy Studies. I also benefitted from the support provided Dr. Robert Becker and the staff of the Strom Thurmond Institute. I also wish to thank specifically the IT department at the Strom Thurmond Institute for their timely assistance with software and network issues.

Most of all I would like to acknowledge the support, encouragement, and guidance from my committee chairman, Dr. David Bodde.

My special thanks goes out to my committee for their advice and counsel: Dr. Holley Ulbrich, Dr. Adam Warber, and Dr. Robert Becker.

In addition, I would like to thank Robert Leitner and the South Carolina Energy Institute for Energy Studies for their financial support.

My work was also generously supported by Ethan Byler and Dr. Christian Prziembel of the American Society of Mechanical Engineers.

Ms Camilla Hertwig of the Strom Thurmond Institute provided invaluable assistance during the course of this study.

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CHAPTER ONE

OPEN INNOVATION AT THE INDUSTRY SCALE

Introduction

Since the successful introduction of low cost, high quality imported vehicles into the US market in the late 1960's and the oil crises of the 1970's, the US auto industry has been subjected to an array of external stresses (Brown, Rusin, & Rakouth, 2010). Gasoline price volatility created instability in customer purchase decisions. Customers would purchase fuel efficient small cars when prices were high, yet shift back to larger, less fuel efficient vehicles when gasoline prices retreated. Regulatory interventions by the federal government and the State of California pushed vehicle makers to reduce fatalities and injuries from crashes, reduce tail pipe emissions, and improve fuel economy.

But between 1983 and 2001, the industry's more fundamental problems were masked as the US economy expanded first under Reagan and then under the Clinton administrations. The auto industry lost money in recession years but otherwise made money in most years. Underneath the veneer of profitability, there were signs of failing industry innovation. First, the industry continuously lost market share against Japanese firms at the low end of the market. In 1984, the industry lost its lead in US automotive patents issued. The gap in patents issued between foreign and domestic firms has continued to widen.

In the early 1990's, state and federal policy makers attempted to use both coercion and collaboration as incentives to move the industry away from oil dependence and toward a more sustainable form of transportation. California attempted to force the US manufacturers to build and market electric vehicles via legislation. General Motors eventually introduced the EV-1 into the California market in the late 1990's. The California mandate, along with EV-1, came to a halt in 2001 as both EV-1 leases and support for the state mandate failed after a legal challenge.

The Federal government, led by the Department of Energy, created a collaborative program in 1993 called the Partnership for Next Generation Vehicle (PNGV) with industry to pursue hydrogen technology. Despite careful oversight and substantial investment from taxpayers and industry, PNGV and its successors have not achieved the breakthrough next generation vehicle.

The final countdown for industry collapse began in 2001, as gas prices began their constant upward movement. Since 2001, the US auto sector experienced continued loss of market share and accelerating financial losses as sales of profitable trucks and SUVs declined. High pension costs negotiated in the expansion years and falling sales of the most profitable vehicles began driving the industry toward insolvency. The auto sector reached its nadir in 2009 when the federal government was asked by the industry to lead a financial bailout of all three of the top original equipment manufacturers (OEM) and provide federally guaranteed working capital loans to many of the suppliers and dealers.

This crisis also brought another major change that the industry had been unable to accomplish for many years: as part of the bankruptcy filing of General Motors and

Chrysler, the federal government allowed pension costs for retirees to be transferred to a third party trust. In addition, many unprofitable manufacturing lines and brands were shut down. After many years of confrontation between the auto sector, its unions, and the federal government, the US automotive OEMs achieved cost parity with their global competitors in a weakened and vulnerable condition but with essentially the same innovation system that had contributed to their collapse.

Towards a Better, Faster and Less Costly Innovation Process

The US auto sector faces a challenging future beyond the restructuring of 2009. Despite achieving manufacturing cost parity for the first time, the industry continues to be challenged by emerging US energy and regulatory policy, rising fuel prices, intense global competition for customers, and the emerging threat of substitution by electric vehicles. The industry must find ways to adapt to the turbulent environment and innovate more rapidly than its global competitors if it is to survive.

There are numerous barriers to faster and less expensive innovation process in the auto sector. First, the sector will continue to face regulatory requirements to reduce externalities associated with vehicle use. Since the 1960's, the industry has chosen confrontation over collaboration with regulators and policymakers on issues of public concern such as safety, pollution and fuel economy. A more collaborative approach from both government and industry could lead to more innovations reaching the market at a faster pace.

The second barrier is the industry's evolving structure; a vertical hierarchy of firms and tiered suppliers. While the traditional closed innovation process worked well until the early 1980's, it has proven to be too slow to respond to the rapid shifts in consumer preferences for more fuel efficient and environmentally friendly vehicles. While some industries have been able to work collaboratively with their supply chains, the American OEM's cost-driven negotiating strategy has been a strong disincentive for innovation from the supply chain. Now that cost pressures have been dramatically reduced via government intervention, the US firms could try to repair their relationships with their suppliers.

Third, unlike other high technology industries that thrive on the innovations from small entrepreneurial companies, the automotive sector never developed a vibrant and healthy ecosystem of spinoffs, startup companies, and venture capital to draw on for new ideas and radical innovations. The auto manufacturing market, because of its closed innovation process and the tendency to be risk averse, is a difficult market for young or early stage companies to enter. Long lead times, challenging payment schedules and extensive testing can squeeze small company cash flow to their breaking point. The path to the auto industry for the small companies is through the tiered supply chain. Should the OEM-supplier relationships become more progressive, it could create an opening for more entrepreneurial startup firms to contribute to the auto industry's resurgence.

Finally, the most challenging barrier is the auto firms' inability to capitalize on emerging technologies, with few exceptions such as the GM Onstar™ system. While often demonstrating concepts years ahead of competitors, the US auto industry often

lagged smaller and more nimble rivals. New knowledge-intensive business models are now emerging in the marketplace that leverage the convergence of semiconductors, software, and wireless communication to create value for car companies, public utilities, insurance companies, and government. Collectively known as “the connected vehicle”, these new opportunities bring information and entertainment into the automobile and allow drivers to interact with the infrastructure around them. These same technologies can also be used by regulatory agencies to collect dynamic vehicle and traffic data for use in reducing transit time and traffic jams.

The Purpose of this Research

The central question of this research is: how can industry-scale open innovation networks accelerate the rate and lower the cost of innovation across the US auto industry? One promising field of research that has had success in other industries is open innovation (OI). Open innovation theory and practice emerged in the past decade after researchers noticed that many large and prominent firms were radically altering the way research and development was being performed. Rather than relying on large internal R&D staffs and budgets, these leading companies are leveraging the knowledge of many external collaborators to develop new products and business models. The majority of existing OI research has been focused at the firm, not the industry-scale.

This research seeks to answer the research questions using an exploratory case study methodology. The case chronicles the creation and experimental testing of a new concept called open innovation networks (OINs) to investigate how open innovation

could be applied at the industry level. An experimental OIN, called the Innovation Network for Sustainable Mobility (INSuM), was developed by Clemson University researchers and tested in an event called the AutoVenture Forum (AVF) held in September, 2010. The design and execution of the forum was funded by the US Department of Energy and the American Society of Mechanical Engineers. The forum was planned with advice and support from senior managers within the auto industry.

The Public Policy Context- Industrial Policy

Industry scale open innovation networks are a possible method to bypass the historical problems associated with industrial policy discussions because they focus all stakeholders, private and public, on solving industry-framed problems. Historically, the argument of market failure vs. government failure has not lead to solutions, but to an invisible “developmental state” (Block, 2008). As the brief litany of policy and market failures highlighted at the beginning of this chapter demonstrates, there is ample blame on both sides for the collapse of the US industry in 2009. But, there is no simple answer to the question of what caused the US auto industry to collapse: was it market failure, network failure (Huggins, 2000) , or government failure? Nor is it clear from existing research into industry structure and innovation why only the US industry (both OEMs and many of the suppliers) failed, while other North American auto firms, Magna in Canada for example, seemed to weather the financial crisis intact. Further, other industries that make so-called "complex assembled products" also did not collapse.

Industry level collaboration and competition within the same network organizational form creates new questions for existing competition and intellectual property law, which are both federal policies. In addition, the success of an OIN calls into question the continued viability and purpose of existing pre-collaborative public-private collaborations, such as the US Council for Automotive Research and other organizations that have their genesis in the 1984 National Cooperative Research Act.

The concept of “innovation failure” is used in this research to describe both the cause of the problems within the industry and also suggest that a major hole exists in federal policies that ostensibly are in place to prevent such a failure. State and Federal policy needs to encourage firms to stay on the “innovation frontier”. The purpose of the OIN is to bring the cutting edge innovations from entrepreneurial startups, the “frontier”, into direct contact with the larger existing firms that can scale up the innovations. Federal support for industry R&D has its place in supporting innovation over the long run, but it will not, as the auto collapse shows, keep an industry alive or competitive.

Significance of this Research

This research has very important implications for US energy policy, job creation, regional economic development strategies, and the long term competitive strategy of manufacturing intensive sectors of the US economy. A successful *industry-scale* OIN may be able to better leverage collaborative relationships with government as demonstrated. Better relationships with government can lead to less costly and more effective ways to achieve energy and sustainable mobility goals. Job creation may be

accelerated as the large automotive firms learn to leverage and scale up innovations from small entrepreneurial companies. Industry scale OINs can leverage existing regional economic development organizations as partners and sources of new startup firms. Finally, open innovation implemented at the industry scale may be able to leverage a truly unique American asset: the tens of thousands of high technology startup companies created each year. All of America's competitors can buy the same tools, learn the same management methods, and gain access to financial leverage. But no other country, per the Acs/Szerb Global Entrepreneur Index, has the depth and breadth of both individual and institutional culture to support entrepreneurs (Acs, 2010).

Outline of the Dissertation

This introduction is followed by a literature review. The literature begins with a brief overview of the original INSuM concept. From the conceptual model that INSuM suggests, the literature review investigates five different areas of research that are relevant to open innovation implemented at the industry scale. A key focus of the literature review is the role of innovation intermediaries. The literature review closes with a summary of gaps in the existing literature and areas where a new theory can be developed. Chapter three starts with the findings from the literature review and build the outline of a qualitative theory of industry-scale open innovation networks. The theory is constructed using a series of clarifying questions about the design, organization, and operation of open innovation networks.

Chapter four is the case study of the startup and operation of the INSuM concept and its first embodiment: the AutoVenture Forum. The first section of the case study is focused on the period of 2007 to 2009: a troubling period in US economic history when the US auto industry collapsed in conjunction with the US banking crisis. The second section of the case documents the design, development and operation of the AutoVenture Forum over the period from 2009 to 2011. The case closes with an analysis of the case study data and compares the lessons learned from the AutoVenture Forum to the theory defined in chapter 3.

Chapter five analyzes the results of the case study and compares them to several different types of innovation schemes and their applicability to the auto industry. Chapter six examines the open innovation network concept from a policy perspective. Chapter seven summarizes the results of the theory building for open innovation networks, the policy analysis and recommends areas for further research.

CHAPTER TWO

LITERATURE REVIEW

An Overview of the INSuM Concept

The INSuM concept, a new type of organization, was developed by Dr. David Bodde of Clemson University over a two year period, from 2008 to 2010. The operation of INSuM was documented in a series of presentations, white papers, proposals and related documents (D. L. Bodde, 2009; D. L. Bodde, 2009). The model claims to create value by adding a complementary component to the existing innovation processes within the auto industry: an “industry-scale” network that connects the auto industry firms to the small, entrepreneurial startup companies. A complete description of the INSuM model is included in Appendices A through E.

The method for bringing the two sides, entrepreneurial firms and larger auto firms, relies on a network organization mediated by specialized intermediary firm. While the concept derives its inspiration from a wide range of business experience, teaching, and perceptions, existing research in management or organizational theory do not adequately describe or model the behavior of the proposed organization.

The concept describes the industry-scale open innovation network as having four primary economic actors: industry partners, entrepreneur partners, the INSuM organization (the “hub firm”), and federal agencies. The term “industry-scale”, as compared to firm-scale, means that all existing suppliers and OEMS in the auto industry,

some bitter rivals, are open to collaborate and compete within the network. The expected size and constitution of the network in the model is unknown. INSuM can be considered a “hub firm”, following the description given by Dhannaraj (2006). Unlike other existing networks, the primary goal of the network is to facilitate deal flow or R&D collaborations between the small entrepreneurial firms and the established industry firms.

The focus on deal flow leads to the creation of a value-added services group, managed by the hub firm, to encourage and streamline the deal flow. Services organized and brokered by the hub firm can be investment oriented or more technical support functions that are primarily targeted toward helping the startup firms better demonstrate the viability of the technology.

Numerous case studies have been published about single-firm open innovation practices. The majority of case studies are essentially firm centered- an innovation ecosystem built around a single firm. No case studies currently explore how the OI theory could be applied at a larger scale. The industry-scale focus of the INSuM, by comparison, creates the potential for a new conduit for policy makers to create public value. However, very little is known about how public policy and open innovation can or should interact (de Jong, Kalvet, & Vanhaverbeke, 2010).

Introduction to the Literature Review

The INSuM concept described above and the descriptive name used to describe its function derive some of its conceptual framework from the a priori theories and practices of open innovation, corporate venture capital, and existing innovation intermediaries. A

role for public policy is indicated but is not thoroughly explained. From the description provided in the INSuM documents, some of the existing economic, management, and organizational theories that could apply toward describing the behavior of the INSuM organization include:

- startup companies as suppliers of innovation
- suppliers as part of the innovation network,
- use of an intermediary to facilitate transactions, and
- a brokerage function.

But the INSuM concept poses many challenges and creates some opportunities that do not exist in the majority of existing research on single-firm open innovation networks or collaborative networks. These include:

- creation of two-sided market to overcome the challenges of dealing with thousands of potential small startup firms,
- both collaborators and competitors are present in the network,
- economic actors in the network are firms, not individuals,
- a focus on early stage startups as the source of innovation,
- a potentially much larger and more complex network structure,
- Third party intermediary, and
- A way for government to participate in the network

I will first review the typology, functions, and roles that hub firms are known or theorized to play as innovation intermediaries. For hub firms and their networks to be successful, they must actively work to create value for network members via

collaborations between firms. The collaborations in OINS are typically between very large and very small entrepreneurial firms. Attempts by the OIN to foster these types of asymmetric relationships can face a number of known challenges. A review the existing literature on asymmetric relationships can help inform how OINS can overcome these challenges.

OINs may be successful in some industries and unsuccessful or unnecessary in others. An extensive literature exists on industry structure and innovation. Some of these reviews have a more traditional or static view while others acknowledge the dynamic nature of competition and innovation. Many studies also point to the importance of the institutional environment that surrounds an industry in driving organizational behavior and innovation.

The final section of this chapter will review existing studies on innovation policy and how they might connect into OINS to accomplish their goals. Because OINs operate at the industry level, they potentially create an efficient conduit to channel public demands directly into the innovation process in order to create public value. The chapter will close with a summary of the key findings from the literature.

Typology of Innovation Intermediaries

Individual firms pursue outside source of innovations for many reasons. One reason is based on the heuristic that if technology change is high and the change is widely dispersed, then no single firm can keep up with all the innovations. This is the driving force behind a broad number of R&D collaborations (Powell, Koput, & Smith-Doerr,

1996). While the Powell-Koput study of biotechnology industry was influential, the conditions that prevail in the biotechnology sector may not be present in other industries. Therefore, other methods may be needed to spur innovation.

Chesbrough, the leading authority on open innovation, has taken a different approach. He has shown that firms, from low tech to high tech, can benefit by leveraging external collaborators in the R&D process. Many studies have documented benefits that have accrued to companies pursuing this strategy. He has also recommended that scholars explore open innovation at the intra-organizational level and network level (Chesbrough & Crowther, 2006), rather than just the firm level. Industry-level, as used to describe the organization under study, includes all competitors and suppliers within an industry.

Collaborative knowledge networks (CKN) are a type of innovation network that share some similarities with open innovation networks (De Maggio, Gloor, & Passiante, 2009). Dimaggio and Gloor define CKNs in the following way:

...are made up of groups of self-motivated individuals, linked by the idea of something new and exciting, and by the common goal of improving existing business practices, new products or services for which they see a real need. Their strength is related to their ability to activate creative collaboration, knowledge sharing and social networking mechanisms, affecting positively individual capabilities and organizations' performance.

There are some important differences between CKNs and OINs. The key actors in CKNs are individuals rather than corporations. There is no mention of competitive behavior in CKNs. Further, there is no mention of cost, a marketplace, or motivations of the actors other than a joint vision. However, the motivations that drive the creation of CKNs and OINs as an organizational type are similar. Both organizations appear to have evolved as a response to their institutional environment and subject to the “the complexity of political, regulatory, and technological changes” (Greenwood & Hinings, 1996).

Three further distinctions between CKNs and OINs are important. First is the concept of virtualization or online communities. Individuals in collaborative networks routinely work together in a virtual environment enabled by sophisticated communications technologies. However, some collaboration among corporations, especially in the investment field, still relies on much more traditional protocols that employ face-to-face communication. The second area is the mediating function performed by the hub firm. Second, collaborative networks may be governed more by a seniority system and operated according rules such as “respect your elders”, while the OINs are expected to be managed and operated by an intermediary or hub firm. The third difference is collaboration. Open innovation networks are highly competitive as firms search for the best deal flow while CKNs are strictly cooperative. This does not preclude incorporation of cooperative behavior among industry firms in the future.

OINs are also members of a class of organizations called information intermediaries (Chesbrough, 2007) in the existing literature. Chesbrough (2007) cites five issues facing open innovation practices that intermediaries may be able to resolve:

(a) managing and protecting identity; (b) managing contamination risk; (c) identifying useful, non obvious sources of innovation; (d) fostering a two-sided market; and (e) scaling efficiently with volume. Because OINS had not been designed as of 2006, Chesbrough's first problem of "managing identity" refers to the for-profit intermediaries, discussed later, that seek to keep the identity of larger firms hidden. In an OIN, all of the companies are aware of the other players. Contamination risk, the accidental release of proprietary information, is a concern to nearly all major companies.

Winch's review of *innovation brokers*, provides a typology that assists in comparing and contrasting the OINs in this research against other types of intermediaries that may work at the industry-scale (Winch & Courtney, 2007). The term broker in this context is derived from social network theory and describes a person or actor that links other actors together. Further, *innovation broker* is defined initially in the paper as a firm that is specifically designed to broker new ideas between innovation suppliers and users or consumers of innovation. Winch does not provide any insights into the rate or cost of innovation facilitated by these organizations nor does he analyze any interactions with public policy.

OINs do not share many characteristics of *knowledge brokers*. Knowledge brokers (Hargadon, 1998) typically are consultancies that create their own solutions to customer problems in the public or private sector. A typical firm would be a product design firm that uses its specialized knowledge to provide solutions to others but does not enter into manufacturing or marketing.

Another form is the so-called *technology broker*. Technology brokers may include a wide range of firms operating one-sided markets that seek to sell or license patents and know how. For example, most universities operate some kind of technology transfer office. The office conducts out-bound marketing efforts to find customers for university developed technology. Unlike OINS, technology brokers operate more as virtual store front and do not attempt to create a specific type of market in innovations.

OINs are also very different from so-called *co-operative technical organizations* (Winch & Courtney, 2007). These organizations can be standards societies, professional associations, or technical committees within either organization. The primary form of network behavior is collaborative and the output of the collaboration is a joint product such as a new industry standard. However, innovations usually occur prior to standardization and frequently must compete for supporters before a dominant design and subsequent standardization is established.

The formal definition of innovation broker that is finally developed (Winch & Courtney, 2007) is closer to the current conceptual definition of OINS:

An innovation broker is an organization acting as a member of a network of actors in an industrial sector that is focused neither on the generation nor the implementation of innovations, but on enabling other organizations to innovate.

However this definition has a few shortcomings. It lacks mention of a mechanism for sourcing innovations, designing an innovation marketplace that is efficient and effective, or leveraging network effects (Katz & Shapiro, 1994).

A new type of for-profit intermediary has emerged in the past decade. Typified by firms such as NineSigma™ and Innocentive™, these firms seek to develop a web-centric platform for the trade in technology and related knowledge. Terminology is again a very important discriminator in the description and functional description. This trade is primarily in knowledge, know-how or intellectual property. There is no specific mention of the brokering innovations between small companies and large companies.

Lichtenthaler and Ernst (Lichtenthaler & Ernst, 2008) note that these organizations have not been subjected to any formal economic analysis as very little data exists.

In the Lichtenthaler and Ernst qualitative study of the NineSigma and others, twenty-five different European firms were analyzed with respect to their experiences in the Internet based technology marketplaces. Of these, only two of the twenty-five were interested in further exploration. A return on the licensing firm investment was considered very low. The authors' discussion of yet2.com is telling: they find that the firm had 90,000 users and successfully brokered 10 technology transfer agreements in 2004. But Lichtenthaler cites that licensors, the potential "customers" of technology trade, were critical of Internet marketplaces as "unsystematic". This criticism suggests that many technologies were available but there *was no specific focus*. The authors' further claim that many of the technologies offered in these marketplaces were not core technologies, possibly reflecting organizational resistance to using the platforms.

The commentary infers that the licensor and licensee firms are caught in Arrows Information Paradox: if transactions are dependent upon the revealing of proprietary information, then disclosure can cause the good being exchanged to rapidly lose value,

while not enough revealing can prevent a transaction from occurring (Arrow, 1962). Chesbrough also makes this point in his discussion of open business models and problems creating a market for innovations (Chesbrough, 2007).

Functions Performed by Intermediaries

Howells (Howells, 2006) provides a comprehensive review and integrative analysis of the role of intermediaries. The key distinction made earlier between OINS and other intermediaries was that OINS attempt to create an innovation marketplace and that the marketplace follows the dynamics of two-side markets. Howells does extend Winch's classification by adding some additional types of intermediaries such as *third parties*, "*bridgers*", and *superstructure organizations*. It is his description of the functions performed in the innovation process that more definitive statements about intermediaries are found. Key functions performed by intermediaries are (a) foresight and diagnostics; (b) scanning and information process; (c) knowledge processing, generation and combination; (d) gate keeping and brokering; (e) testing, validation and training; (f) accreditation and standards; (g) regulation and arbitration; (h) intellectual property; (i) commercialization; and (j) assessment and evaluation. Most of these are descriptive enough, but none of them identify the key discriminating features of OINS.

Dhanaraj and Parkhe (2006) provide the most comprehensive theoretical treatment of intermediaries and incorporate the concepts of firm's behavior in innovation networks. A working definition of innovations networks is also provided: "they are often being viewed as loosely coupled systems of autonomous firms". The term "hub firm" is

used to describe the function of innovation intermediaries in a network. The hub firm's perspective must be the creation of value and the ability of member companies to extract value from it. Dhanaraj proposes that while interactions, called collaborations in this research, between firms are expected, it is highly likely that the hub firm can accelerate these or intentionally create barriers that make them difficult.

A framework is presented to organize and characterize the functions that the hub firms. Three major types of functions are performed by hub firms: network design, orchestration processes, and outcome. Network design functions including managing the membership in the network and managing the structure. Key processes within the network that are managed by the hub are knowledge mobility, innovation appropriability, and network stability. The most important process orchestrated in an OIN is deal flow. Collaborations facilitated by the hub firm demonstrate knowledge mobility. Firm-to-firm collaborations constitute the essence of knowledge mobility innovation networks.

It is not clear why the hub firm may be able affect the appropriability regime, especially between companies that are so different in size. In an OIN, there is strong asymmetry in the two sides of the market. Many of the large firms on one side are publicly traded or private with sales in the billions of dollars, suggesting substantial and established intellectual property regimes. The small companies may or may not have issued patents but clearly are at an extreme disadvantage in a dispute. Given that large firms voluntarily join the network and accept its formal or informal social contract, it is unlikely that they would engage in behavior that would prejudice the network against them. The essential point in Dhanaraj is that opportunistic behavior has to have a check

and balance system. Limiting opportunistic behavior is an issue of governance of the hub firm and the network.

The opportunity for the hub firm to engage in principal-agent behavior such as adverse selection, moral hazard, and opportunism is clearly present in OINs as a type of network (Jarillo, 1988). The hub firm will be in a position from the accidentally spillover of trade secrets and other proprietary knowledge from the continuous deal flow. However, like investment banks that are privy to inside firm knowledge, the OIN could quickly lose its membership if trust is not maintained within the network.

Dhanaraj further suggests that hub firms can facilitate deal flow by focusing on processes that collectively comprise an informal social contract: trust, procedural justice, and joint asset ownership. Some of these components of the social contract may be affected by high sensitivity of the members to the pricing model used in the multi-sided market.

Value Creation in OINS

Value creation in an innovation network is a process that begins with the hub firm facilitating beneficial collaborative relationships between small firms and large firms. The hub firm's recruitment, selection process, and heuristics (Åstebro & Elhedhli, 2006) helps to overcome many of the problems associated with the "informal venture capital market" (Sohl, 1999). Over time, these collaborations, fostered by the network, convert into more formal ties via contracts or equity investment. Large firms are motivated to join and participate because the network hub can create a high quality deal flow of

potential candidate small firms which reduces transactions costs associated with search and validation (Pyka, 2002) of potential investment by larger firms. The value of reducing the search costs may be substantial. More than 60,000 firms are funded annually by angel investors, while typically only 3000-4000 firms may receive venture capital.

The hub firm, when attempting organize an OIN for the first time, is immediately faced with a problem of developing an effective incentive structure to bring the two sides of the market place together. The second challenge is the nature of the market: a market for innovations can be defined using existing financial terminology as a “thin market” (Roth, 2008) , as providers of innovations and seekers of innovation may be widely dispersed, prices and valuations are highly volatile and never cross paths without some kind of intermediation. Thus, hub firms have to solve both problems simultaneously if collaboration and value creation are to occur.

Creating an innovation network from existing industry players will tend to reproduce the existing social networks that already exist (Walker, Kogut, & Shan, 1997). If a firm with extensive social capital enters the network, it may dominate inside the network also. However, social capital theory predicts that the small firms or those with limited social capital that have the most to gain (Walker et al., 1997)

The “thin market” problem has been widely studied and solved in the field of E-commerce. E-commerce terminology refers to the intermediary as the “platform” (VanHoose, 2003). Vanhoose provides four basic types of two-sided markets: (a)

matchmakers, (b) audience-making, (c) shared input market, and (d) transaction based markets. Figure 2 shows a simple schematic of a two-sided market.

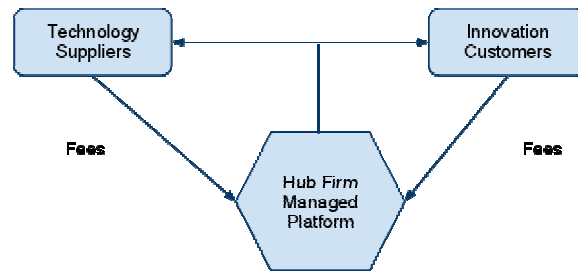


Figure 1. Basic Two-Sided Market

OINs are designed to fulfill the match-making function by helping companies find each other. In this respect, the OIN is similar more in concept to the dating club (Evans & Schmalensee, 2005) than the financial intermediaries discussed by VanHoose.

In the E-Commerce world, transactions costs are highly specific and narrowly defined. For example, the platform's major goal is enabling buyer-seller payments via an automated electronic clearing mechanism. There is no information asymmetry in the transaction. In the market for innovations, there are fewer transactions to cover the transaction costs, and many different types of knowledge goods being brokered.

Information asymmetry can be very high because none of the goods, innovations from the small startup companies, are standard or have known value ex ante. While transactions costs are often studied in innovation networks (Pyka, 2002), there is limited overlap with the E-commerce model.

Only a handful of papers have been published that study how two-sided markets are coordinated by innovation intermediaries. Lopez and Vanhaverbeke (Lopez & Vanhaverbeke, 2009) define these more specialized innovation intermediaries in the following way: “platform providers in two-sided innovation markets created to coordinate the flow of innovation requests and solutions across distinct, distant and previously unknown innovation actors”. Their insistence on the use “distinct, distant” and the requirement of “previously unknown” shows that they are primarily referring to the for-profit intermediaries mentioned earlier.

Management of Asymmetric Relationships

Dhanaraj has pointed out that a key function of the hub firm is maintaining network membership. In the industry level OIN in this research, this means fostering collaborations and relationships between very small start companies and the much larger, established industry firms. These types of collaborations between small entrepreneurial companies and larger firms can be described as asymmetric relationships (K. Blomqvist, 2002). The asymmetry refers to not only to size, but sophistication, access to resources, maturity of management team, and other attributes. Minshall et al (T. Minshall, Mortara, Elia, & Probert, 2008; T. Minshall, Mortara, Valli, & Probert, 2010) studied the problems that occur when startups and large firms attempt to collaborate and defined a linear continuum that describes how firms may proceed from informal introductions to formal relationships. These papers are useful for from a practical sense but do not address the context of collaborating within an innovation network environment.

Informal associations like OINs imply the existence of a social contract as a governance mechanism. The role of trust and contracts in asymmetric relationships was studied by Blomqvist (K. Blomqvist, Hurmelinna, & Seppänen, 2005). The author defines the general problem of initiating asymmetric relationships succinctly:

Small firms entering an asymmetric partnership often stake their reputation and future on the large partner's integrity and willingness to find win-win solutions. Large companies may not have as much to lose, and they have better chances of avoiding opportunism in that they have more resources for instituting legal actions, and they can refuse further transactions and find other partners instead.

This suggests that yet another feature of these collaborations are the "credible commitments" of the larger firms to engage in meaningful discussions with the smaller firms. Firms that can develop trust can reduce contracting costs and related transactions costs of doing business (K. Blomqvist et al., 2005). A major limitation of the paper is that it is based on a single case study of two Scandinavian firms: one large and the other small.

The previous definition is useful when describing collaboration within OINS but it does not follow that transactions costs explain why firm collaborate. A network view (Chen & Chen, 2002) of asymmetric alliances takes a different view. Strategic alliances are "a situation where two or more firms unite to pursue a set of agreed-upon goals, in which they share the benefits; and in achieving these goals, partner firms independently control over the performance of assigned tasks and contribute on a continuing basis in one or more key strategic areas".

A more dynamic and network view of firm collaboration was first offered by Granovetter (1983). According to this view, all firms are embedded in one or more networks in which they collaborate with others to create value. Chen differentiates between the static implications of the transaction cost view versus the more dynamic network view from Granovetter. However, the dataset and analysis in Chen's analysis, while extensive, is focused exclusively on the role of smaller domestic Taiwanese firms and their relationships with larger international firms.

Industry Structures and OINs

A number of studies have been published on the open innovation practices in automotive industry (Brown et al., 2010; Ili, Albers, & Miller, 2010), consumer products (Dodgson, Gann, & Salter, 2006), telecommunications (Dittrich & Duysters, 2007), and open source software (West & Gallagher, 2006) to name a few. Industry structure is especially relevant to the operation and success of OINs. The role of industry structure and its effect on innovation is sometimes associated with the emergence of dominant product design. A dominant product design can alter the structure and nature of competition and innovation within an industry (Utterback & Abernathy, 1975). The net effect on the industry is standardization (Suarez & Utterback, 1995), which shifts the industry toward price and performance-based competition. This shift toward a more stable form of competition can force small innovation firms out of the market until a major technological change or disruption starts the competitive process once again.

Other outcomes of the dominant design include a shift by the industry toward a more hierarchical and bureaucratic form (via emphasis on structure, rules, and goals) where larger firms vested in the dominant design seek to capture and control value in the supply chain (Abernathy & Utterback, 1978). This description of technological change on industry structure has strong overlap with the concept of punctuated equilibrium (Gersick, 1991) as applied to organizational theory. Theories about organizational change within the firm are shaped by how one views the process of change. Punctuated equilibrium states that organizational structure will be resistance to major change, allowing only incremental change. Revolutionary or disruptive organizational change brought on by technological change can cause sudden shifts in how firms organize. Overtime, firms adapt to this new perturbation and the tendency to allow only incremental change sets in once again.

Industries vary dramatically in their adoption of technology and their manufacturing or process methods. This research paper is primarily focused on what are called “complex assembled products” (Utterback, 1994). The opposite of the complex assembled products would be non-assembled products such as continuous processes that produce chemicals. This particular distinction has its disadvantages as the industries chosen for study by Utterback and Abernathy were primarily focused on electro-mechanical assemblies. An argument might be made that complex drugs are assembled from a set of precursors. However, drug manufacturing does not entail the large investment in manufacturing assets typical with vehicles, aircraft, or large electro-mechanical equipment.

Industry innovation may also be driven by modularity (Langlois, 1999). Product modularity utilizes standard interfaces that enable “autonomous innovation” to occur in any or all of the modules. Langlois (1992) review of stereo components and personal computer industry suggests that “innovation in a modular system can lead to vertical and horizontal disintegration, as firms can often best appropriate the rents of innovation by opening their technology to an outside network of competing and cooperating firms.” This same approach was used (Galvin & Morkel, 2001) in a study of the bicycle industry, a type of complex assembled product. In this study, the early standardization of the bicycle has led to the disintegration of the supply chain as predicted by Langlois and reduced innovations beyond the basic component level.

Open Innovation Case Studies and Empirical Data

Classification of the industries is one way to discuss the role of OI. R&D intensity, defined as the total of direct and indirect R&D expenses divided by sales, is generally accepted by the OECD and the US government as separating industries in a “low-medium-high” technology classification system (Acs & Audretsch, 1987; NSF, 2008; Peneder, 2003; Thornhill, 2006). Low technology firms have R&D intensities of less than 1%, low-medium are between 1 and 2.5 percent, medium technology firms are 2.5 to 7 % while high technology firms are considered greater than seven percent. It is not clear from the existing literature if open innovation is migrating out of the high technology segment into other segments.

Proctor and Gamble, the consumer products company, was one of the early case studies in the implementation of successful OI practices (Dodgson et al., 2006). The company has developed an innovation process known as “connect and develop” that enables the firm to work with external researchers and contributors to create innovations and solve problems for the firm. P&G operates in six NAICS codes which have R&D intensities ranging from 0.7 (Food) to 7 (chemicals). Using the OECD criteria, P&G has business units operating in all four technology sectors. Since the case presented by Dodgson does not break out OI success by sector, it is difficult to draw conclusions from this study about which line of business is benefitting most from OI practices.

Telecom firms have been studied to examine individual firm strategy. Dittrich and Duysters (2007) studied how the mobile telecom firm Nokia used a combination of “explorative and exploitive” methods to find and collaborate with external partners. The case study concluded with the following quote (Dittrich & Duysters, 2007):

This study also illustrates that Nokia effectively uses an open innovation strategy in the development of new products and services and in setting technology standards for current and future use of mobile communication applications.

Within the telecom industry, Nokia is considered a high-technology company because of the percentage of sales per net revenue that is applied to research and development, a quantity often called “R&D intensity”.

At the other extreme from Nokia but within the same industry, the German telecom giant Deutsche Telecom was profiled in a case study in 2009 (Rohrbeck, Hölzle,

& Gemünden). The authors cited existing news sources that the firm was a “dinosaur” and on “verge of extinction” in 2005. The authors further note that: “Throughout the study, various examples have been identified that documented that the open innovation instruments are applied very effectively in this corporate R&D unit”. With R&D intensity in the telecom industry of just above 1.0 or low technology, Deutsche Telekom might be a candidate for a lower technology successful implementation.

Comparing and contrasting the Nokia and Deutsche Telecom case studies shows that open innovation seems to work well at firms that have very different R&D investment strategies, even in the same industry. Thus R&D intensity may not be a defining factor of which firms or industries are better able to take advantage of open innovation. Nokia, considered high tech because of their high R&D intensity, uses OI methods throughout the firm’s product development processes. According to the authors of the Deutsche Telecom study, the larger German firm is using OI methods in a variety of business segments.

Open innovation in its current state is subject to external validity challenges (Chesbrough & Crowther, 2006; Yin, 2009). Many of the studies of OI implementation used industry leading companies, a form of selection bias, as examples of successful implementation, and nearly all examples came from the high technology industry already known for cutting edge innovation and management practices. Other critics have argued that OI is really just “old wine new bottles” (Trott & Hartmann, 2009).

Startup Companies-Suppliers of Innovations

Startup companies must be recruited for the network to operate. Because the network primarily seeks to recruit from the early stage or pre-venture capital funded ranks of companies, there is a search problem. One problem is finding qualified companies for the network is the lack of a master list or database of early staged, investor-financed firms. Another problem with finding small viable firms is the well known “Darwinian Sea” that separates early stage startups from financial and market success” (Auerswald & Branscomb, 2003). The Darwinian Sea metaphor suggests that only the strong survive, or only the most capable and adaptable firms can reach the financial security that comes with profitability and growth.

The vast majority of venture capital firm avoid early-stage investing. The void or lack of early-stage, high risk capital is filled by corporate venture capital, non-equity corporate partnerships, angel investors, matched by state and federal grants. This early-stage market is highly inefficient for three reasons (Sohl, 2007): (a) angel investors are difficult to find due to their desire for anonymity, (b) a high level of search costs for both angels seeking investments and small companies seeking angels limits the quantity of deals that can be managed by investors, and (c) there is an inadequate amount of early-stage capital.

The literature on corporate venture capital is a major pillar of the empirical support for open innovation networks. It is well known that corporate investors in small firms may invest for other reasons than just financial gain. One major driver of corporate investments (CVC) is to gain the knowledge and innovations that lie outside the firm in small companies (Dushnitsky & Lenox, 2005). Dushnitsky goes on to show in a

longitudinal study over twenty years that firms that engaged in CVC had higher levels of patenting than firms that did not use CVC.

Entrepreneurial startups are likely candidates for larger firms to acquire new innovations and knowledge. Shane (2001) demonstrates that high value technological innovations are more likely to come from new firms (startups).

Public Policy and Industry Innovation

The process of innovation has been described by a wide range of models. The one most commonly cited or implied in policy documents and congressional testimony is the linear model. The linear model explains innovation as a process that begins with investments in education and research. This leads to the creation of inventions and new ideas. New ideas are then matched with problems and opportunities by private sector firms to create new products. When new products are introduced into the market place the model stops.

Understanding the assumptions in innovation models is important to public policy as they often shape how policy makers respond to macro economic trends. There are several key assumptions that underpin the linear model. The first is that the federal government should intervene in the creation of new knowledge via research funding because the private sector will tend to underfund the more risky basic research that governments traditionally sponsor. The private sector under invests R&D because it cannot capture all of the value due to direct or unintentional spillovers. The second assumption is that the return on public R&D is extremely large, larger than even the

return on private R&D. Jones and many other have calculated the social return to R&D at a minimum of 30% (Jones & Williams, 1998). This second assumption assumes that the benefits associated with the commercial introduction and scale up of a new invention accrue domestically.

When innovation is defined using the linear model, policy makers generally have only one response to public concern over the rate of innovation: increase spending on education and R&D, the primary inputs to the process. This was clearly on display in the recent study produced by the National Academies of Science (Augustine, 2005). Yet this logic is challenged by other, more current reports that show that the amount of R&D (Jaruzelski, Dehoff, & Bordia, 2005) spending by major US corporations is no longer strongly correlated to increases in revenue. This last point also challenges one of the major assumptions, that the linear model drives the creation of public benefits.

Other studies suggest that even if the linear model does explain some of the innovation behavior, it has a fatal assumption about what happens after the innovation enters the marketplace. Grove (2010) explains that introducing a new product is not enough from a policy perspective. How and where that innovation is scaled up matters greatly. If publicly funded research is converted into new products but those products are then manufactured off shore, the linear model essentially fails to generate the expected public benefits and the US is denied the social return on the original public investment.

In the private sector, the innovation model for a single product is not considered linear, as in a simple sequence of well known processes. Some products may reach the market place via a linear model but many products follow a very different path. Von

Hippel (2007) describes user driven innovation where interaction with lead customers drives the next generation of products, not R&D. Some contemporary models describe the recursive nature of some innovations. In these models, experience with early products is used to alter existing research or development priorities and create the next generation product.

All of these existing models share a common bias. They assume that the innovations originate from inside the firm. New data and research suggests that this once dominant paradigm is beginning to change. Studies of corporate venture capital behavior indicate that many firms are actively looking outside the firm's boundaries to find complementary research and innovations that can be combined into a new product or service. Other scholars have pointed out that public-private partnerships are often formed because neither the private firm nor the government has all the resources internally to create a new invention (Stiglitz & Wallsten, 1999).

Policy makers at all levels continue to be highly motivated to encourage domestic industry innovation. Many of the existing policies are rather blunt objects and not targeted at a specific industry. Operating an open innovation network at the industry level may create a new type of "conduit" for state and federal policymakers to learn from and contribute to the success of an industry, while bypassing many of the traditional problems where agencies try to pick and choose technology winners (Dobrinsky, 2009). Dobrinsky's analysis maintains that a knowledge oriented industrial policy in contrast to traditional industry policy approaches may be a better way for the public sector to engage

with a major industry. The term *knowledge oriented industrial policy* is defined in the following way (Dobrinsky, 2009):

...to denote a new brand of public sector interventions targeting various structural aspects of the economy through transmission channels and mechanisms that hinge on the driving forces of knowledge flows and stock and incorporating a system understanding of the policy rationale.

The discussion in Dobrinsky comparing traditional industrial policy and knowledge oriented policy mirrors the larger discussion between traditional neoclassical economics and institutional economics. Of specific importance to this study is that traditional industrial policy views innovation as a linear model where the government supplies complementary investments into basic research and education at the beginning of the model. This leads, over time, to commercialization of technology or the sale of innovative new products and the introduction of new process technology. A knowledge-based view of industrial policy acknowledges the importance of networks and the “highly uncertain” nature of innovation outcomes.

De Jong et al (2010) have a more specific approach to analyze what kind of policies affect open innovation in general. The authors state that entrepreneurship, tax, research, investment, education, labor markets, and competitive (anti-trust) policies can affect the individual components of open innovation. While this is a useful categorization of the policies in use, there is no data provided that suggests that one policy is more successful than another in encouraging open innovation or any kind of innovation.

A good example of the lack of data on the effectiveness of innovation-related policies is in intellectual property. Strong appropriability regimes and their enforcement are considered essential to a broad knowledge commons and the ability of firms to earn economic rents from their patents and know-how (Teece, 2010). However, weak appropriability regimes may actually be more conducive to innovation. By comparison, zealous and uncompromising enforcement of intellectual property can lead to legal stalemates because of the limited monopoly rights given to patent holders.

There are a broad number of policies that have been enacted to encourage innovation in general. A smaller number of policy instruments have specifically targeted an industry or a specific problem within an industry. Prizes and advance market commitments (AMC) are two highly specific instruments that attempt to advance the state of art in a specific application. Kremer (2010) argues that patents are one type of award but have problems of inefficiency. Prizes are effective in focusing innovation on a single problem but there is no follow-up and the resulting innovation maybe more of a demonstration project than something that can be scaled up through the industry. Advance market commitments (AMC) are legal commitments by government to purchase a substantial number of a given product if the “prize” conditions are met. This policy should lead to greater level of commitment by the industry to scale up the innovation. The implicit assumption is that prizes and AMCs should be targeted at the industry.

Trying to spur innovation using an external mechanism can be problematic. The Progressive Automotive X-prize was a multi-year competition, hosted by a non-profit organization that ostensibly tried to spur innovation in the automotive industry by

awarding monetary prizes to firms that could break a 100 miles per gallon (equivalent) performance barrier while meeting a subset of the Federal Motor Vehicle Safety Standards (FMVSS). No US automotive OEMs or major suppliers participated in the X-Prize. Only two of the one hundred and thirty entrants into the X-Prize have made progress toward commercialization. By contrast, the two leading companies in the electric vehicle market, Tesla Motors and Fisker, have received major support from the US Government, Toyota Motors and General Motors respectively (Audretsch, Link, & Scott, 2002).

Government funded research projects primarily target specific firms through a competitive bidding process. The Small Business Innovative Research (SBIR) program is funded by appropriation of the R&D budgets for major agencies. SBIR grants have been instrumental in helping launch high technology companies (Audretsch et al., 2002; Audretsch, 2003) . Considering the sheer number of firms funded by angel investors each year (more than 60,000), the few thousand firms funded since the beginning of the SBIR program represent a small fraction of the available startup firms for a network.

Any public support for an open innovation networks may have to resolve potential conflicts with the current administrative focus on regionalism and clusters (Munro, 2010). Cluster theory is well established in the economic literature (Porter, 2008). Clusters and regional economic networks primarily seek to foster the formation of new companies. But regionalism does not have to be in conflict with the purpose of innovation networks. Using a network view, OINs would treat regional economic organizations as innovation suppliers for industry networks.

Key Findings from the Literature

The literature review clearly shows that the OIN concept is a kind of “bridging” theory that interconnects many areas of existing research. Studies of existing intermediaries are a valuable contribution to the understanding of how OINs should work. While no existing research has specifically studied “deal flow” in the context of this research, the type of deal flow in the OIN is unique and presents several challenges. Throughout the INSuM documents and the existing literature is the implicit assumption that these small, early stage firms are abundant enough and contain enough latent value to justify the existence of an OIN.

The existing literature on relationships between the US auto industry and government does not support an optimistic view about industry cooperation with government participation in the OIN. This is primarily due to the history of confrontational relations between the auto industry and government. The literature also suggests that strong government participation, as evidenced by the close relationship between the semiconductor industry and the biotechnology in industry, can be beneficial to industry. However, the bailout sought by the auto OEMs and their suppliers required extraordinary concession by the management, the unions, and the government to reach a final deal. This “near death” experience may have changed the industry permanently and put it on a more collaborative footing.

The existing literature is also very thin on key topics relevant to OINs. The economics of networks are suggested in the literature but not really tested. The preliminary results about third party intermediaries are not promising. The literature

inter-organizational collaboration does not define an OIN as used in this research. This may be due to the problem that “industry “failure”, as evidence by the collapse of the US auto industry in 2009, is unprecedented in modern US economic history.

CHAPTER THREE

RESEARCH QUESTIONS AND METHODOLOGY

The Central Question

The central question of this research is: how can industry-scale open innovation networks accelerate the rate and lower the cost of innovation across the US auto industry? This research uses an exploratory and qualitative, single case study methodology (Yin, 2009) to build a theory of industry scale open innovation networks.

Research Questions

The central question in a qualitative research study can be further focused through a series of exploratory questions about industry-scale open innovation networks, as suggested by existing qualitative research methods (Creswell, 2009). The questions are designed to probe the role of the hub firm and its relationship to other members of the proposed network, the nature of the deal flow as a value creating process, the importance of startups as the primary source of innovations, the underlying economic theory, and to better understand how public policy can or cannot be accommodated via the INSuM concept.

Open innovation networks are expected to have characteristics of both collaboration and competition. At face value, this immediately raises a concern that an OIN, as described in the INSuM project documents, may run afoul of competition

(antitrust) policy. Existing competition policy only allows industry competitors to collaborate under carefully controlled circumstances (Brooks, 1993). In the initial view of the OIN, the large firms collaborate to specify the investment focus of the deal flow process. The larger firms also compete to attract the most compelling candidate small firms into collaborations. Therefore, the OIN may be managing an innovation brokerage service. But the goods being exchanged in the marketplace do not have a clear value ex ante. Once collaboration occurs, it may be months or even years before the value of the collaboration is known ex-post. A necessary first step in determining if industry-level OINs are really a new type of organization is to compare the proposed OIN in this research to other types of collaborations that target innovation.

Q1 What are the expected differences and similarities of OINS from other types of open innovation or innovation networks?

The second question probes into the primary goal of the proposed network: creating value by facilitating collaborations between small firms and large firms. The INSuM documents assume that the larger firms, which traditionally have eschewed relationships with startups, will find value there now. But the INSuM concept does not suggest how value might be accumulated within the OIN, or how the various network members can appropriate value. For example, if General Motor's venture capital subsidiary is able to cherry pick all of the best firms or outbid other firms because of their size, this could lead to other firms exiting the network. Clearly the startup firms win in any bidding contest. The concept also claims that the OIN will be complementary to existing firm-centric innovation efforts. The documents do not describe the boundary

between the firm's participation in the OIN and their own innovation ecosystems. The boundary that is implied is via the type of firm that the OIN seeks to bring to the network: early stage startups. This is a significant boundary as these firms vastly outnumber the more prominent and well known firms that have raised significant venture capital.

The INSuM documents do not suggest that value is created solely by the amount of a transaction that was brokered by the hub firm. The source documents leave open the possibility that the two sides of the market may find different types of value in their participation. The INSuM proposal also does not rule out the possibility of a wide variety of value creation mechanisms. For example, should the number of startup companies admitted into the network gain enough size and momentum, the hub firm may be able to create a situation where multiple startups are encouraged to work together to solve more complex auto problems than a single firm could manage. In summary, there are many ways that the hub firm may create value but it is not clear which should come first or which can be monetized.

Q2 How does the hub firm create value?

The third question examines the incentives that bring together the two-sides of the proposed primary value creation mechanism: R&D collaborations between small entrepreneurial firms and the larger industry firms. Unlike existing private and public equity markets, the market managed by INSuM is about making new relationships. Consummating these types of relationships does not contain an immediate payoff for a third party investor.

The institutional arrangements that the hub firm creates to operate the market define the limits of who is considered part of the network. An explicit selection process exists for the startup firms but one is not specified for the larger industry firms. The challenge for the hub firm is that the larger OEMs bring with them their own supplier networks. Each of the companies in the supplier network brings their set of existing relationships. Ford has a major telematics partnership in place with Microsoft. Google™ also has a major investment in automotive infotainment. Likewise, Denso of Japan and Robert Bosch of Germany also sell to the US OEMs. The presence of some of these players might be an incentive for small companies to seek admission to the network but it could also cause other firms to drop out for competitive reasons.

For the network to create value for any of the large firms, the hub firm must be able to provide a *unique deal flow of small firms* that is not available through existing methods, or is too costly or time consuming to acquire. A small firm can be considered unique if the larger firms have not previously had any detailed interactions with the smaller firm.

Motivation for the early stage companies and their investors to join the networks may be driven by a multitude of factors. Keeping the small firms engaged in the network over time may be dependent on the hub firm's ability in attracting and keeping senior representatives of industry firms in the network, suggesting that some aspects of two-sided markets may be present.

Q3 What are the factors that motivate and incentivize R&D collaboration between the two sides of the network?

The literature on the economics of networks is vast. The unique model proposed by INSuM creates a problem in defining the economics of the expected deal flow. First of all, there is no real pricing mechanism described. Startups prepare their own documentation. Documentation is validated by the hub firm but no financial valuation is done on the startup company.

The older and more established method of evaluating why an inter-firm collaboration, like those described by INSuM, involves the reduction of transaction costs. A second reason is the acquisition of resources. Combining the large firm's resources with the small firm resources could create value that is larger than value of the two resources considered separately.

A third method of examining the economics of collaborations is through an analysis of risk and uncertainty. One method to value these kinds of strategic choices from the perspective of the large company is through real options. Real option reasoning, applied in this case, places a value on what the industry firm can learn through participation in the INSuM network and from collaborations initiated with the small firms. The economics of real options as applied to open innovation networks can be explained as a series of call options that are purchased by the larger firms. The call options have no expiration date but provide the option owner with a "right" to future investment.

From the perspective of the hub firm, real options also suggest a way to value the INSuM network and its operation because:

- each large firm that joins the network buys a call option to participate in the network,
- the cumulative value of the initial call options reflect the value of network membership , and
- as individual large firms begin to exercise call options on the deal flow provided by the hub firm, the value of the network should increase.

Firms that exercise their membership option can reduce uncertainty about the direction and path of technology development. Firms that engage in the collaborations with small firms from the network can teach more about a specific technology that firms that do not collaborate.

A fourth way to evaluate the economic theory at work in the OIN is drawn from so-called network effects (Katz & Shapiro, 1985). Katz and Shapiro refer to goods that increase in value with the number of economic agents consuming the good. Inferring from the INSuM model, large industry firms are expected to collaborate when defining the scope of the deal flow and then compete for whatever the hub firm brings to them. If the OIN can document a series of successful collaborations that lead to new value creation within the firm, the other large firms may become more motivated in developing collaborations.

Q4 What economic principles govern the operation of an open innovation network?

Many industry studies point out that industry structure can impact innovation and the sources of innovation (Robertson & Langlois, 1995). “Complex assembled products”

such autos, aircraft, electric machinery, process equipment, military weapon systems, and ships are integrated systems built from a network of vertically organized and dedicated suppliers (Suarez & Utterback, 1995; Utterback & Abernathy, 1975). Modular systems, such as personal computers, are built by assembling units from modules that interconnect via standard interfaces and are produced through a horizontal supply chain. Non-assembled products such as those found in biotechnology may benefit from OINS but this area has not been studied.

Finally, the industry or industry value chain appropriability regime may be the most important factor in defining the OIN concept. When large firms such as GM and Ford do not control either the upstream or downstream innovation, an opportunity should exist for small companies to enter into the market and create value.

Q5 What factors of industry structure affect the design and operation of an OIN?

Government agencies are specified in the INSuM concept as being key members of the network. Yet, it is not clear exactly how and why an agency would participate in an OIN. Traditionally, government agencies have encouraged innovation, most directly, through a variety of programs that encourage the licensing of federal technology to private firms. At the other extreme, agencies have intervened directly in the marketplace to accelerate adoption of emerging technologies in areas of national interest, such as loans made to electric vehicle makers and advanced battery companies and subsidies for the production of ethanol. Agencies may enter directly into agreements with one or more industry partners via a CRADA. In other cases, agencies may provide discretionary

funding for specific projects, such as the DOE's \$5M funding for the Automotive X-Prize technical infrastructure. Finally, the government can drive down manufacturing costs of a new vaccine by issuing a binding contract to purchase economically valuable quantities should the vaccine meet the prize requirements.

All of these previous mechanisms are based on established benefit-cost analysis (BCA) or similar methods of thinking. Applying BCA to justify agency participation is problematic for the reasons mentioned earlier. It is difficult to put a dollar value on R&D collaborations. Real options, one of the methods for valuing collaborations between industry firms, might be a better way for agencies to evaluate participation in the OIN. The Department of Energy is already an avid user of real options (Hand, 2001). Given the high levels of risk and uncertainty now present in the US auto industry, an ideal environment for real options reasoning, agency financial support and participation in an industry-scale OIN could be a low cost way to both encourage innovation and decrease uncertainty. The agency benefits by supporting the OIN financially and learns how to differentiate between real R&D problems and simple industry intransigence. If the agency learns that there are many ways to achieve social value, it needs only to encourage industry along a viable path.

The ITS or "connected car" paradigm is an example of the problem and the opportunity. Cost-benefit analysis currently does not support implementation of ITS via regulatory mandate. The social planners at the Department of Transportation could sponsor an INSuM event or series of events that focus on the generation of data needed by the DOT to implement some of the ITS goals. Sponsoring the events, a form of

buying a call option, is much less expensive than engaging in a regulatory battle with the entire auto industry or attempting to pass on the costs of a massive infrastructure project to taxpayers via higher vehicle taxes or other charges. Should OIN (the real option purchased by the agency) not produce the value that the social planners want, they can always resort to regulatory mandate.

Q6 How can government agencies create social value by participating in an OIN?

Having government agencies involved in the OIN immediately creates a potential for conflict with existing auto industry firms over governance. Regulatory agencies that act as consumer advocates such as the EPA and NHTSA could bring a chilling effect to innovation. But other agencies that have more collegial ties to the industry such as the Department of Energy, the Department of Defense, and the Department of Commerce can bring considerable subject matter expertise to the OIN. If agency staff were granted a position on a board overseeing the OIN, the agency might be tempted to push for a more public value agenda.

If the primary contribution from the public sector is government technical expertise, this will tend to benefit the small firms more than the large firms. This is simply because many of the largest auto firms have had extensive working experience with major agencies since the 1960's. The hub firm might consider brokering access to existing government initiatives that encourage the formation and growth of high technology startup companies such as "Startup America", the Small Business Administration's new loan program, or the Department of Energy's program to license

some 15,000 patents to small companies for \$1000 per patent (USGOV, 2011). It is sufficient to say that there are many possible ways that the federal government may engage with the OIN that could create social value without creating conflict or causing market distortions. But, fund raising is not the sole purpose of the OIN and would be redundant to existing efforts. Fund raising for promising small firms has traditionally been the responsibility of the firm's principals, their board of directors, local investors, and regional and state economic development organizations.

Q7 What forms of collaboration between government agencies and the OIN maximize innovation and minimize conflict?

Research Methodology

The research uses an exploratory case study to build the initial theory about industry-scale open innovation networks. Case studies are well established in theory building (Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Yin, 2009). The case study documents the design, startup and operation of an experimental open innovation network over the period of 2008 through 2011. A key part of the case study was the planning and execution of the experimental OIN's first event called The AutoVenture Forum™ held in Novi, Michigan on 22 September 2010. See appendices A, B, and C for details of the planning of the event.

The unit of study in this case is the network created by the research team at Clemson University. There are five major sub-groups or economic actors within the network: the hub firm, the large industry companies, the startups, venture and angel capital funds, and

broker/specialists. The network communicates through a variety of external networks, via information brokers, to find network members and resources.

The sampling strategy of this case study is to acquire data and documents from all those who participated or somehow influenced the formation of the network and the AutoVenture Forum (AVF) event. Design documents and discussion are documented in emails, proposals, presentation slide decks, and white papers exchanged between the INSuM team members and external organizations.

Data were collected on the startup companies that were recruited for the project. Of the twenty-nine that applied, twelve were selected to present their business plans to the auto industry. These documents provided by the applicants prior to the AVF event include executive summaries and presentations. Analysis of the executive summaries and selection of presenting companies was accomplished via a company evaluation process developed by the project team. Investment data about the companies was also acquired through search of the US Securities and Exchange Commission Form D: Notice of Exempt Security Offerings and through a variety of databases that track early stage company formation and fund-raising activity. The University of Connecticut's Center for Venture Research was approached as a collaborator but my request for background data was declined.

Data collection included two surveys of participants. After the first event, an Internet based survey using the Survey Monkey™ online survey tool were conducted of attendees. This first survey contained eight questions and was conducted 30 days after the event. The second survey was much more detailed. The survey instrument was

prepared specifically to generate data to provide answer to the research questions. The instrument was reviewed and approved by the Clemson University Internal Review Board in April 2011. The survey was then administered to the attendees from April through June of 2011. In some cases, large companies limited my ability to contact attendees to a single representative.

The most comprehensive data comes from second survey: the telephone survey of participants of the AutoVentureForum. Attendees were contacted via email or telephone to setup an interview time. Once an interview time was established, a case study protocol document was sent to the attendee via email. At the beginning of the conversation, each interviewee was advised of the rules of data collection and the steps taken to insure their privacy.

While a few interviews were done without recording, this procedure was stopped as manual transcription by phone proved inadequate. A protocol change was made to allow recording of interviews. This was approved by the University's Internal Review Board. A voice-over-IP recording software package was purchased and installed. A commercial VOIP application was used to call the attendees. Once the conversation was completed, the recording was stored on a server. At a later time, the recording was played back and the audio tracks were manually transcribed into a text document.

The primary analytical technique used to analyze the case study is the use of an organizational-level logical model (Yin, 2009). A logic model was developed within the original research on the INSuM project. The logic model can be captured in the following statements:

- The traditional closed innovation process within the auto industry is no longer competitive
- The US auto industry is under persistent external stresses and must evolve
- A method must be found both accelerate the rate lower the cost of innovation
- Small, entrepreneurial firms can provide a source of external innovation
- Open innovation networks can couple the strength of the small firms to the needs of the industry firms

The model was shared collaboratively with the auto industry's senior executives in a January 2010 meeting. As Yin states (Yin) "Evaluators also have demonstrated the benefits when logic models are developed collaboratively- that is, when evaluators and the officials implementing a program being evaluated work together to define a program's logic model". For example, the INSuM project suggests that the resulting OIN will behave according to two-side market theory. I can test the survey data for evidence that these dynamics exist. Likewise, the logic model's outcome is new, unique collaborations between a small firm and a large automotive industry partner. Evidence of this collaboration would support the logic model.

Logic models as an analytical approach can benefit by the use of rival models or explanations (op. cit.). There are several rival views about innovation in the auto industry that are helpful in testing the solution proposed in this research. First, advocates of the "linear model" of innovation focus their attention to increasing the inputs to the innovation process, principally increasing R&D spending. Some data supports this view. Another view of auto innovation is that government intervention into the market place

raises domestic industry costs and creates competitive disadvantages vis-à-vis international competitors. Reducing regulation on the industry would make the industry more competitive and more innovative. An area closer to this research claims that US auto industry OEM-supplier relationships are at the center of their innovation problems. Extensive survey data supports this view. Improving relationships between the two could solve the innovation problem by leveraging more supplier-driven innovation (Henke & Zhang, 2010). A final view is that the industry simply refuses to accommodate any notion of sustainable transportation, is tone deaf on issues of pollution or health issues, that gasoline consumption is a critical issue, or that climate change is at best, irrelevant. Proponents of this view generally argue for heavy government intervention into the marketplace (Sperling & Gordon, 2009) as these symptoms point to massive market failure.

The case study data was organized into families. Each family represents a specific sub group or economic actor within the OIN. For example, all of the entrepreneurial startup company documents are collected into a single family. The families of documents are indexed and relationally linked together using a software tool called Atlas.ti.

Using the research questions as a guide, a coding strategy was developed. Documents in the families were coded using the Atlas.ti tool. The codes represent key concepts from the theory and the research questions. The documents can then be searched for codes and groups of codes to extract content about a specific question.

The codes can also be grouped together to locate higher order concepts. This is especially useful in analyzing the recorded interviews. For example, INSuM model makes a claim that innovation markets behave more like two-sided markets. This can be tested by grouping the answers to the survey questions about two-sided markets and comparing the different views. The differing views can be used inductively to give support for the two-sided market claim.

Case Study Data Collection

Case study evidence consists of internal and public documents. The pre-AVF event data included:

- correspondence among the INSuM team members from March 2009 through July 2011,
- presentation slides given by various INSuM team members throughout the case study period,
- white papers and briefing documents published by the INSuM team,
- summary documents of meetings held with auto industry staff and others,
- copies of marketing literature used to recruit companies,
- application documents from the 29 startups that applied for the first AutoVenture Forum,
- INSuM team analysis of the 29 startup company documents,
- trip reports by team members throughout the period,
- econometric data about the industry, and

- Center for Automotive Research Annual Management Briefings.

The post-AVF event data included:

- structured survey document used in the interview process,
- initial survey response data from the October 2010 online survey,
- recordings and transcripts from the 35 interviews conducted in the April to June 2011 timeframe,
- opinions and discussions among team members and participants, and
- three academic papers published by the INSuM team at symposia and other meetings around the country about the INSuM concept and the AutoVenture Forum.

The email correspondence was used primarily to document dates of decisions, trips and meetings. The INSuM model was documented directly the original materials published at Clemson University.

Data about the number of startups companies was generated from documents published by the Angel Capital Association, the Center for Venture Research, and various state level venture capital organizations.

The analysis of the interviews generated a number of different documents in addition to the transcripts. A spreadsheet was created that contained a synthesis of data about the startups. Some of this data was extracted from transcripts and other data was collected from Internet sources. Some of the external Internet sources included the Securities and Exchange Commission (SEC) website, company websites, and databases containing published articles.

The online survey tool, SurveyMonkey™ that was used in the October 2010 survey provides details of those who answered the survey. Data from the survey were copied from the PDF report and pasted into a spreadsheet program, and the same charts were re-generated for easy incorporation into the final document.

A pre-AVF list contained 139 names of attendees. The registration documents for the AVF only showed 78 names. Numerous attendees entered the conference during the day and did not register with the ASME staff. The estimated total number of attendees at any one time was approximately 90, done by visual count. A substantial number of attendees did not or would not leave their email or telephone information. Of the 52 that did leave their information, I gained access to 35 total or 67% of the available attendees, or 44% of the registered attendees. Twenty one different companies and organizations, in addition to the startups were present. The companies represented are listed in Table 1:

Ford Motor Company	General Motors
Chrysler Motors	USCAR
BMW	Faurecia
Delphi	Robert Bosch
GM Ventures	Michelin
Connected Vehicle Trade Association	Specialty Equipment Marketing Association (Automotive aftermarket)
Intel	Hughes Telematics
Autonet Mobile	Yazaki
Visteon	Alion
Magnet	OSU
Infield Capital	Autoharvest
Automation Alley	Kauffman Foundation
TAU Engineering	Sunny Acres Engineering
Raravis/Grupo Antolin	Detroit Regional Economic Development Association
University of Michigan	

Table 1. List of Companies Attending

In some cases, a department or company had sent multiple attendees. In these organizations, I was assigned one person by the firm to respond to my request for interviews. One of these organizations provided an interview and the other sent back a written answer to the questionnaire. The latter written answers were answered with responses such as “yes”, “no”, or “I have no experience to answer this question”. The poor quality of this response was in stark comparison to many senior executives who stayed on the phone for an hour or more.

The recorded interviews totaled about 150 MB of data or 30 hours of voice recording. The interviews were transcribed using simple MP3 playback software and headphones. In numerous cases, the recordings contain echoes or garbled information. These were noted in the raw transcript files using ellipsis (...) or question marks. When the interviewee made an off-hand remark or shifted toward a passive voice, a clarifying comment or word in parenthesis was annotated via an inline text comment. Clarifying questions in the transcript would start with a “Q” and then be followed by a shorthand version of my question.

In most of the interviews, the interview departed from the survey to ask follow-up questions to pursue specific points. This became extremely valuable as the wording in the questionnaire was sometimes confusing for the interviewee. On occasion, additional examples of specific topics were provided and the interviewee was asked to comment. For example, when questions about the role of government in the OIN were asked, respondents frequently asked questions such as “can you give me an example?”

A final step in organizing the interview data was assigning alphanumeric codes to each of the interviews in order to insure privacy of the interviewee. While this technique is problematic in some types of qualitative research, the benefits to this research project were much more detailed answers to some of the exploratory questions.

Case Study Organization

The case study is organized into three sections. The beginning of the case study starts in 2007 with the US auto industry heading toward bankruptcy. Data from the US Bureau of Economic Analysis, US Census, and the US Patent Office document the key indicators of the declining rate of innovation in the domestic auto industry. Also data extracted directly from the Center for Automotive Research Annual Management Briefings in 2007 and direct quotes from the presentations from the auto industry were used to describe the predicament of the auto industry “in their own words”. This set the stage for the need for a transformative innovation process. The second section in the case study documents the startup of INSuM, which began in 2009. This section carries through to October 2010. The third section analyzes the results of the surveys. The final section identifies some key learning from the case study about the INSuM model.

CHAPTER FOUR

THE INSUM CASE STUDY

Introduction

The importance of successful innovation as a “game changing event” is well known. In 1941, the US Army Air Force entered World War II at a disadvantage: many of its planes could not climb high enough or turn fast enough to out maneuver Axis aircraft. Over a very short time, American ingenuity and manufacturing, backed by extensive Federal investment, radically improved our combat aircraft fighting capability. By 1944, US fighter planes were superior to all existing enemy aircraft (Chambers & Anderson, 1999) . Speed of innovation can also be a deciding factor and in some cases, more important than quality. In the fighter plane example, the outcome of the war would probably have been very different if US aircraft manufacturers finally delivered a superior fighter plane in 1950. The speed of innovation can lead to domination of the battlefield and often in the marketplace.

The cost of innovation is a different matter. Not all challenges faced by US industries can be approached with the single minded dedication and an unlimited budget, typical in global warfare. In business innovation, the rate and cost of innovation is affected by many different parameters such as industry structure and the presence of a dominant product paradigm. The government roles in innovation are to create and maintain the institutions that enable economic and social progress to occur together. In

the US auto industry, for example, most innovations have originated from inside the industry's research labs. These new ideas, along with the thousands of other components, must find their way through the hierarchical tiered supply chain, be integrated into a subsystem, and eventually make their way out to the customers into a fully assembled vehicle.

Innovation in the auto industry can be affected by existing and emerging regulatory requirements. New vehicle designs must be flexible enough to incorporate these requirements. Ideally, regulators would enact new or more aggressive standards to accommodate public demands, such as lower traffic fatalities or higher gas mileage. The industry would then be expected to leverage the competitive forces of the marketplace to create the most efficient solution. But regulators can also ignore competitive forces and attempt to force adoption of a specific technology.

For more than a decade, the National Highway Transportation Safety Administration (NHTSA) has pursued an Intelligent Transportation System (ITS) research agenda to make cars safer and reduce congestion. In the past, the agency had scored some major successes with the introduction of seat belts and airbags. But with ITS, the agency insisted upon its own implementation and custom radio communication system. The proposed system is complex, currently unfunded, expensive, and with many parts of the concept still undefined.

At the same time, Ford and GM, developed and have put profitable systems in place that that could be leveraged by NHTSA to achieve some of their goals. Other vehicle manufacturers have also developed proprietary in-vehicle sensor systems that

employ short range radar with rear facing cameras to warn drivers of potential dangers. Complementary system suppliers to the auto industry such as vehicle navigation companies are planning their own methods to improve safety by using their existing in-vehicle displays and networks to warn drivers of approaching dangers or traffic jams, and offer alternative routes. Still other companies avoid new on-vehicle hardware all together and simply use smart phone technology, existing pervasive cellular networks, and crowd-sourcing software to allow commuters to share traffic updates as they see them.

This brief example illustrates the nature of many of the problems between the auto industry and its regulators. The plethora of solutions reminds one of the accepted heuristic in the high technology world: there are many smart people working on these problems and most of them don't work for any one auto industry firm, or for the government. It makes sense to find a way to get the smartest people from across industry and government to collaborate on potential solutions at the industry level but leave the implementation or the "how" to the competitive forces in the private sector and ensure that consumers have a choice of different solutions to accommodate the government's desire to reduce the cost and frequency of vehicle crashes.

Open innovation, an emerging management theory, advocates that firms should take these very steps and leverage these external sources of knowledge to create new value for their customers (Chesbrough, Vanhaverbeke, & West, 2006). And, where a firm has unused technology, that technology should be marketed outside the firm to create new value in collaboration with others. These external sources of innovation can

exclude existing public or private research laboratories, universities or startup companies. Firms can also combine internal resources with external resources to create a new firm, if that pathway creates more value.

But all firms, regardless of size, are limited in their ability to find, sort and identify the most promising solutions that lie outside the firm or the industry. Social networks and existing networks of innovators can be leveraged to find these potential partners. New concepts called open innovation networks or OINs are emerging around large diverse technology firms as a kind of innovation ecosystem (Adner & Kapoor, 2010). Typically the large firm will divert some of its earnings to cultivate a private ecosystem that is designed to support or enhance the large firm's products directly or through complementary products that drive demand for core products.

But these networks suffer from a common problem: their ability to attract the best and most innovative external partners is limited by the amount of investment dollars, expertise, and management time that the focal firm can apply to managing the innovation ecosystem. The focal firm must absorb all transaction costs and manage the search for new technologies. If one or more of the small companies or research labs in its personal ecosystem fails to deliver, it can create substantial problems for new products or erode confidence in the ecosystem as a source of innovation. A kind of innovation "fatigue" may set in, putting additional pressure on the ecosystem organizers and managers (Mcgregor, 2007).

However, the search for new innovations can be separated from the ongoing maintenance of the single firm's innovation ecosystem. Major industry firms can work

together to consolidate their search processes to create a constant flow of innovative, new companies. Similar to the collaborative or “pre-competitive” research allowed by the National Cooperative Research and Production Act (1993) (NCRPA), an industry-scale open innovation network can be managed by third party intermediary to find and evaluate the promising technologies and present them to industry members.

The OIN concept in this research is similar to the NCRPA but also has some major differences, see Table 2.

Attribute	NCRPA authorized Joint Ventures	OIN
Scope	Federal Agency and Private Industry	Industry-Scale
Goal	Coordinate pre-competitive research	Create an industry scale market for innovations
Source of new ideas	Research labs at Universities, federal labs, private firms	Early Stage Startup Firms

Table 2. CRADA versus OIN

The primary goal of the OIN is to accelerate innovation across the domestic industry, where the goal of NCRPA is to coordinate and allocate research funding. Second, the OIN concept focuses on innovations: technologies that have already entered the marketplace in the form of new services or products rather than funding promising research. Third, the OIN looks for innovations primarily within the population of angel and venture capital backed startup firms. There are a large number of possible firms and innovations. In addition, these firms need a partner that can scale their innovation, a capability of the larger auto firms. Fourth, the primary work of the OIN is the constant search, validation, selection and presentation of new startup companies into the network. By viewing the OIN as a two-sided marketplace, the work of the intermediary or hub firm is to balance the incentives, costs and value so that both the large firms and the small

firms stay engaged and benefit from their participation in the network. The ongoing selection and presentation of new candidate startup companies is a type of “deal flow”, similar to the processes that exist in investment banking.

Industry-scale OINS have not been developed, implemented, or studied in the literature. Some practitioners in Europe have been experimenting with a type of industry scale innovation network. One example is the Network of Automotive Excellence (NOAE). NOAE manages innovation competitions that seek innovations from small firms. NOAE, a nonprofit, is funded by the German Federal Ministry of Economics and Technology. The ministry’s industrial investment is drawn from the eight regions of Germany and focuses the innovation effort on nine different “thematic” areas or “clusters”.

The actual role and internal organization of the proposed innovation intermediary in the proposed network is unknown. Further, it is not clear if existing theories of innovation and inter-firm organizations can model or predict the behavior of OINs. Finally, very little research has been published on early stage firms as a source of innovation for large firms. An experiment is needed to test the conceptual model developed by the research team and Clemson University.

Case Study Purpose

The purpose of this case study is to test how an industry-scale open innovation network can increase the rate and decrease the cost of innovation, while accommodating

the needs of regulatory agencies to create public value. The study focuses heavily on the role of the innovation intermediary in managing the activities of the OIN.

The auto industry was chosen as the target industry for several reasons. First, the industry size and importance to the economy makes the test important for public policy. The auto industry is the largest component of the manufacturing sector of the economy and a major consumer of many other manufactured goods and services. Next, the industry is at the center of numerous regulatory and incentive programs. OINs could become a new policy tool if it can be demonstrated that government policy goals can be addressed collaboratively. Finally, the industry has extensive experience with many types of joint ventures and a major public-private partnership. The industry's participation in the project can provide additional insight into how the OIN, as an organizational form, compares to other types of collaborative inter-organizational alliances.

The case analyzes the origins, design and execution of an experimental open innovation network. The organization, called the Innovation Network for Sustainable Mobility or INSuM, was funded by a grant from the United States Department of Energy, the American Society of Mechanical Engineers, Clemson University, and benefitted from the full cooperation of the United State auto industry and their major suppliers.

The US Auto Industry in 2007

The University of Michigan's Center for Automotive Research (CAR) has been hosting its annual management briefing seminars for the auto industry for the past forty-

five years (CAR, 2011). The content of the week-long series of briefings reflect many of the contemporary issues facing the auto industry. In 2007, the auto industry was rapidly heading into a financial crisis, gasoline prices hit their all time high mark, and it appeared that bankruptcy of General Motors and others was a possibility in the near future. A now prophetic session called “Innovate or Die” was included in the weeklong agenda.

Hosted by CAR’s David Cole and Richard Gerth, the introduction to the session had this to say about the importance of innovation:

With the dramatic rise of low labor countries, organizations in high labor countries must develop strategies that prevent their products from becoming commodities. Strategies based on improving time and reducing costs, while necessary, are not sufficient; new strategies must be based on innovation. Innovation should exist in all areas of an organization ranging from products, services, manufacturing processes, and strategies to business models and organizational processes. Further, the knowledge that is driving innovation, while growing at an exponential rate, is not being implemented as fast as it is being generated, creating an increasingly large implementation gap.

The “gap” metaphor implies that there is abundant knowledge in the marketplace for the auto companies to access but the industry must look at new business models and the entire value chain to identify where the new value can be best used. These observations are entirely consistent with the theory of open innovation.

The organizers of the “Innovate or Die” session were on point. Since 2001, the auto sector had experienced a continued loss of market share and a string of financial losses as shown as shown in figure 3.

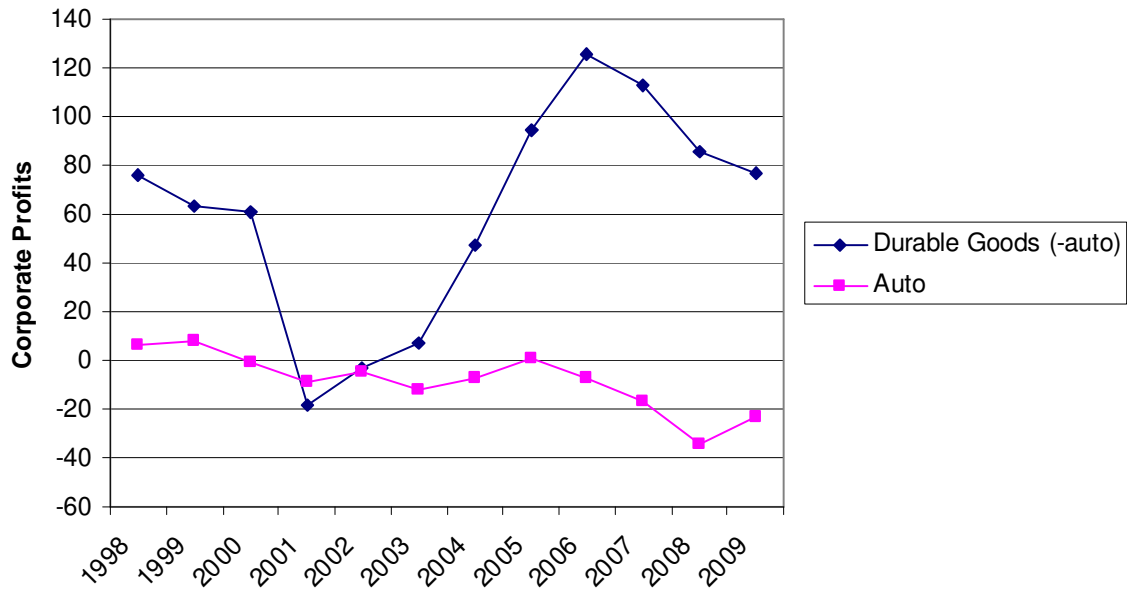


Figure 2. Automotive Sector vs. Durable Goods Profits

Employment over the same period dropped rapidly beginning in 2005 as shown in figure 4.

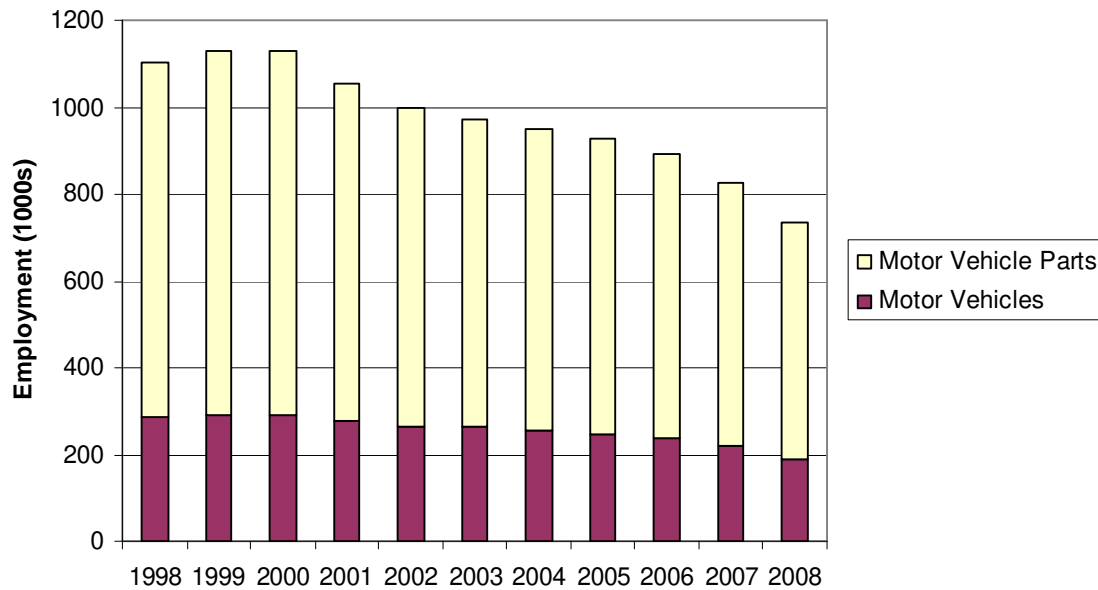


Figure 3. Employment in the US Auto Industry

As gas prices rose to record levels, customers switched their purchases away from the highly profitable SUVs and minivans to more fuel efficient vehicles, usually imports. Combined with high pension costs and falling sales of the most profitable vehicles, the industry began a descent toward insolvency.

The auto sector finally reached its nadir in 2009 when the federal government had to lead a risky financial bailout of all three of the top US original equipment manufacturers (OEM) and provide federally guaranteed working capital loans to many of the suppliers and dealers (Webel, 2011). The crisis also brought another major change that the industry had been unable to accomplish for many years: as part of the bankruptcy filing of General Motors and Chrysler, pension costs were transferred to a third party trust and many unprofitable manufacturing lines and brands were shut down.

After many years of confrontation between the auto sector, its unions, and the federal government, the OEMs reached cost parity with their global competitors (McAlinden, 2010). In less than a decade, the largest manufacturing segment of the US economy had transitioned from profitable to completely incapacitated.

Formation of the AutoVenture Forum

In March 2009, while the auto industry was going through the bailout process, researchers at Clemson University proposed a radical concept to revitalize innovation in the auto industry (D. L. Bodde, 2009). The paper advocated the creation of an open innovation network that brings a previously under-utilized source of innovation to the auto industry: high tech startup companies. The project received initial funding from the US Department of Energy. The lead investigator on the project, Dr. David Bodde of Clemson University, was well known to the US auto industry. Dr. Bodde had served on the National Academy of Sciences team that conducted annual reviews of the CRADA between the US DoE and auto industry called FreedomCAR and Fuels Partnership.

The INSuM white paper led to a series of meetings with senior executives in the auto industry including the US Council for Automotive Research (USCAR) during second quarter 2009. Because industry-scale open innovation networks were an untested and unknown concept at the time, the auto industry and the Department of Energy suggested that the Clemson team conduct a first test of the concept prior to engaging in longer term collaboration.

In June 2009, the lead investigator was encouraged to approach the American Society of Mechanical Engineers senior management as a possible sponsor for the

project. ASME had been investigating new ideas for innovation through their Breakthrough Innovation Fund. The proposal from Clemson University was evaluated and selected for funding. The project funding also included logistical support from ASME and assignment of a senior staff member to support the project.

The ASME link brought several advantages. First, ASME has more 120,000 members, including many in the automotive industry (ASME, 2011). Second, their location in Washington, DC provides easy access to federal policy makers and other organizations involved with innovation policy. Third, the ASME executive proved to be invaluable in all areas of organizing and managing the first investment event.

At Clemson University, a cross disciplinary team consisting of Dr. Bodde, one doctoral student, a senior staff member of ASME, and staff from the South Carolina Institute of Energy Studies (SCIES) was formed in 2009 to begin project planning and startup. The starting point of the project was a white paper written by the lead investigator (D. L. Bodde, 2009). The paper introduced the concept of the AutoVenture Forum (AVF): a type of networking and collaboration event to test the central concepts in the INSuM project. The introduction of the paper succinctly defines the scope and intent of the research effort:

We propose a fundamentally different innovation process for the transition to sustainable mobility—an open-source innovation network that would enable collaboration among entrepreneurs, corporate innovators, technologists, investors, and customers independent of their location. The network could speed the sustainability transition by connecting the innovative capacity of entrepreneurs

with the systems integration, manufacturing, and market channels of the industry incumbents.

One of the most challenging aspects of the proposal was the source of new innovation: fast growing startup companies. The existing auto industry, based on the internal combustion engine, has traditionally not been an attractive partner for new startups for numerous reasons: (a) the industry is generally a “late adopter” of new technologies (Gassmann, Enkel, & Chesbrough, 2010), (b) the industry had developed a reputation of sourcing its innovations from its own research labs and engineers (Gassmann et al., 2010), (c) lead times between design wins and first production orders can be years apart, and (d) safety and performance validation of new components is costly and time consuming. Finally, the auto industry historically has swapped or cross license patents rather than acquire patents from outside the industry (Merges, 1999) (W. M. Cohen, Nelson, & Walsh, 2000).

The term “sustainable mobility”, a prominent concept within the model, was further defined in the white paper as:

We use the term “sustainable mobility” to include three essential goals: (a) improving national and economic security by depending less on oil, (b) reducing the environmental footprint of road transportation, and (c) building an economic and profitable auto sector with the help of more agile innovation processes.

This particular definition of sustainable mobility is written using a private sector perspective. This definition also lacks any mention of two other major externalities from surface transport: the medical cost of traffic crashes and the lost productivity due to traffic congestion.

This perspective also assumes that public sustainability goals can be achieved primarily through product and process innovation in the private sector. However, the auto industry history shows that this is not always the case. The industry has traditionally fought against all types of safety, emissions, and fuel economy regulations (Sperling & Gordon, 2009), despite the remarkable success of emissions and safety regulations. Yet, at the same time, the industry has maintained a cooperative research and development agreement with the Department of Energy for eighteen years to pursue advanced technologies for fuel cells and batteries, to name a few.

The sustainable mobility claims of the INSuM team generated a challenging problem. Given the history of confrontation between the industry and government, the organizational form, and the unique pairing of large companies and startup companies to drive the innovation engine within the model, how then can government become a partner in innovation rather than an opponent? If the well documented battles over corporate average fuel economy regulation and other major policy conflicts cited by Sperling were any indication, it would seem government was going to turn a blind eye toward industry innovation driven solutions and exercise regulatory authority to get what it wanted.

The INSuM Model

Design of the network began in Q2 2009. The features of the initial network design are shown in Figure 3 (D. L. Bodde, Skardon, & Byler, 2011). The model portrays INSuM as the central hub firm that coordinates industry partners, federal agencies, entrepreneurial companies and partners, and external service providers. The primary operational goal of the network is to create unique and high value deal flow of early stage companies to the industry firms.

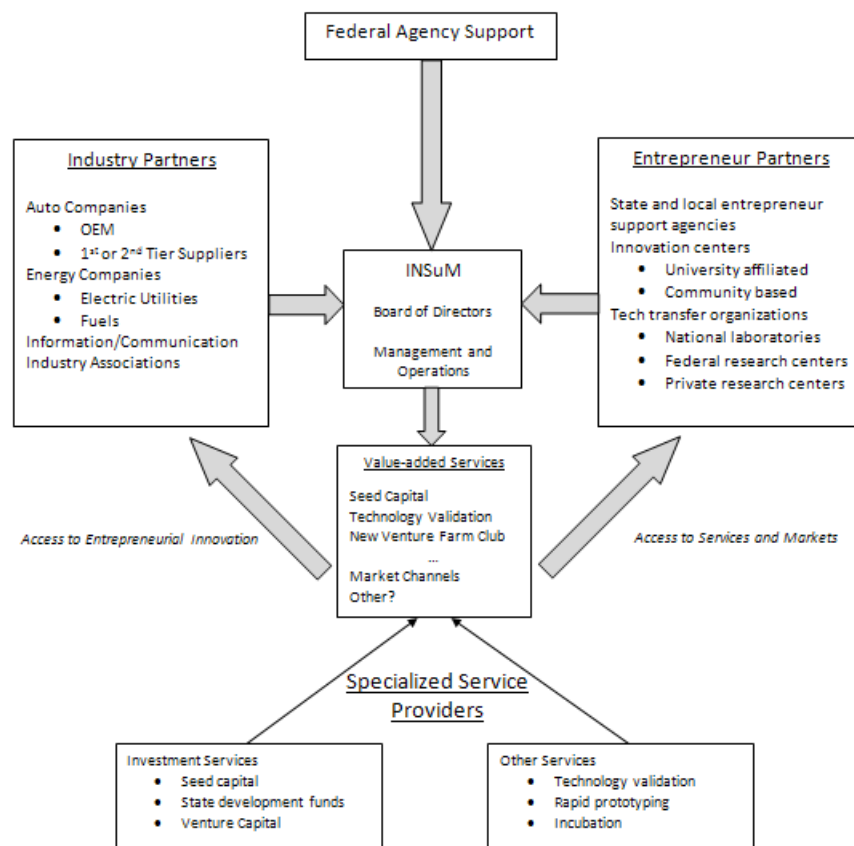


Figure 4. The Original INSuM Model

The model proposed that value and service are created for each “side” of the market via deal flow or collaborations between startups recruited by the entrepreneur partners and the existing industry firms. The primary deal flow events would be

quarterly forums where INSuM would work with industry to identify key needs. INSuM would use this list of needs to solicit, evaluate and select 8-12 candidate companies to present to the assembled group of industry companies.

The attraction for entrepreneurs and their companies to attend the event was the opportunity to present their company to the senior managers from several major industry companies at a single time. Collaboration with a major firm could be a prelude to investment and possible profitable exit for investors. Therefore the startup companies had much to gain from participation and very little to lose.

From the industry perspective, the two-sided nature of this “innovation marketplace” created some challenges. Bringing in the major OEMs and suppliers into a two-sided marketplace also brings in the industry’s competitive structure and its institutional values, norms and beliefs. To execute on the INSuM model, the individual industry players would need to accept both a collaborative and competitive role in the network. The collaborative role had already been established when the INSuM chose to approach USCAR for guidance. The competitive role would start once engagement with the startups was initiated by the INSuM team. From meeting summaries and discussions with team members, the informal expectations were that ex post, future events would primarily be paid for by the larger firms. Thus, the larger firms would be subsidizing the recruitment of the smaller firms. This dictated that the most important network task would be to gain the commitment of the major industry firms to attend the conference in good faith. Once the major firms had committed, their commitment could be leveraged to motivate the startup companies to apply.

Another issue facing INSuM was the use of the OIN as the organizational form. Previous industry-scale collaborations such as FreedomCar had been unsuccessful in preventing bankruptcy of the industry or driving innovation. The traditional closed innovation process of the major firms had also been unable to satisfy customers and fend off foreign competition. The INSuM concept implied that the auto industry needed to look outside its traditional organizational and institutional boundaries to find the innovations needed to survive. This view was consistent with Langois and Robertson (Langois & Robertson, 1995) :

We argue that the choice of an organizational form suitable for a particular context depends, among other things, on the nature of the innovation, the uses to which it will be put, and the existing distribution of available capabilities in the economy, including sources of information. Because of the variety of possible forms and the importance of on-the-spot knowledge, the choice among organizational forms should not be tightly constrained by government policy but should be left to firms to adopt the arrangements that best suit their individual circumstances.

More flexibility by government regulators to achieve their goals is also needed. The government's preferred method of encouraging commercialization of public research, cooperative research and development agreements (CRADAs) created by the Federal Technology Transfer Act (1986), may need to give way to more flexible and less costly methods such as prizes and advance market commitments (Kalil, 2006). Prizes could be integrated into the operation of the OIN. The INSuM proposal sees the Federal Government as a partner in innovation, not an opponent, but that view may not be shared

by the industry participants in the OIN. The challenge for the INSuM team is to find the right set of institutional incentives that can motivate industry and government to collaborate while enabling an increase in deal flow in the proposed innovation network. The implied contractual relationship between the OIN participants and the hub firm indicates the possibility of principal-agent issues as discussed in Chapter 2.

Gaining Entrepreneurial Partner Participation

The source of innovation in the INSUM model are the many startup and early stage companies that are funded by angel investors each year. But there are several problems with finding and recruiting these companies: (a) the geographical distribution of these companies has not been studied at this level of detail, (b) the small company's willingness to establish affiliations with Internet accessible databases is unknown, and (c) there is no comprehensive search engine that can identify these early stage startups. The Securities and Exchange Commission does track private investment. Private companies are required file a Form D for any investment over \$1M. Form D filings can be searched electronically from the SEC (SEC, 2011) and other fee-based search engines. However, the average angel investment is typically less than this amount.

The INSuM solution was to develop a channel to the entrepreneurial companies via three groups of organizations that are normally involved with funding and supporting entrepreneurial startup companies. The first group includes the local, state, and regional economic development networks that actively work to encourage startup formation and growth. The second group consists of the angel capital associations or investor networks that provide the early stage funding. The third group of channel partners are the

technology transfer organizations that are common to all federal research labs and most research universities. The technology transfer offices are primarily a source of spinouts: new companies that have licensed technologies from the laboratory or the university.

Angel investors dominate the funding for startups and early stage deal flow. Approximately 60,000 startups and early stage ventures are funded each year (ACA, 2010) while technology transfer spinout companies are estimated at 500 companies a year (AUTM, 2010). Angel investors provide more 95% of early stage funding with venture capital firms funding the remaining 5%.

The INSuM team believed that expending time and effort on developing relationships with these organizations could develop into a low transaction cost method for finding and recruiting new startup companies for the network. However, to get the voluntary support of these diverse organizations, the INSuM team would have to demonstrate that the industry-scale innovation network approach could create novel collaborations between the auto industry and the entrepreneurial startups.

Gaining Industry Participation

Building a marketplace like INSuM requires a careful balance of incentives, value propositions and pricing. Because the network operates at the industry-scale, fierce industry competitors will be “in the same” room with the small startup companies, along with government representatives. The hub firm, the organization that embodies the INSuM concept, must accommodate both sides of the market and gain participation. The Federal government, as a partner, creates a unique challenge as it does not participate in

any deal making but could provide incentives, intellectual property, and access to resources that can enable some of the collaborations to complete. Unfortunately, government agencies that might contribute funding to the network could also be very disruptive and destroy the innovative culture within the network by attempting to use the network as a way to create or push a specific flavor of industrial policy. A current example of government agencies pushing policy over innovation is the Intelligent Transportation System (ITS) intent to issue rule making in 2013 to require automakers to install a government designed radio into each vehicle to transmit and receive traffic data.

Gaining initial industry support and participation for the INSuM innovation network was made easier because of the existence of USCAR. By approaching USCAR first, the INSuM team was able to reach senior thought leaders in the industry quickly. This access was facilitated by the lead investigator's prior working relationship. This use of social capital is a key point in the successful startup of the new network. Had the team not had this prior relationship, the ability to gain support may have been more time consuming and less effective.

Governance and oversight of the hub firm was planned to include major participants from the industry and other stakeholders. An informal governance council was created in Q4 2009 that included representatives from USCAR, the venture capital community, and automotive OEMs and the Tier 1 suppliers. INSuM staff worked with the governance council to shape and narrow the focus of the first investment event, subsequently called the AutoVenture Forum. By the end of Q4 2009, the INSuM team

had gained the support of the industry and USCAR for the first event. Planning for the event began in earnest.

Gaining Government Support

Government support was already in place for exploring innovation in an award made to the South Carolina Institute for Energy Studies, the organization that managed the INSuM project as part of a larger Department of Energy grant. The original award, made in 2008 was to fund a hydrogen fueling station study. INSuM was partially an outgrowth of the 2008 award. However in 2009, the incoming Secretary of Energy dramatically reduced the priority and funding for hydrogen related transportation, citing many unsolved challenges (Blanco, 2009). To some degree, this left the project a bit stranded. The principal investigator and the lead investigator contacted the program manager at the Department of Energy and gained their approval to focus part of the grant more generically on the problem of innovation.

The more serious challenge to the continuation of the INSuM project was the absence of a major incentive for the Department of Energy or the Department of Transportation's Intelligent Transportation System (ITS) Initiative to become involved or express their interest in the formation of the network as a possible new conduit for policy. Part of the incentive problem was due to the mixture of agencies involved with the transportation system. The Department of Energy is heavily involved with research while NHTSA is primarily a regulatory agency that does not conduct its own research.

The INSuM team attempted to counter this problem by working closely with USCAR as documented earlier. USCAR was the auto industry partner for the Department of Energy's CRADA with the US auto industry and had been closely involved with the DOE in joint research since 1993. To some degree, sustainable mobility, as defined by the INSuM team, included fuels and vehicle technology. This research area was clearly under the auspices of DOE. But the project also had claims that related directly to intelligent transportation, an area held closely by the DOT.

The team at Clemson reasoned that without industry support or a viable demonstration that an open innovation network could create value and drive deal flow, it made no sense to approach the federal agencies for support. If the first test of the concept was successful, then the agencies should be approached to participate. However, a major concern faced the INSuM team: given the sometimes combative relationships between the auto industry and government, inclusion of government as a partner in the innovation may cause some or all of the larger firms to back out. This would have to be tested in the first experiment.

Planning

A planning meeting was held in Detroit on 20 January 2010 to discuss the implementation of the first investment forum. In attendance as an informal advisory committee were executives from USCAR, the major US OEMS and suppliers. The meeting reinforced the fundamental concepts and purposes why the industry should establish an industry-scale open innovation network. Two example startup companies

were discussed as typical of the kind of pre-competitive technologies that were in the marketplace. September 22, 2010 was set as the date of the pilot for the AutoVenture Forum.

The initial event was planned by INSuM as a one day investment forum and deal-making. The INSuM team would be responsible for managing all aspects of event management, selecting the startup companies that would present their business plans, and writing a follow-up analysis of the event. The industry's primary contribution was to send senior executives to attend the forum, meet with companies that they found compelling, and assess the dynamics of the event.

During the day, selected startup companies would have fifteen minutes to present their company's solution for the auto industry and then have five minutes to answer questions. Several breaks were planned to allow networking and the one-on-one interactions. No attendance fees were charged to either side but attendance was by invitation only. Startups would have to pay their own way to the conference. The agenda was set, communicated to the informal industry governance council and the recruitment process started.

Industry executives at the meeting also introduced a new industry sponsored open innovation-related effort called AutoHarvest. Autoharvest was formed in 2010 to create new markets for existing auto industry intellectual property and facilitate collaborations. The company is lead and advised by former auto industry executives and researchers. Autoharvest is initially focused on making a market in advanced manufacturing intellectual property developed by the auto industry along the lines recommended by

Chesbrough (2003) and following, to some degree, the example of existing intellectual property intermediaries (Lichtenthaler & Ernst, 2008)

The emergence of AutoHarvest lends support to the concept of “industry scale open innovation”, the fundamental principle behind this research. But it is not clear that INSuM and AutoHarvest are complements. The Autoharvest initial business model is primarily targeted at finding licensing partners for automotive intellectual property, or an inside-out focus (Pankin & Stief, 2011). INSuM is more outside-in focused; looking to bring new externally created technology and know-how into the auto industry. A major difference in the two approaches is that INSuM seeks create an innovation market by matching technology providers to the explicit needs of the industry.

A concern arose among industry and INSuM during the initial meeting and in subsequent discussions about how to control and define the scope of technologies that would be present at the event. The auto industry is huge, spanning many continents, with most companies operating a global supply chain with hundreds of suppliers. How could the first INSuM event be focused so that (a) it could narrow the scope of the technologies, (b) would still be of interest to the enough of the auto industry to still attend and (c) stay away from technologies involved with individual core competencies such as engines and drive-trains?

The answer from the industry was to focus on the interface between the vehicle and its external environment: an information intensive area called telematics. Four concepts were agreed upon to focus the event and recruit startup companies: (a) vehicle-to-vehicle communication (V2V), (b) vehicle-to-infrastructure communication (V2I), (c)

Vehicle to Grid (V2G), and (d) human-vehicle-interface. Collectively these were named “V2X” technologies. According to project documents (Leitner & Bodde, 2010) : “No automotive technologies will be excluded from consideration. However priority will be given to companies with emerging technologies”.

Many types of value chains may exist within the V2X concept. Good examples that many car-buyers are familiar with are the ONSTAR™ navigation and crash reporting system and the newer Ford Sync program. An emerging profitable business model is the pay-as-you-drive concept, where electronics in the vehicle monitor driving behavior and car insurance rates are lowered for good driving.

All of these programs can be viewed as operating across a series of interconnected value added components. A generic value chain model, drawn from industry and confidential sources, can be assembled to illustrate (see Table 3).

	FORD SYNC		Wireless TELCO Operator			FORD Sync	
	ONSTAR™						
	PAYD						
Human Interface	Electronics Module	Software	Comm Mgt	Secure Comm.	Customer Center	Content Management	Content Provider

Table 3. Existing Telematics Applications

In general, data moves bi-directionally in the model between the Human Interface and the Content Provider. Some specific or dedicated flows also occur. Part of the ONSTAR crash detection system automatically routes information from the Electronics Module to the Customer Center and to local EMS/Fire and Rescue.

The first block in the model is the Human Interface. In currently equipped cars, this is a built in dashboard display that responds to either touch or voice commands. It is primary way the driver interfaces with the rest of the system. The Electronics Module controls the Human Interface and interfaces to the Communications Management section. The Electronics Module can also connect data dynamically from the vehicle while in operation from the on board diagnostic port (OBDII) located under the steering column on all US passenger cars sold since 1997. Software is separate system that connects all the in-vehicle systems together.

The Communications Management section varies by application and vendor. Some systems, such as PAYD insurance have a dedicated communications hardware module. Ford's Sync system uses the owner's smart-phone. The Secure Communication block contains the embedded encryption and verification software that allows the in-vehicle systems to communicate with the Customer Center. The Customer Center normally is the human operated call center that responds to specific requests or events, such as crashes or being locked out of the vehicle. Content Management and Content Provision are normally associated with pushing information and entertainment to the Human Interface. In the PAYD insurance systems, driving behavior data is collected by a secure, proprietary system.

Fundamentally, the industry executives that met with the INSuM were skeptical that the event could create any unique opportunities. After all, as one of the largest manufacturing industries in the world, the auto industry had no shortage of new suppliers trying to gain admission into the tiered supply chain. The auto companies and several of

the suppliers conducted ongoing technology scouting operations and sent staff to all major conferences regarding new technology that could have impact on the industry. Some of the larger auto industry players also staffed corporate venture capital departments that specifically targeted emerging technologies and companies. Industry opinions were mixed about the chances that any unique deal flow would occur through this new organizational form. The lead investigator spent considerable amount of time and travel attempting to manage the expectations from the auto industry.

As the event began to take shape, two concerns became dominant within the INSuM team. First, would the hub firm find enough “quality” startup companies for the event? Secondly, would the event result in any kind of unique collaborations or potential deals? INSuM knew that there should be enough startups. While tens of thousands of new startups are funded each year, the problems would be finding and recruiting those that met the investment criteria. Collaborations, the second concern, between the small companies and the large industry firms would be driven two factors: (a) the credible commitment of the auto industry to come to the event in good faith, but also (b) the ability of INSuM to generate quality deal flow of attractive technology based startup companies that were either new or unique to the existing auto industry scouting efforts.

Recruitment of Early-Stage Ventures

The INSuM initial plan to recruit startup companies combined a mixture of presentations at major events with conventional outbound marketing and web based registration intake. The focus on V2X technologies included a range of possible

companies from wireless technologies, software to manage wide area networks, enterprise class databases, and information-entertainment content provision (infotainment). V2X was also a good choice as it is platform agnostic: it can be applied to existing vehicles in the form of after-market products, designed into new vehicles, and also applicable to emerging electric vehicles.

The INSuM team developed a plan to generate deal flow of candidate companies (Byler, 2010a). The plan targeted a specific list of existing innovation related content providers, events, industry organizations, and investor organizations such as the Angel Capital Association. The two senior members of the team then developed a schedule covering the February to July 2010 timeframe to make presentations at major events about the pilot program. However, the lead investigator indicated that direct contact with potential startups may be the most effect way to generate deal flow in the first AutoVenture Forum, at least in the first experimental event.

The lack of a clear and effective channel to quickly locate and contact early stage companies that met the investment criteria was a challenge. This “search problem” is driven by two fundamental attributes of early stage companies: the tendency toward regional affiliation, and the quirks and idiosyncrasies of angel investors as compared to venture capital firms. Early stage startups affiliate more with regional economic development networks than national networks (Brenner, Cantner, & Graf, 2011; Lechner & Dowling, 2003; Lee, Florida, & Acs, 2004). This regionalism is due, we think, to the regional nature of angel investors. Sohl (1999) has commented that angel investors avoid public scrutiny while venture capitalists are prominent in many innovation and

technology related venues. The least controversial of Shane's treatment of the angel investing community and startups in general, suggest that most angel investors are very "hands off" in their approach and do not participate the day to day operation of the startup (S. Shane, 2009; S. A. Shane, 2008). The regional nature of startups creates a challenge when recruiting nationally or internationally for an open innovation network like the AVF. This is in stark contrast to the highly visible nature of venture capital firms.

Some early stage ventures are difficult to find because of the development status of their product or service. Established companies ensure that their products are listed in appropriate buyer's guides, Internet search engines, and can be found easily by potential customers. On the contrary, early stage company software and Internet based services may only exist as a prototype being tested at a larger firm under strict disclosure conditions. Search engines cannot differentiate between established and early stage ventures.

Weak or pending patent protection can affect the small company's decision to release information. This can be a major concern if the product is directly competitive with existing larger company offerings. However, discussions with both the entrepreneurs and the industry attendees at the first AVF suggest that both sides wanted to avoid an intellectual property conflict. But the industry attendees insisted on the startup companies agreeing to some form of explicit acknowledgement about avoiding disclosure of proprietary information.

In summary, a number of challenges existed for finding and recruiting startup companies for the innovation network. The companies are locally focused in fundraising, suggesting that a direct approach to the hundreds of local angel groups may be necessary to find candidates. The startup companies appear to affiliate regionally with economic development agencies and network but the extent of this affiliation is unknown. Many of the regional economic development organizations and networks are mostly technology agnostic, making it quite difficult to identify a potential candidate company nationally for a specific application. Finally, early stage companies often keep information about their product development efforts concealed in a way that restricts the ability to find them. This has the effect of increasing the time and costs absorbed by the INSuM team in finding candidate companies.

The Selection Process

As the senior team members began to make presentations around the country to drive applications for admission to the network, the rest of the development team focused on the selection process. The selection process is a key part of the hub firm's ability to create value for two primary reasons. First, if the deal flow is marginal and simply insufficient to justify the time for industry executives to attend, it can trigger an exit of the major industry players from the network. Second, the deal flow within the network needs to complement existing firm efforts and not simply re-introduce existing technologies using a different format.

The ideal company for the network's selection process had four primary attributes: pre-competitive, deal-ready, early stage, and "first professional money in". The term "deal-ready" is used in many of INSuM's documents and presentations and describes a company that has the basic components of business in place. These include: (a) a viable value proposition for the auto industry, (b) some form of third party validation that the technology or product works as described in the company literature, and (c) the product is ready for testing and evaluation by the industry. A final category was used to discriminate between companies that met the basic four investment criteria and those that also targeted the investment theme of the first AVF event, vehicle connectivity.

The term "pre-competitive" research was used by the INSuM team to describe early stage companies that have licensed basic research from federal or university laboratories. Later this phrase is also used to describe the small technology startups, in general. Under the auspices of the NCRPA however, the term "pre-competitive" is not defined.

"Deal-ready" implies that the candidate startup company has enough organizational structure and product infrastructure to be a suitable partner for a larger firm. Corporate investment into startup companies can occur at any stage from inception forward. The preference of the INSuM staff was to find companies that could demonstrate a product or technology capability to the larger firms' satisfaction. For example, early stage spinout firms, usually run by researchers that have left their position at a major lab to start a company, may be too early for the auto industry. In the life

sciences market place, the existing R&D structure within the larger firms may prefer to partner with these very early stage firms. Finally, a deal-ready startup can clearly explain how its product or technology can create value for the auto industry. This requires an understanding of the business models and so-called value chains at work in the auto industry.

Early stage companies that have raised some amount of angel capital are an example of “first professional money in”. Generally, professional venture capital investors avoid so-called early stage companies, preferring to fund the expansion of firms that have cleared the many product and technology validation hurdles that exist in the market place. Some early stage companies are funded by the entrepreneur herself or through friends and family. The primary reason for using these criteria was that angel investors do conduct some due diligence on the early stage candidate companies prior to committing capital. This prior due diligence should lower the cost of validating the candidate company for entry into the network, according to discussions within the INSuM team.

Operation

The INSuM model became public and operational in March 2010 with the launch of the organization’s website, hosted by ASME. A variety of outbound marketing efforts ensued. The proposed channels to the startup companies were activated through a series of presentations by the two senior staff members of the INSuM team. Press releases

under both ASME and Clemson University letterhead announcing the first event were sent to a broad range of media outlets.

Response from the auto industry was encouraging and immediate as expected by the INSuM team. A number of organizations that had participated in the planning meetings and conference calls in January of 2010 announced their intent to attend. These companies also gave permission to use their corporate logos in the recruitment process for small companies.

The initial outbound marketing plan to reach out to startups began in mid-April 2010 with presentations in the Detroit area. Presentations in April and May of 2010 coincided with the annual Society of Automotive Engineers (SAE) annual meeting. SAE is the largest of the three professional organizations that have a primary or secondary focus on the automotive sector. The meetings and presentations in Detroit were followed by presentations from April through July at the annual meetings of major organizations such as the Angel Capital Association and conference calls to a broad array of federal laboratory facilities and organizations that are tightly connected to the federal technology transfer system (Byler, 2010d).

While the outbound marketing event was underway, there was considerable concern within the INSuM team that the “message” about the AVF was not reaching the startup companies or, would not reach the entrepreneurs in time. Part of this delay was expected as INSuM was attempting to create a new marketing channel (Byler, 2010b) using an unknown and untested venue as the draw for small companies. However, some preliminary feedback from sources close to the team suggested that the investor

community might be disinterested or unwilling to recommend the event to startup companies in their networks.

The problem of locating, contacting and recruiting early stage companies became a focal issue during the April to July 2010 timeframe. The team had prepared a list of V2X related startups from culling a wide range of Internet and print media sources. A secondary list of companies that had received Small Business Innovative Research (SBIR) grants was generated from federal government sources. Of the 378 companies in the two lists, only one company would end up applying and presenting at the AutoVenture Forum in September 2010: Power Tagging of Boulder, Colorado.

By early June 2010 (Byler, 2010c) the AutoVenture Forum had begun to take shape. Nine entrepreneurial firms had signaled their intent to apply. A list of candidates included thirty-two startups culled from various sources along with a short list of twenty-six SBIR funded companies. This list was still considerably short of the mark. The team had estimated that at least twenty five viable applicant companies were needed to select twelve presenters.

The decision was made in early July 2010 to begin direct marketing to potential attendees using a post card format document that could be mailed or used to direct the recipient to the AVF website for registration. Another decision was made to alter slightly the rather narrow descriptions of the targeted firms in the post card marketing piece. This had the downside of potentially driving an extremely large number of applicants however the other criteria might also restrict the number of applicants. The direct mail post card coupled with phone calls to key executives within the angel capital

networks was successful. The field of applicant companies swelled quickly to twenty nine by the end of July and the submission process was ended.

The geographic distribution of the candidate companies by state is shown in Figure 4. A majority of the firms that applied were from Michigan, which was expected. Also, South Carolina had 3 firms in the applicant pool. The dominance of these two states, not generally known as major producers of angel backed startup companies, in the distribution immediately raised the possibility of selection bias within the team’s discussions.

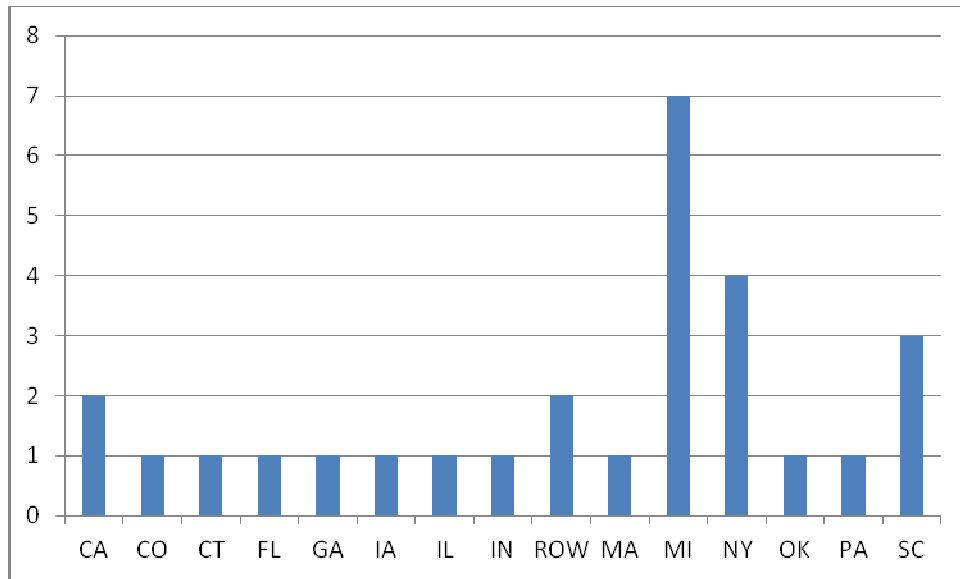


Figure 5. Applicant Count by State

However, given the small size of the sample and the unknown population of startups that had seen or been exposed to the literature about the event, making any preliminary judgments about bias were not pursued.

The distribution of the applicants by targeted area was a surprise. Figure 5 shows the percentage of applications by major technology area.

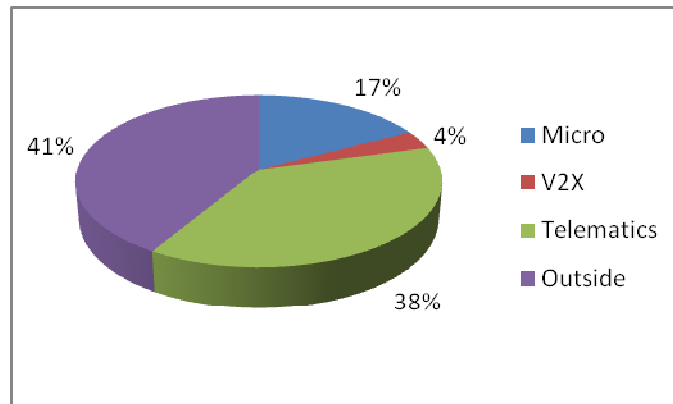


Figure 6. Applicants by Technology Area

The high percentage of applicants that were outside the criteria may be endemic whenever an open call for candidate companies is used. The largest group of candidates was in the telematics area. Only a single company, Power Tagging, truly fit the category of V2X as their business model is targeted at electric vehicle-to-grid integration.

Selection and Coaching

The selection process began in late July. Two team members reviewed all of the documentation submitted by the candidates. The selection criteria, mentioned earlier, were used to evaluate each company. Two staff members reviewed the company literature and supporting documentation such as patent filings available via Internet based search engines. The lead investigator served as a third vote and tie breaker in the event that the two staff members disagreed on a nomination.

A number of candidates were eliminated quickly. Two candidates had already taken in major venture capital funding, while eleven companies had viable business

models but were outside the focus on vehicle connectivity in the upcoming event. Four companies were either too early stage or submission documents were so poorly written as to prevent any validation on the technology, business model, or the key staff. The good news in this data was that the majority of the candidates matched the type of company the INSuM team was targeting in their outbound marketing program.

The companies selected for the event were then subjected to a more detailed due diligence analysis, prior to notification. For example, the US Patent office database was used to validate the claims of issued patents or patent applications filed. A number of other checks were made on the companies. No major discrepancies were found but total available market and projected market share claims were heavily discounted as a criterion. Much greater scrutiny was applied to the business model being proposed and the underlying value proposition. No further companies were eliminated in this phase but several of the companies either did not or could not fully explain why their value proposition would be of interest to the auto industry.

Two of the team members then arranged conference calls and webinars with all selected companies to rehearse their presentation and review the disclosure rules for the Forum. The rehearsal was used to insure that (a) there was a clear and compelling value proposition for the auto industry to start a collaboration, and (b) that the individual companies explicitly stated what kind of relationship they were seeking. All presenting companies were required to agree to the disclosure rules and a “hold harmless” clause. Once the coaching was completed, the presentations were bound together and an overview of the companies was sent to the auto industry and the other attendees. The

auto industry used the INSuM team's summary to select the appropriate staff to send to the event. Notifications were sent out to all firms in August 2010 and the agenda and presentation sequence was completed.

The disclosure agreement and hold harmless clause was a major concern for the auto industry, and not simple formality. Because of the industry's size, major auto OEMs and suppliers are often targets of lawsuits, some from jilted inventors. The auto industry is cautious and risk adverse in its collaboration with outsiders, such as the startups coming to the AVF event. As an example, several of the major auto OEMs required their staff not to open email, letters or acknowledge any correspondence that may contain "unrequested" confidential information. Thus we required each participant to certify the following:

All participants understand and agree that (1) no proprietary or confidential information will be exchanged or otherwise transferred in the course of any workshops, meetings, discussions or other communications sponsored, facilitated or otherwise promoted by the *AutoVenture Forum*; (2) any and all information disclosed to other participants is provided without any restrictions whatsoever on its use or further distribution; and (3) it is the responsibility of each participant to avoid disclosure of any information which it considers to be proprietary or confidential until such time as a specific bi-lateral confidentiality agreement is concluded between any participants who may wish to carry the discussions into areas or levels of detail requiring such protection.

The second requirement, the hold harmless clause, protects the organizers of these events:

Participation in the *AutoVenture Forum* (AVF) does not ensure that presenters will find the customers, capital, talent, technology, or other resources they are seeking. AVF does not participate in the selling of or solicitation of offers to purchase technology, rights, or securities. AVF does not offer any opinion regarding applicable intellectual property or securities rights or laws. Participants in AVF should obtain legal advice and other professional counsel regarding applicable laws. Participants remain responsible for the accuracy and completeness of the presentation and any representations it makes to the conference. If any purchase, investment, collaboration, or technology transfer occurs as a direct or indirect result of AVF, it will be solely on the initiative and responsibility of the participating entities.

Alternatives to the INSuM Model Emerge

During the startup and operation of the INSuM network in the April to July 2010 timeframe, two new automotive innovation concepts emerged. The first of these two alternatives was the Progressive Automotive X-Prize™ (Maxmen, 2010). This competition began its final year of testing evaluation in 2010 for a vehicle that could exceed 100 miles per gallon (equivalent) and still pass most of the federal motor vehicle safety standard tests (FMVSS). The X-Prize committee would award \$10 million in prizes to the top finishers in three different classes of vehicles. The second alternative to INSuM was the formation of the AutoHarvest Foundation. AutoHarvest was formed as a non-profit organization to leverage automotive patents and know how into other industries.

INSuM staff was invited to attend the Automotive X-Prize final competition held at the Michigan Motor Speedway in July 2010. At this point in the X-Prize competition, the field of contestants was down to sixteen vehicles. Funding for the program had come from a number of private donors. The US Department of Energy contributed \$5 million dollars to pay for technical infrastructure. No US automotive companies or suppliers had any visible presence at this three year long event that had considerable visibility from the Obama administration.

The AutoHarvest Foundation was formed as a legal entity in early 2010 by auto industry veterans (Pankin & Stief, 2011). The foundation has received support from Ford Global Technologies, LLC, The Chrysler Group, LLC, General Motors Company, Covisint (an enterprise-class supply chain management system with origins in the auto industry) , the University of Michigan, The Ohio State University - Center of Automotive Research, C.S. Mott Foundation, Ann Arbor SPARK, Michigan Economic Development Corporation and others not mentioned by name.

The AutoHarvest team made contact with the INSuM team directly. Discussions between the two organizations quickly lead to a memorandum of understanding and an agreement to collaborate. AutoHarvest attracted a board of directors with extensive experience in the Auto industry. Directors of the company have prior experience with the Center of Automotive Research at the University of Michigan, Nippon Denso, Delphi, and General Motors among others.

The stark differences between these two organizations illustrate the bipolar world of innovation in the auto industry. The industry tends to drive innovation internally,

hence the lack of support for the X-Prize. And second, the relationship between the industry and government has varied from collaborative, such as FreedomCar, to direct confrontation with numerous administrations, regulatory agencies and Congress over safety, fuel economy, and emissions. The X-Prize organization had no visible support from the US auto industry but had highly visible support from the Obama administration and the Department of Energy. No studies have yet been done on the effect of the X-Prize on automotive innovation, despite the prominence of innovation prizes and alternative incentives play in the Obama administration. AutoHarvest, by contrast, has not received funding from Congressional or agency sources but is heavily vested with auto industry support.

The Presenters and Attendees

The startup companies are mapped by the business models along the connected vehicle value chain introduced earlier, as shown in Figure 6. Each of the companies is represented by a random alphanumeric code such as “Pn”.

P27, P30, P24	P10,P3, P20	P4, P11	P13, P29,P17			P1,P6	
Vehicle Microelectronics		Telematics and V2X					
	Smartphone			TELCO Cellular Provider			
Human Interface	Electronics Module	Software	Comm Mgt	Secure Comm.	Customer Center	Content Management	Content Provider

Figure 7. Simplified Connected Vehicle Value Chain

The attendees at the event were represented the auto industry, consultants, angel and venture capital firms, academia, regional economic development organizations, and researchers representing military vehicle research programs. Attendees by category are listed in table 4:

Category	Companies Represented
Automotive OEMS	4
Tier 1 Suppliers	5
Telematics	3
US Military	1
University	2
Early Stage Venture Capital	3
Regional Economic Development	2
Non Profits	1

Table 4. List of Attendees by Category

Execution

The first INSuM event, the AutoVenture Forum, was held on 22 September, 2010 at the Rock Financial Showplace in Novi, Michigan. Approximately 90 people total attended the event. The event was moderated by the lead investigator. Attendees were limited to 15 minutes of presentations and five minutes of follow-up questioning from the audience. Tables for the presenting companies were setup around the edge of the conference room. After four companies presented, a networking break was used to allow

more one-on-one discussions. Lunch was provided and additional time for networking was added to the lunch break. In general, the breaks were extremely busy with all startups getting ample visitors from the audience.

Three tables were set aside at the front the conference room, closest to the stage for General Motors, Ford and Chrysler staff. Each of the auto OEM tables was well manned with six to ten employees. The major suppliers such as Delphi Automotive generally sat at a table together. Startup company representatives and the remaining attendees, while not presenting, sat dispersed through the audience.

Immediate follow-up

An online survey of attendees was prepared by the INSuM staff using the Survey Monkey™ tool. Approximately thirty days after the event, an email was sent to all attendees of record with a link to the survey. Most questions also had room for comments. The survey instrument is shown in Appendix G. Of the 90 attendees, 26 responded, for a 29 % response rate.

Some of the questions from quick survey provided preliminary validation for the basic concept of INSuM: creating new collaborations between the auto industry and the high technology startup companies. Question 1 asked the each presenter to identify their role in the AutoVenture Forum.

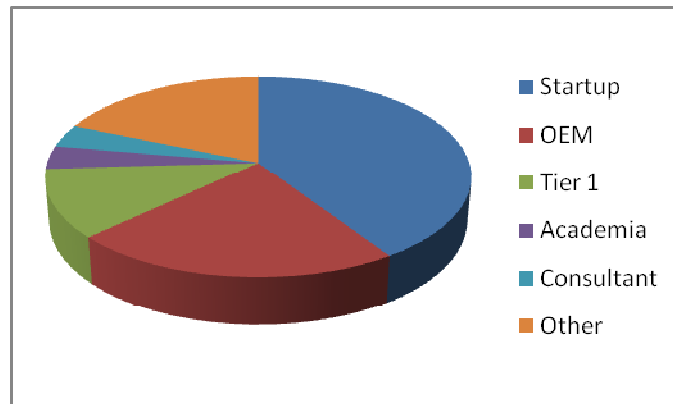


Figure 8. Question 1 from the Follow-up Survey

Question 2 asked if the attendees found the forum valuable. No respondents rated the event low or none.

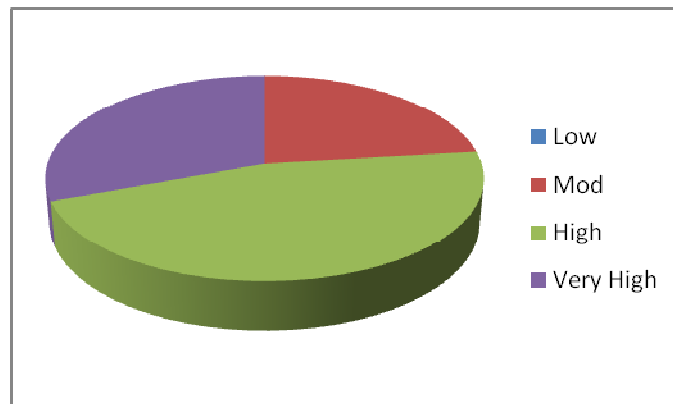


Figure 9. Question 2 From the Follow-up Survey

Question 3 asked: “what was the primary value obtained from the meeting?” The initial responses, opportunity to establish relationships and understanding a wider range of technologies were provided as possible choices. The “other” category was provided to capture write-in responses. Only four “write-in” other response were recorded and two of these were directly related to the first category, the opportunity to establish relationships.

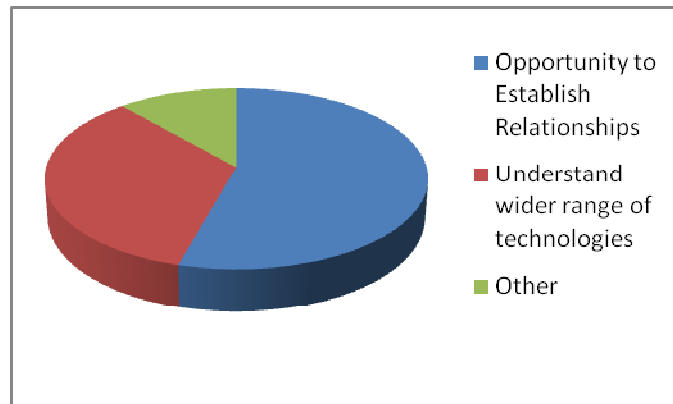


Figure 10. Question 3 from the Follow-up Survey

Question four asked how the attendees planned to follow-up. No prompts were provided for this question. The 26 responses were categorized and then summed to create the following chart.

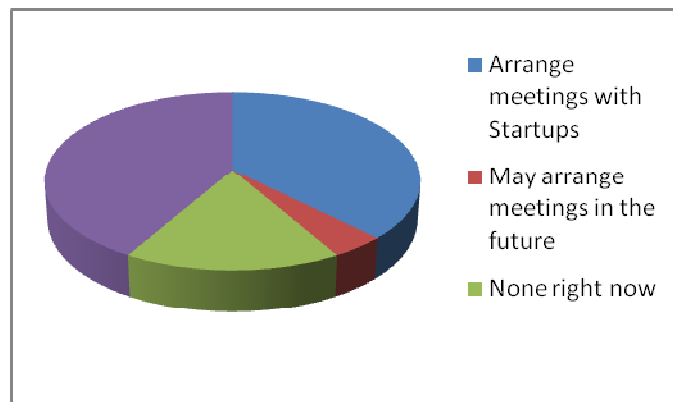


Figure 11. Question 4 from the Follow-up Survey

The category “arrange meetings with Startups” was encouraging as an initial signal that the central goal of the AutoVenture Forum may be working. Finally, question six asked the attendees to rank the AutoVenture Forum with other or similar events. More positive

news came via word-of-mouth later in the fall of 2010 that one of the presenters had been approached by a major auto industry firm for a formal alliance and that collaboration was proceeding rapidly.

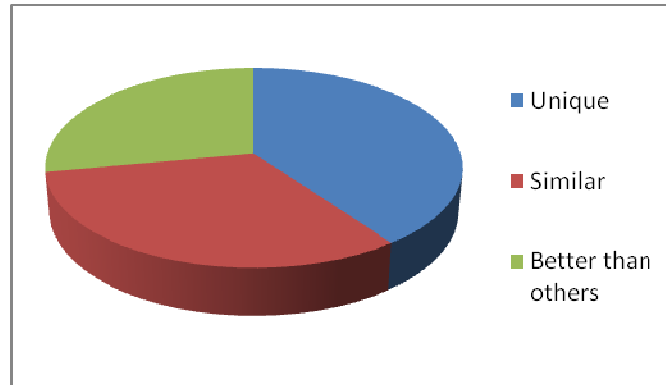


Figure 12. Question 6 from the Follow-up Survey

A surprising response was the large number of respondents that ranked the Forum as a unique event. One third of the attendees ranked the event as similar to others. It is not clear from this preliminary survey if this “similar” ranking suggests that the AutoVenture Forum is not unique or is being done elsewhere.

In summary, the preliminary survey responses were encouraging: the INSuM concept for accelerating innovation through collaboration via an open innovation network might be working. This would be tested in more detail by this investigator in the spring of 2011.

Post Event Follow-up

In October 2010, the lead investigator published a summary of lessons learned from the first INSuM event (D. L. Bodde, 2010b). Many of these lessons validated the initial INSuM model. A major challenge, but not unique to INSuM, was the management of expectations prior to the event. The lead investigator stated:

Realistic expectations must be set for both the entrepreneurial ventures and the auto companies. Entrepreneurial ventures must understand that the AVF enables them to begin high quality conversations that can lead to business relationships. But nurturing these relationships requires time and patience. The entrepreneurs are unlikely to walk out the door with a check in hand. Auto companies must not expect the entrepreneurs to understand their industry as well as they do, and must exert themselves to understand how a particular entrepreneurial venture can benefit them.

This summary provides another perspective on asymmetric relationships, but one that is similar to those found in Minshall (2008; 2010) .

Most importantly, the comments highlight one of the unique aspects of the AutoVenture Forum and why it is called a network and not a marketplace or some type of alliance. The Network is designed to initiate new collaborations between startups and larger firms. If an investment or formal alliance occurs it will be outside the scope of the forum. The problem of absorptive capacity, inferred by the investigators comments, imply a role for the INSuM team in coaching the larger firms in how to “manage the expectations” when working with the small firms.

Detailed Survey of the Participants

At approximately six months after the event, the INSuM team began the final and most detailed analysis of the INSuM model and the AutoVenture Forum Event. While the initial survey provided some indications that the overall model proposed by the INSuM team for innovation was working, a more detailed survey was needed to examine many of the concepts about the hub firm and its role in facilitating innovation.

The master survey instrument was separated into three slightly different sub-surveys, each with a different perspective and slightly phrasing of several questions. Figure 12, below shows a simplified version of the basic INSuM model. One survey targeted the startups, one targeted the large industry firms or innovation customers and a third survey targeted all other categories.

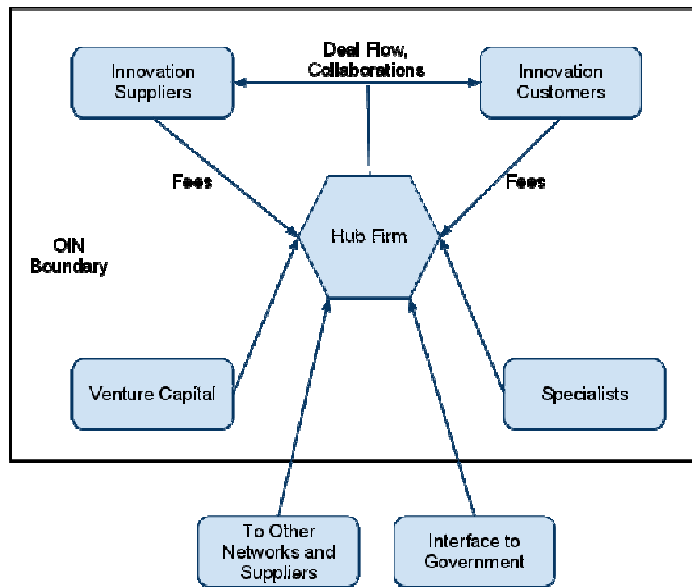


Figure 13. Simplified INSUM Model

The first section of the survey was designed to capture impressions and thoughts from all attendees if the AVF event value created value. This section also collected responses about collaborations between attendees. The second section of the survey solicited responses about the hub firm. More specifically, the interviewees were given a scenario that INSuM organization was now a permanent entity. This was followed by a series of questions that probed how the hub firm should be organized, managed, governed, and pay for its operating costs. The final section of the questionnaire targeted the issue of government participation in the INSuM model and the AVF events in particular.

In the event that the interviewee only allowed a short interview, three questions were used as “priority questions”. The first question asked if the interviewee found the

forum valuable and to explain the value they perceived in attending the forum. The second question asked if any relationships with the startup company presenters were created or formed due to the AVF. The third question asked about the possible relationship between the network and government.

A total of 35 interviews were conducted, representing 29 of the 40 total different organizations attending the conference. Among the twelve startup companies, one was acquired shortly after the AVF and no longer returned calls. Two others startup did not respond to repeated phone calls and emails.

Results from the Survey- The Auto Industry Perspective

Thirteen interviews were conducted with representatives from USCAR, the major auto OEMS, tier 1, tier 2, and tier 3 suppliers. In general, the reaction from the auto industry, including USCAR, was that the first event created value. Interviewees were not asked to quantify the value. Value was perceived, via content analysis, in different ways such as scouting new technology, finding new ways to solve internal problems, low cost way to evaluate numerous technologies, and understanding the emerging business models. The strongest support for the concept of value creation came from the tiered suppliers and USCAR representatives. Some firms that had headquarters outside the US were more pessimistic about the value of the network due to the preference of the home office to source all innovation in the home country. Most importantly, the auto industry OEMS and major suppliers wanted the answer to a single question: Did the event cause

some new collaborations to take place between the tiered suppliers and the startup companies that would not have occurred otherwise?

The answer to this question came swiftly. A summary of the collaborations started by the first AVF in shown in Table 5:

<i>Q1 Startup</i>	Description: discussion → proposal → signed agreement to collaborate
P13	signed a collaboration agreement with an industry firm shortly
P27	Startup P27 reported ongoing meetings and discussions with an industry association and one auto firm
P30	meetings and ongoing discussions with an industry firm
P6	some new contacts but no new collaborations or discussions
P3	new discussions and meetings with two different industry firms
P20	a new discussion and a proposal with an audience participant outside the auto industry
P11	ongoing discussion with other presenters
P24	ongoing discussions and some meetings with two different industry firms.
P4	ongoing discussions with an industry firm and a venture capital firm
P1	Firm was acquired shortly after AVF (not as a result of the AVF)

Table 5. Summary of Collaborations with Startups

One auto industry firm reported that collaboration had already started with startup P13, a cross-network effect and the most anticipated outcome of the event. Many of the auto industry participants reported various stages of emails, meetings (both before and after the event) with the startups but none were mentioned by name. This was consistent with a question from the initial survey conducted in October 2010 just after the event. In a “same-side” effect, one of the tiered suppliers in the audience was very enthusiastic about

a new contact and potential deal with another much larger firm that resulted directly from contacts made at the event.

The following quote from auto industry participant A1 is indicative of those that found value in attending the first AutoVenture Forum:

From my perspective, it was extremely valuable...I really liked the breadth of the technologies...The spectrum of the presentations was very broad. Companies range from real early to SMEs that were profitable. Within that constrained area, I was impressed with the quality of the presentations

Clearly the startup companies did a good job communicating their value in the view of Auto Executive A1.

One of the more pessimistic views expressed by A3 indicated that the forum was of little value. A3 indicated that all of the technologies presented would have to be translated into a foreign language and sent to the home office for evaluation. This created problems because the home office wanted to keep innovation in the home country. However, other questions answered by A3 generally supported the idea that some innovation could come from the startups. A3's explanation shows a common perception that also surfaced at the January 2011 Industry planning meeting and was incorporated into the guidance for the first event:

Electronics is the best way to break into the auto industry because electronics is not hardware based, but, is more programming based, software, for transistors and diodes and all that stuff can be assembled. A lot of companies know how to do that, the industry knows how to do that. It's the idea of what is being outputted or managed. So I think electronics are better suited than someone

with airbag technology or someone with new steel technology or something like that.

Industry executive A4 did not criticize the forum so much but was skeptical of the outcome. Early on in the formation of the project, it was clear that the innovation network outcome should be new collaborations. A4 put his skepticism in the post event interview this way:

The value is actually for me is hard to see right now...Bottom line, did you get an inventor to actually connect with the audience/potential customers? Did you get follow-up calls?

The simple answer to A4's challenge is yes: there are documented collaborations that occurred as an outcome of the event. The challenge to answering the question is that until collaboration occurs between A4's company and a startup he may be skeptical of reports of similar collaborations among his competitors.

Several questions probed the attendees about the challenges of doing business with small companies. Firms that had implemented open innovation strategies had much more positive attitudes toward working with startups than other firms. Firms practicing open innovation are determined by publications from senior managers or pages within the company website dedicated to open innovation. Attendees from the OI practicing firms did not express any reservations about the traditional issues of asymmetric relationships. Attendee A8 had this to say:

We are skilled to participate at any level in terms of maturity of the technology. Obviously we don't want to get stuck into a research loop. Other

than that, we are setup so we can work with smaller companies. So, whether they are self funded, angel or VC, we are fine with that...Their (the startup) singular focus on specific technology is advantageous.

A second set of questions targeted the AVF as an organization. The goal of these questions was to see if an organization boundary, a set of rules, and business model for the AVF could be suggested by the auto industry attendees. These questions also provoked a wide range of responses. Many of the attendees at the conference were in either technology scouting or affiliated in some way with corporate venture capital efforts. In some interviews, the interviewer attempted to suggest possible business models. The responses from industry concerning possible business models were consistent with how two-sided networks are operated: the larger well funded companies subsidize the recruiting and selection of new AVF startups (Rochet & Tirole, 2004). Several of the interviewees jumped immediately into explanations about reductions in transactions costs, a fundamental concept behind the economics of innovation networks (Pyka, 2002).

Simplistically, the AVF or innovation network was seen by some participants as a way for large companies to reduce their search costs for potential partners. By collaborating with other industry firms in supporting the operation of the network, the cost of finding candidate startups is spread across the membership. It is important to distinguish the use of term “search costs”, a component of transactions costs. Coase (1960) showed that firms exist because cost of contracting with individuals is higher than

simply hiring the same people as employees. At some point though, firms find that some processes can be done less expensively by using outside contractors.

A limitation of the transaction cost view though is two-fold. First, the search for startups is only secondarily about cost reduction. The primary goal is finding ways to reduce ongoing and ever present R&D risk and uncertainty in emerging technologies. Participation in the network allows the firms a close, ringside seat to the turbulent world of emerging technology. By funding the network, the auto companies can operate a filter that brings the most promising early stage ventures to their doorstep at a reduced cost and without the attendant risk associated with direct involvement.

This view then lends itself to a more important observation that participation by the larger firms in the AVF or any industry-scale open innovation network is equivalent to a purchasing a real option (Vanhaverbeke, Van de Vrande, & Chesbrough, 2008) and (D. L. Bodde, 2011). Auto companies pay an option fee to participate in the network then use the option to identify and then collaborate with promising candidate firms selected by the AVF. The AVF uses the option fees to operate the network.

The most diverse set of responses came from questions in the third section of the survey targeting the possible of role of government in the network. Some respondents claimed that they would back out of any future events if the government became a partner. Others were more nuanced in their answers claiming that some agencies that had traditionally supported innovation, such as the Department of Energy and the Department of Commerce, might be better partners than independent regulatory agencies

or those charged with consumer advocacy responsibility such as the National Highway Transportation Safety Administration and the Environmental Protection Agency.

When time allowed, additional follow-up questions were asked by the interviewer about the type of government involvement. Responses from industry strongly supported the view that a partnership between INSuM and the federal laboratories was highly valued. Some responses suggest that government participants in future AVF events could help the innovation process by providing incentives. Overall though, the benefits and costs of having government participation in the network will require a more detailed study if the AVF team attempts to bring government into the operation of the network. This is the most critical issue facing the future of open innovation networks.

Results from the Survey- The Startup Companies

Eight of the nine startups interviewed found value in the event. The same eight reported a combination of ongoing or follow-up visits and discussions with the auto industry participants. One firm reported the start of a formal collaboration underway with a major automotive firm, confirming the information that came from analysis of the auto industry side of the network.

The challenges to doing with business with the auto industry varied widely across the startup companies. The list of challenges cited by the small firms did not include any surprises: (a) long time lines associated with doing business with the auto industry firms, (b) knowing the right people to contact , and (c) being too early in the marketplace. The answers to questions about government participation were not as strident in tone as the

auto industry responses and also did not suggest any ideas about how the government should be involved in the operation of the network.

Not all of the startups perceived a problem with doing business with the large firms. Startup P13, as an example, did not see any particular challenges in dealing with the auto industry due to their size. Possibly this was due to experience of the CEO of the startup or the presence of former auto executives on the management team. The experience of the senior management of the startup and their ability to create new relationships has been covered extensively in other research.

Results from the Survey-Other Attendees

Other attendees surveyed included academia, regional economic development agencies and networks, consultants, and early stage venture capital firms. All of these attendees were supportive of the value creation, as mentioned by the other groups. There were a number of collaborations discussed by these attendees. Some of the regional economic development group or academic research centers saw opportunities where the startup presenters had not really taken advantage of existing test facilities and capabilities that could have strengthened the startups value proposition. This observation is insightful, as it directly supports a claim made by the AVF team that the network can add value by brokering an array of services to the startups.

Discussion

The primary expectation from the view of the auto companies was the creation of new and unique collaborations. This expectation was met, to some degree, by the

collaboration reported by P13. The summary of startup company collaboration from Table 4 indicates that a range of new collaborations can be facilitated via the OIN concept. There is insufficient data to determine if P13's relationship will accelerate the rate of innovation at their partner firm.

The primary research question asked if an OIN can "lower the cost of innovation". The interviews are not clear that the OIN represents a "lower cost" innovation process. None of the firms interviewed objected to paying annual membership dues or paying to attend the event. In the experiment, the real "cost" of the AVF was paid for via grant money from the DOE and ASME.

An unanticipated problem was the challenge of finding and recruiting startups for the network. Based on the INSuM model diagram, we expected that using multiple channels to reach the regional investor and economic development networks would be sufficient. Multiple efforts and extensive follow-up were needed to identify the possible candidates. Conventional wisdom, such as using lists and government databases proved to be unproductive. One list contained data on 350 small firms that had received government small business innovative research awards. Yet only one of these firms was recruited for the network.

All of the major OEMs interviewed stressed that more supplier involvement in the OIN was necessary as innovation was being "pushed" into the supply chain. Future events like the AVF will need to accommodate the more diverse needs of the supplier base. The diverse businesses within the auto supplier network could also be seen as broadening the technological reach of the OIN. For example, existing auto suppliers

include not only traditional suppliers such as Magna (seats) and Michelin (tires), but also Motorola and Intel in semiconductors, and Google and Microsoft in the software industry.

Despite much of the overwhelming positive support for the first AVF from all participants, the issue of government involvement causes the most concern and the most strident responses among the auto industry participants and some of the startup firms. Several questions about governance of INSuM were asked but these responses did not yield a substantial amount of information or insight about how the hub firm should be managed or governed.

CHAPTER FIVE

ANALYSIS

Introduction

The case study created several significant findings. First and most important, collaborations between small, high tech firms and the auto industry can be accomplished with industry-scale open innovation networks. Economically and politically, this finding is important as it suggests that the auto industry may be able to leverage a unique national asset, our entrepreneurial culture, to re-establish their competitiveness. Other countries can purchase the same materials, buy the same advanced manufacturing tools, or learn how to copy the Toyota Production system. But no countries that currently compete with the United States have the institutional infrastructure to copy the depth and breadth of our entrepreneurial culture as measured by the global entrepreneurship index (Acs, 2010).

The second major finding is evidence supporting two-sided market dynamics and the crucial role of the hub firm or innovation intermediary. The need for the hub firm was suggested by several factors:

- The hub firm clearly provides the platform so that the two sides can transact;
- The lack of existing interactions between startup firms and the auto industry suggests an intermediary (the hub firm) and a platform (the AVF) in order to transact efficiently; and

- The mismatch in firm size and risk between the two sides of the market requires the OIN to price admission and participation differently for each side;

The rest of Chapter Five is organized around analysis of the research questions and a discussion of alternative theories or explanations that could potentially lead to a lower cost and faster innovation process within the auto industry.

Analysis of the Research Questions

The first research question asked:

Q1 What are the expected differences and similarities of OINS from other types of open innovation or innovation networks?

Evidence from the post-event interviews supports the claim that OINS are distinct from other types of networks. One of the claims of difference was that OINS would demonstrate both competitive and collaborative behavior. Collaborative behavior was documented by the role of USCAR and other industry firms assisting the definition of the initial scope of INSuM and the investment focus for the first AVF event (D. L. Bodde, 2010a). Competitive behavior was documented by the transcripts from the major OEMs and the tier 1 supplier firms. Competitive behavior was observed in the attitudes such as auto industry participant's A7's comments: "If the objective of the event is to make connections, then I am going to be very careful of who I approach and when I approach them, if X, Y and the Tier1s are in the room". Note that A7's comments also infer competition between the OEMs and the major suppliers. A7 also explained how they can both benefit from the AVF but also secure some privacy in setting up meetings with

potential firms: ” Maybe the way to avoid that is (having separate meetings)...well, one thing we did is we went through the list of companies before the event, we contacted one and had a call before the event.”

Deal flow is not a unique claim about the AVF. Many opportunities exist for the major auto firms to hear about new technologies and startups. The type of deal flow, early stage firms, is claimed as unique. Some of the startup companies were known to some of the participants, as several had won regional entrepreneurial competitions or been featured in different media. The large firms also acknowledged that this was the first time they had learned, in detail, how individual startups could leverage their business models for use by the auto industry.

The second research question was:

How does the hub firm create value?

This question is taken directly from the logic model in Chapter 3 that claims that innovation networks are a solution to the industry’s innovation problems. The problem with using the term “value” is that it can be interpreted by the interviewees in a variety of ways. But as stated in the primary findings at the beginning of this chapter, the most sought after proof of value creation was accomplished: a unique collaboration between an auto industry firm and a startup occurred.

A more general analysis of the responses indicates a majority of participants saw value from the event, but for many different reasons. Only 3 of the 36 attendees

surveyed said that they would not participate in a follow-on event, all for different reasons. A summary of the value statements is listed in table 1.

Survey participant	Value Statements
Startups	Exposure to technology scouts, customer introductions, introductions to venture capitalist, seeing the other new idea
Other	Watching the process, interactions between startups and auto companies, opportunities to help the startup firms, nothing new or groundbreaking that I had not seen before, one of the startups was introduced to another firm by a VC and potential deal is possible, meeting companies from outside the auto space
Auto Firms	Survey of the technology, process of selecting the startups worked well, got exposed to entrepreneurs that we might not otherwise have any opportunity to see, saw concepts that we'd never thought of, not much value as all R&D is done outside the US, not sure- did you get a collaboration between a small firm and a large firm?, difficult as the startups don't really speak the automotive "language"

Table 6. Summary of Value Statements by Attendees

Also, within the audience at the AVF were “brokers” from other networks, such as venture capitalists and regional economic development groups. Some of the VC firms setup meetings after the AVF event with firms within the venture capital portfolio. This represents a second way that small firms might benefit from attending these events. It also provides initial evidence that brokers within the audience can add value.

Ultimately, the evidence suggests that there is substantial value from many sides of the marketplace. Startups gain value from interaction with large firms and others in the audience. Auto companies see value both in the process and in the initial selection of

startup firms. The others in the audience including consultants, investors and universities, also found value in learning about new technologies. Most of those who did not find value were looking for highly technical content, which was outside the scope and intent of the first AVF event.

The third question was:

Q2 What are the factors that motivate and incentivize R&D collaboration between the two sides of the network?

This question was primarily answered by validation of the INSuM logic model: that unique deal flow was properly created and managed by the hub firm so that startups and industry firms and other attendees all received some value from their participation.

A secondary answer to this question comes from an early question in the survey that asked firms why they decided to attend. The auto firm's answers indicate they were focused on identifying complementary technologies, technology scouting, but also studying the process established by INSuM. The small firms were clearly drawn to participate because of the opportunity to interact with senior managers in the auto industry and venture investors that they might not otherwise meet. The other attendees, many of them brokers within their own networks, were looking to see what kind of technologies from outside the traditional auto sector were attractive to the auto firms and eager to make new connections.

Both of the startups and large firms were asked about fees and how the network would pay for the operation of the OIN. For those who saw value in the network, the answers were consistent with the theory that the larger firms would subsidize the smaller

firms. The smaller firms were all extremely price sensitive about any fees to participate in the network.

The fourth research question was:

Q3 What economic principles govern the operation of an open innovation network?

The data generated by the first AutoVenture Forum was provided initial support for the assertions in chapter 3. First, evidence exists that an OIN operates or “brokers” a two-sided market. Second, reducing transactions costs and risks associated with the search for external partners are an important motivation for participation in the OIN.

Preliminary evidence document the presence of network effects, where unanticipated collaborations occurred between startups, between startups and venture capital firms and between small and large auto suppliers.

The role of industry structure in innovation was evident in many responses. The fifth question asked:

Q4 What factors of industry structure affect the design and operation of an OIN?

Industry structure, primarily through the auspices of USCAR, asserted itself from the beginning. It was USCAR that organized and provided a forum for the lead investigator to describe the nature of the experiment early in 2010. While USCAR primarily coordinates research with the federal government, they have sufficient *gravitas* to compel an automotive audience to listen to a new idea. Without an organization like USCAR to

bring the industry leaders together, the challenge of organizing the AutoVenture Forum might have been extremely difficult and much more costly.

For example, after the first AVF event, an effort was started by the INSuM team to schedule a second event. One of the auto supplier organizations, the Original Equipment Suppliers Association or OESA, was approached about hosting such an event. The general concept was that OESA might do for the suppliers what USCAR does for the OEMs. Despite their public comments about encouraging innovation, OESA did not have the interest, ability, time, or funds to compel industry suppliers to discuss how an event might be organized. The challenge for the hub firm is that the suppliers are, for the most part, diversified businesses, unlike the OEMs. They don't control the downstream appropriability regime; that is owned by the OEMs.

Also, some very pronounced differences were observed in supplier behavior and attitudes. Two of the suppliers at the AVF event were clearly focused on open innovation as a corporate strategy. Both of these firms were also very aggressive in learning about the startup firms. And, both did not see any problem with dealing with small firms, such as the startups at the AVF. This is consistent with data gathered in a recent survey about open innovation practices in the European market (Ili et al., 2010). Put another way, when the auto suppliers embrace the concepts of open innovation more broadly, it will dramatically increase the OIN's ability to organize these types of investment events and create value.

Question six asked:

Q5 How can government agencies create social value by participating in an OIN?

Questions about government participation caught the vast majority of attendees off guard. One startup CEO captured many of the sentiments when he stated that if the government is involved it dramatically reduces the perception that the AVF is “purely commercially oriented”. As mentioned earlier, the concept of government participation at any level reduced many attendees motivation to participate in future events.

This indicates a possible disconnect in the original INSuM model between theory and practice. There may not be an active role for government in the OIN initially. If INSuM continues to evolve and pursues government participation or funding, it will need to re-think how and why government should be involved if it is to retain the membership. Since no government officials were available for interviews, there is no data to suggest how the government agencies might view the INSuM model. This topic is pursued in more detail in the sections below on alternatives to the open innovation networks.

In summary, partial answers to the seven research questions were found in different parts of the case study data collection. The finding of value creation through collaborations brokered by the hub firm remains the most important finding. The case study data did not provide any definitive answers to the two questions about government participation in the network. This issue needs further research.

The last research question was:

Q1 What forms of collaboration between government agencies and the OIN maximize innovation and minimize conflict?

The lack of government agency participation in AVF prevented any discussion from the government perspective. Until recently, the majority of the collaborations between government and industry were limited to research efforts organized by USCAR and implementing regulatory mandates forced upon the industry by the US EPA and NHTSA.

If I set aside some of the immediate reactions that some of the attendees had toward government participation, there were indications that there might be some ways that government agencies could benefit. As documented in the case study in chapter four, finding a way to leverage the national lab's technical expertise could be useful. But overall, the suggestions I made during interviews did not elicit comments or opinions from the interviewees that indicated new concepts or ideas.

This topic was also probed via another question that asked about what other "services should the OIN perform". Very few interviewees came up with ideas unaided, despite the presence of a large number of programs that are run by local, regional, state and federal agencies to encourage entrepreneurship and technology transfer.

Alternatives for the Logic Model

A key element of the theory behind open innovation networks as a new and more effective way to spur innovation is the underlying logic model. From chapter three, I repeat the underlying logical model:

- The traditional closed innovation process within the auto industry is no longer competitive
- The US auto industry is under persistent external stresses and must evolve

- A method must be found both accelerate the rate lower the cost of innovation
- Small, entrepreneurial firms can provide a source of external innovation
- Open innovation networks can couple the strength of the small firms to the needs of the industry firms

While the case study provides ample support for this logic model and presents evidence supporting the OIN framework, there are many departures from this logic model that might also be used to increase the rate of innovation and lower its cost. The first alternative to examine is the linear model of innovation, the dominant paradigm in public policy.

Alternative 1 - The Linear Model of Innovation

The linear model is the traditional view of innovation held by US policy makers and agencies (Godin, 2006) . The model postulates that innovation proceeds in a rational, sequential process:

- Federal funding for basic research
- Applied Research
- Product Development
- Production
- Diffusion (sales)

The most recent example of the linear model at work and the power that it wields within congress is the 2007 America Competes Act (ACA). The ACA passed the house 367-57 and by unanimous consent in the Senate. The ACA was a direct outgrowth of a 2005

report from the National Academies of Science (Augustine, 2005). The NAS report claimed that there was substantial and growing “innovation gap” and that the only way to fix the gap was to dramatically increase the funding for basic R&D and science and math education.

The linear model justifies public support for basic research through a traditional argument: the private sector will under-invest in R&D because of the inability of private firms to capture all the value of its R&D effort. By contrast, public investment in R&D attempts to encourage spillover into the private sector. The problem is that taxpayer funded research also spills over into foreign governments and research labs.

In comparison to the OIN, the linear model is an extremely blunt instrument. While funding for basic science research has a long established appeal, the linear model of innovation does not provide explicit solutions to the auto industry where innovations are already widely diffused. Second, investment in basic research can takes years or decades for commercialization occurs. Third, despite the claims of the large social returns from public R&D literature (Branscomb & Auerswald, 2002; Griliches, 1958; Jones & Williams, 2000), the auto industry must generate private returns before the public can benefit.

Alternative 2 - Innovation Driven By Regulation

This concept has caused some of the most acrimonious debate between the private sector and government regulators, most likely because there are clear successes in regulatory innovation but also massive failures. The auto industry, for their part, has

issued statements that still cause one to cringe. Bob Lutz, former chairman of General Motors, issued this assessment of global warming legislation and the effect on the auto industry: “Global warming is a crock of [expletive deleted]”.

There have been many successes where regulation has created much social value at a moderate cost. Seatbelts, emission controls, and airbags are all technologies that the industry initially fought against but finally accepted (Sperling & Gordon, 2009). One can probably count the most recent CAFÉ standards signed into law in 2007 as creating social value. While all of these innovations added cost to vehicles, none of them created any specific competitive advantage for the domestic auto industry.

But the converse of the regulatory argument does not hold. Reducing regulatory restrictions on the auto industry can backfire. In early 1980’s, President Reagan and congress put an stop to all further action to increase the CAFÉ standards from the initial 1976 fleet average requirement of 25 MPG. The Department of Transportation was forbidden by Congress to spend any funding on new CAFÉ standards. The block stayed in place until 2001, nearly twenty years. During this time gas prices were mostly stable, but the US OEMs consistently lost market share to imports and made most of their earnings through SUV and truck sales. When gasoline prices began their inexorable rise in 2001, the industry was ill-prepared to compete.

Alternative 3- Supplier Driven Innovation

An area closer to this research claims that auto industry OEM-supplier relationships are at the center of their innovation problems. Extensive survey data

supports this view. Improving relationships between the two could solve the innovation problem by leveraging more supplier-driven innovation (Henke & Zhang, 2010). The benefits from improving relationships with suppliers include:

- Supplier willingness to invest in new technologies spreads the cost and risk of technology development
- Access to successful supplier innovations increases OEM competitiveness
- Continued collaboration between OEMS and their suppliers results in better resource utilization and also creates switching costs, preventing OEM or supplier from exiting the relationship prematurely

Some of these ongoing efforts with the US auto industry are slowly beginning to pay off. The most recent 2011 Planning Perspectives OEM-Supplier Working Relations shows that the gap between high performing foreign firms and the US OEMs is closer now than at any time in recent history.

The initial AVF event also demonstrated the complementary nature of open innovation networks to furthering existing supplier relationships. The first event was focused on telematics: the process of enabling the vehicle to communicate with the external environment. The telematics value chain is modeled in the following chart:

	ONSTAR™						
	FORD Sync™	Microsoft™ (Tier1)	Smart phone	TELCO Cellular Provider			
Human Interface	Electronics Module	Software	Comm. Mgt	Secure Comm.	Customer Center	Content Management	Content Provider

Figure 14. Telematics Value Chain

Both GM and Ford operate a telematics value chain but both systems, while radically different in implementation, have created ample opportunity for small firms to contribute.

A larger concern about innovation with a hierarchical supply chain is how to insure that the companies in the supply chain, some 800 different firms in the case of Ford, are all busy doing innovative things to help Ford be more productive and competitive. The hierarchy in the auto industry is also a type of chain-of-command, similar to the military rank structure. OEMs don't normally work directly with Tier 3 suppliers as that would be bypassing the Tier one, primary system integrators. One auto industry executive put the issue of innovation and the supply this way:

So that's where, in a lot of the cases, ... is where some of the innovative type of work is done. ... but some of the Tier 1s are using Tier 3s we've never heard of, and they are actually very creative. And so we have to make sure that we are culturing, cultivating, and nurturing the tier 2, tier 3s. And, how do we do that without circumventing the Tier1? It's a very tricky thing.

As a result of this single experiment, it does appear that the OIN can create collaborations between the startup companies and the tiered supply chain. The challenge facing the OIN is convincing the bulk of the auto industry supply chain that valuable innovations can come from outside the existing supplier network.

CHAPTER SIX

OINS IN A POLICY CONTEXT

Introduction

Industry-scale open innovation networks (OINS) and the hub firms that manage them are a new type of organizational structure designed to accelerate innovation, lower its cost, and make the process of innovating more effective for participating firms. Industries that manufacture complex assembled products such as automobiles, farm and construction equipment, aircraft, military systems, and industrial machinery are the primary application area at this stage of theory development. The major driving force behind the adoption of open innovation and the use of open innovation networks is global competition and technological change. Falling behind in the global innovation game over time leads to a variety of problems that include: (a) lower productivity, (b) stagnant or declining wages, (c) higher unemployment, and (d) a lower standard of living (Solow, 1957).

OINS may interact with two extreme “camps” of industrial policy: those who oppose any government involvement in the market and those that argue that government has a beneficial and key role to play. These two viewpoints are best summarized by the dynamic tension between antitrust policy that encourages competition and industrial policy that advocates government intervention in specific markets or sectors. However,

closer inspection will show that both industry and government agencies are known to advocate for industrial policy to serve their own needs, as pointed out by theories of regulatory capture (Stigler, 1971) and claims of market failure. Likewise, if the situation is favorable, large industries will lobby against any government intervention that could limit their ability collect economic rents. To some degree, OINS may become a dual use technology: for the benefit of industry and/or for agencies to influence the technological trajectory (Dosi, 1982) of an industry.

The dual-use concept is easy to comprehend. The “industry-scale” scope of OINS coupled with the need for the hub firm to encourage collaborative and cooperative behavior among the major firms in the network raises questions about OINs as a tool for industrial policy makers to influence which technologies get adopted in a specific industry segment. The same terminology could attract the attention of antitrust regulators concerned with collusion among industry firms that might use the OIN as a novel way to create monopoly rents or limit competition via the control of emerging technology that flows through the OIN.

Policy interactions with OINS should depend on three factors: (a) how the OIN is funded, (b) how the OIN is governed, and (c) the operative role of government. If government agencies decide to participate in the funding, governance, or operation of an OIN, then concerns from the private sector about industrial policy may become vocal depending on the specific circumstances of the industry. The type of agency involved with the OIN, as highlighted in many of the interviews in Chapter Four, may temper the participation of many in the industry causing the OIN to fail. Should major industry

firms that collectively have substantial market power be the dominant source of funding or governance, then government concerns about monopoly or cartel-like behavior within the OIN could spur regulatory scrutiny. If the OIN seeks a middle ground where both its funding and governance are carefully chosen to limit the influence of any one group of stakeholders, then both anti-trust and industrial policy concerns may abate.

Determination of the “middle ground” will be an ongoing effort in the development of the theory of open innovation networks as outlined in this research.

This chapter will examine how hub firms and OINs interact with existing antitrust and industrial “policies”. In order to analyze the policy context of hub firms in more detail, a functional definition of OINS using existing terminology common to economics and finance is useful for organizing and framing the analysis. An OIN, as highlighted in chapter 3 of this research, can be described as an (a) independent brokerage organization, that (b) coordinates early-stage technology transactions via a multi-sided market mechanism, (c) between small firms and large firms, (d) in a specific industry or industrial segment. The hub firm is assumed to be independent from the large firms and maintains only a contractual relationship. “Brokerage” means that the hub firm seeks to connect buyers and sellers but does not enter into the transaction between the buyer and seller as a partner. “Brokerage” also implies that the hub firm is paid for its work through a combination of fees and commissions based on the deal flow that it brings to the major firms. “Coordination” implies a voluntary institutional arrangement among all parties to abide by the rules of the networks. “Early-stage” specifically means small firms that have received only their first round of professional funding. A “multi-sided market”

must be designed to enable the transactions as early stage technologies have no “price signal” that communicates value to buyer and seller. The technology, product or service has an unknown or untested economy of scale. Risk associated with the technology is considered very high. Put another way, extremes of information asymmetry are inherent in the operation of the OIN. “Large and small” acknowledges the asymmetry between the two sides of the market. “Technology transactions” coupled with “small firms” indicates that existing research labs and their scientists are not, at this stage, economic actors in transactions of the OIN. The primary economic agents that participate in the deal flow within the network are the small and larger firms. This deal flow could evolve over time if OINS become more widely used.

Industrial policy does not have a single definition or application. In the US, there is no single “industrial policy” agency. However, many agencies at the federal and state level engage in what could be described as industrial policy. The framework provided by Cohen (Cohen, 2009) is helpful in making sense of the wide ranging definitions and applications of industrial policy. Cohen’s framework examines the evolution of industrial policy across three “generations”: neoclassical foundations, structuralist, and pragmatic. A deeper reading of Cohen shows that while scholars clearly see an evolution of industrial policy, arguments from all three generations are still used to justify or vilify policies that target a specific industrial sector. As reinforcement for this approach, White’s analysis of anti-trust and industrial policy as being in a dynamic tension also involves considerable effort to define industrial policy (White, 2010). Cohen’s analysis shows that the specifics of industrial policy application depend upon a

wide range of factors, with no single factor being sufficient to explain how the policy instrument is designed or implemented.

In Cohen's analysis, neoclassical industrial policy primarily uses the language of market failures and regulatory failure to describe or justify government intervention into the market. Failures are brought on by un-priced externalities, asymmetry of information, and positive feedback which can lead to economies of scale that result in monopoly rents. But these critiques do not help one understand the many factors causing failure that could be industry specific, geography specific, or information specific.

Structuralist arguments for industrial policy correct some of these deficiencies and are focused on knowledge based economic theories of the economy and include a wide range of supporting theories. Evolutionary theories suggest that there is no one industrial policy path, but that each country or region develops and adapts a successful formula over time that leverages their indigenous strengths. Other theories look only at the incentives and institutional arrangements that encourage innovation and collaboration. Collaboration with government is highly encouraged via "a financial incentive for cooperation, making the granting of public funding contingent on different forms of cooperation between businesses" (E. Cohen, 2009).

The pragmatic view of industrial policy is driven by four major observations (op. cit.). The first is "innovation and technological adaptation... are the main engines of productivity growth and therefore per capita GDP growth. Innovation and adaptation take the form of new products, new production processes, and new organizational forms within businesses and markets. "OINs clearly fit into the description of new forms of

organization. Second, the process of innovation occurs “largely within firms and they depend on firms’ incentives to innovate, which are – in turn – influenced by economic policies and economic environment (patent and intellectual property policy, R&D subsidies, competition policy, availability of skilled workers, and so on). “. The wide range of variables in the “economic environment” observation suggests a heuristic that no single policy may be sufficient to encourage innovation. Schumpeter’s waves of “creative destructive” makes a return to the forefront, reminding us how technological change can quickly replace existing practices and/or products and services within an industry. The consequences are clear: “innovation contributes to increasing disparities between those who adapt quickly to technical progress and those who do not; in particular, it generally tends to widen the income differential between skilled and unskilled labor.” The fourth and final observation is the importance of the availability of highly skilled labor. Skilled labor requires continuous investment in education of the next generation engineers, scientists, and mathematicians.

The ultimate message from Cohen is that collaboration between industry and government may be stronger than either acting alone. The challenge is to find the right mixture of policies and engagement scenarios and rules. New concepts that enable more successful collaboration between government and industry would be of great value. This reinforces the claim of this research that OINs may constitute a new kind of “dual use” technology to help industry and government achieve their goals.

OINS and Competition Policy

Competition or antitrust policy is concerned with policies to “encourage competition that comes with markets and encourage the allocative efficiency that comes with competition” (White, 2010). US competition law has evolved over time as it accommodated changes in norms and new economic evidence (Kovacic, 2003). The future antitrust concerns about OINs will be focused around the hub firm’s need to facilitate coordination and cooperation with multiple industry competitors and how the governance and funding for the OIN is managed. This does not imply that large firm members in an OIN all come from the same industrial segment. For example, a major supplier to Ford’s new Sync infrastructure is Microsoft™, a firm not normally associated with the auto industry. Antitrust regulators could pursue Microsoft as they feared that the firm would attempt to use the OIN to dominate software application inside a new platform- the connected vehicle.

As outlined in Chapter Four, the AutoVenture team spent considerable effort encouraging auto makers and their major suppliers to participate in the 2010 AutoVenture Forum event. But the majority of the work and meetings were coordinated through an existing organization, the US Council for Automotive Research. USCAR is a corporation that coordinates pre-competitive research between the Department of Energy and the major US auto makers via a special federal contract called a cooperative research and development agreement (CRADA). The CRADA stipulates that the private sector, represented by the auto makers, cannot direct how the Department of Energy public funds are spent but can only make recommendations.

USCAR also manages a number of collaborative research programs registered with the Department of Justice as required under the auspices of the National Cooperative Research Act (NCRA). The NCRA provides a limit, not an exemption, to existing antitrust litigation by removing the ability to collect treble damages from breaches of competition law while engaged in cooperative R&D. Competitors or “non affiliated firms” are allowed to engage with one another, cooperatively, in a range of specific research activities. But the OIN, or more specifically the hub firm, is neither a joint venture nor a standard organization, the two types of organizations that are specifically called out in the NCRA statutes.

The initial experiment in the AutoVenture Forum limited the initial role of the OIN to the “brokerage” function listed previously. This function also eliminates the role of the OIN in participating in any research. If the OIN were to stick to the brokerage function alone and not become party to any of the cooperative behaviors authorized by NCRA, then the OIN may not be able to gain protection from antitrust damages. But other aspects of OINs may suggest a different interpretation.

The creation of a “multi-sided market” in emerging technology is a solution to overcome a problem of “thin markets”. Thin markets, such as early stage technology firms, have few buyers, high transaction costs, and few trades. The creation of a market for technology by the OIN does not imply that this is the only way these emerging firms can market their products and services. However, within the two-sided market concept, the primary issue is “who pays”. If the large firms pay the OIN under contract to participate in the network and share information with the hub firm, then there may be an

expectation of a joint venture as defined in NCRA. The rule of reason in the NCRA suggests that the OIN may indeed qualify for inclusion:

§ 4302. Rule of reason standard, In any action under the antitrust laws, or under any State law similar to the antitrust, laws, the conduct of—(1) any person in making or performing a contract to carry out a joint venture, or (2) a standards development organization while engaged in a standards development activity, shall not be deemed illegal per se; such conduct shall be judged on the basis of its reasonableness, taking into account all relevant factors affecting competition, including, but not limited to, effects on competition in properly defined, relevant research, development, product, process, and service markets. For the purpose of determining a properly defined, relevant market, worldwide capacity shall be considered to the extent that it may be appropriate in the circumstances.

A final point about anti-trust law and OINs is the management of intellectual property. Assembling a broad portfolio of intellectual property can limit competition and bring charges of monopoly behavior under existing antitrust statutes. The AutoVenture team initially steered clear of intellectual property law by requiring that participants sign a “do not disclose” and “hold harmless” document that made it clear that participants were forbidden from releasing any proprietary information to the AutoVenture team or the any of the attendees at the investment forum. This requirement was imposed for several reasons. First, the larger firms are cautious about being approached by small firms offering new technologies. Second, the hub firm needs to avoid the appearance of any type of principal-agent behavior where the hub could privately benefit from the

cumulative acquisition of proprietary information from either side of the network in a way that harms any of the participants.

The governance and funding of the hub firm will present the major challenge for policy. The presence of major executives from the auto industry on a governing or advising board of the OIN could be problematic as viewed from the Department of Justice's antitrust division. As mentioned earlier, OINS do not easily allow classification as joint ventures or standards organizations. On the other hand, funding of the OIN by the auto industry or its affiliates such as USCAR could create the appearance that the OIN is just an extension of the joint research already explicit in the existing CRADA. Thus, funding of the OIN via an existing CRADA may make the antitrust issues moot.

In summary, the language used and descriptive terms of how OINS operate quickly conjures up images of traditional fears of anti-competitive behavior. However, peering into the black box of an OIN and using a specific description of their behavior quickly shows that many of the anti-trust concerns are more subtle. While OINS current do not clearly fall into the two primary categories of organizations covered by NCRA, OINs may still need to register in accordance with the Department of Justice, but this is very low cost form of insurance. Further, funding of the OIN via a CRADA could eliminate any concerns about antitrust or anti-competitive behavior.

OINS and Public-Private Partnerships

At the other extreme from the NCRA act are cooperative research and development agreements (CRADAs) that enable partnerships between public institutions

and private firms, mentioned earlier. CRADAs can be challenging for the private sector as the agency partner has substantial control over how public funds are spent. These agreements can constitute the *voluntary engagement of private industry with industrial policy*. The writers of a CRADA must balance the needs of the agency to create public value while the private sector will seek to maximize the firm's competitive advantage through the joint development and acquisition of proprietary knowledge. Existing law allows the agency and the participants in the CRADA to keep the results of the collaboration secret.

The auto industry has operated one of the largest and longest running CRADAs—currently called US DRIVE. US DRIVE originated as the Partnership for Next Generation Vehicles in 1993 in the first Clinton Administration. This CRADA has been modified by every succeeding presidential administration. Despite spending an estimated five hundred million dollars a year, no detailed analysis of the economic impact of this partnership on innovation has been done. Yet, year after year, the program is thoroughly reviewed by a board appointed by the National Academy of Sciences.

The USDRIVE CRADA can be critiqued for what did not happen. Despite the intense American-only effort to develop advanced batteries and fuel cells suitable for passenger cars in the 1990's, it was a “hail Mary” effort by Toyota of Japan that created the most popular and highest selling hybrid vehicle in the US, the Prius™ (Sperling, 2001). According to sources close to Toyota, Toyota was extremely concerned by the size and funding of the USCAR CRADA, as foreign firms were not allowed to participate. Since Toyota did not have access to an equivalent consortium partially

funded by the Japanese government, they decided to use the best available technology to bring a hybrid vehicle to market. Honda followed soon after. The US manufacturers, ostensibly benefitting from the federal government's industrial policy of investing in next generation propulsion, did not respond with a commercially viable vehicle until 2010 with the advent of the Chevy Volt™. By this time, however two new competitors had entered the US market: the Nissan Leaf™ and the Mitsubishi iMIEV™ battery powered vehicles. Sadly, fuel cells, the ultimate solution to a cleaner transport system, never made an appearance. The Obama administration drastically reduced funding for fuel cell development in 2009, effectively shutting down the effort for the foreseeable future.

This simplistic critique of the USDRIVE (formerly PNGV) effort is not meant to criticize those who performed the research but to look closely only at the outcome and goals of the partners. The CRADA is an outgrowth of major pieces of legislation from the 1980's, primarily the Federal Technology Transfer Act (1986). The act encouraged interactions between publically funded research and institutions with the private sector. In general, sharing the cost and leveraging the expertise of multiple organizations is a sound strategy. But using the government as a partner may bring additional constraints. Historically, the federal government invested in basic research and laboratories to find solutions to strategic concerns of the United States (Schacht, 2010). The implication is that private firms engaging in CRADAs with federal laboratories or agencies will absorb some of the public partner's goals and desires to commercialize publically funded technology, rather than focusing strictly on bringing new products to market.

What does the USDRIVE experience suggest about OINs, especially in the automotive sector? Earlier, it was noted that using a CRADA to fund an OIN might have its benefits but careful attention must be paid to the details of the funding and the governance of the hub firm and the network. Despite the strongly worded comments from the auto industry that bringing government as a partner in the OIN would cause them to exit, There is in fact a real opportunity to define a novel way of engaging government with industry via the OIN.

For example, the current Obama administration sees innovation prizes as a way to encourage private sector innovation around a topic of importance to government (Anonymous, 2010; Bhushan, 2010; Kalil, 2006; Maxmen, 2010). Prizes are attractive mechanisms for the government because: (a) no cost is incurred if there is no solution, even though the government may be the recipient of many innovative ideas, (b) it shifts all development costs to the innovator, (c) it is a one time cost, and (d) the government does not become a partner in the innovation. But prizes have some limitations including the applicability to large scale or extremely complex ventures. Prizes bypass many of the concerns about the costs and mutual obligations that come with a CRADA. But from an innovation perspective, prizes provide no ongoing development support. The auto industry clearly recognized this limitation and provides a cautionary example.

The automotive X-Prize contest, managed by a non-profit and funded primarily through donations and a grant from the Department of Energy, attempted to demonstrate that 100 miles per gallon equivalent (MPGe) vehicles could be designed and developed. The contest ran over several years, attending at approximately the same time as this

research. But since the X-Prize completion, none of the winners or contenders in competition have been able to market passenger vehicles that could pass all of the National Highway and Transportation Administration's Federal Motor Vehicle Safety Standards (FMVSS). The X-Prize received no visible support or participation from the US auto industry, despite its extremely high profile. Ultimately the competitors found that incorporating all of the existing regulations for vehicle safety as specified in the FMVSS would add considerable weight and structure to the cars, reducing their effective range and efficacy. But most of all, the ten million dollar prize was vastly inadequate to bring a new vehicle to market. The general literature suggests that designing and manufacturing a new vehicle cost more than a billion dollars, clearly beyond the range of any likely prize money.

The X-Prize investment by the Department of Energy does indicate that the federal agencies may be able to fund the infrastructure for competitions. Thus, the OIN could argue that the prize actually constitutes a "new collaboration" as outlined in Chapter 1, and solicit funding from a federal agency for infrastructure costs, as was the case with Automotive X-Prize. By keeping the federal agency at arm's length through such a funding mechanism, a hub firm might entice the major auto industry players to participate.

Summary

The public policy context of OINS is clearly centered on the dynamic tension that exists between antitrust policy and the wide assortment of instruments collectively known

as industrial policy. The interaction with each policy by the OIN is contingent upon how the hub firm is governed and how it is funded. The challenge for public policy is to find a middle ground that provides incentives for both industry and government to participate in the OIN while minimizing the risk of excessive regulatory scrutiny or scaring off potential participants because of the government's role.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

Summary

Open innovation networks at the industry-scale have been successfully designed and operated, creating value for all types of participants. Hub firms, the organizers and managers of the network, are integral to network formation and operation. The case study provides preliminary support that OINs are both complementary and beneficial to existing firm-centric innovation efforts.

Some support exists from the case study for the creation of public value through OINs. The public value can be achieved in two ways: (a) through the creation of domestic jobs driven by collaboration between firms and (b) achievement of social goals at lower cost through collaboration between the OIN and government agencies such as incorporating all of the major sustainable mobility goals. Support of job growth could be measured by simply counting the jobs created as a direct result of the new collaborations brokered by the OIN. Claim (b), the achievement of social goals could be measured by the rate of success in achieving societal benefits of reducing carbon emissions, the speed of implementing and certifying new safety technologies, and a reduction in injuries and death.

However, a major limitation in theory development regarding OINs is the sustainability and stability of OINs. The first case study demonstrated many of the

possible benefits of OINs. More cases and examples will be needed to define how OINs can become self sufficient and lead to long term gains in industry innovation cost and speed.

The next few paragraphs will highlight some of the most significant findings from this research. Following the findings, I will provide some recommendations for further research.

Finding 1: Quality Deal Flow Was Created

Despite the mixture of skepticism and optimism among executives in the auto industry at the outset of the case, the format used for the AutoVenture Forum created value for all types of participants. The deal flow organized by the hub firm staff resulted in numerous new collaborations between large firms and startups, between startups, and between brokers and startups. To date, one formal collaborative agreement has already been signed.

Finding 2: Two-Side Characteristics of the Open Innovation Networks

The theory suggested that one reason why large auto firms don't collaborate with smaller firms is because of the thin market problem; it is difficult and costly for the large firms to find one small firm among thousands that has a "special sauce" for a particular problem. The solution to thin markets, where barriers exist to low cost transacting, is through the formation of intermediated multi-sided markets. Evidence was found from many aspects of the case that "innovation markets" are inefficient and require intermediation. This is significant as it also may explain why typical one-sided markets

where the value of the product cannot be determined in advance yield such poor results. The customers for technology must be motivated, aggregated by the hub firm, and then incentivized to participate in the market.

Finding 3. Collaborative and Competitive Behavior Inside OINs

The case study highlighted an often overlooked aspect of the US auto industry: the close collaboration created by years of participation in USCAR. Pre-event collaboration was crucial in defining and shaping how the OIN's first event would progress. However, once the event went into operation, healthy competitive behavior took over. Interviews among competing auto OEMs acknowledged this behavior. While some suggested that they were a bit reluctant to ask many questions in front of competitors, others were highly motivated to pursue any and all possible types of deal flow regardless of whom else was in attendance.

Finding 4. Transaction Costs Are Not Enough to Explain OINs

While transactions costs are the most obvious theory to apply to the economic operation of OINS, they are insufficient to explain the observed behavior. The fundamental problem underlying the economics of OINs lies in the nature of the deal flow. Early stage companies are high risk and have unknown value ex ante. Thus conventional methods for portfolio analysis or return on investment are inadequate. The most promising area for documenting and measuring the economic value of OINs is through real option reasoning. Data to support real option thinking was found in the interviews with select industry firms venture capital firms that attended. This is important

as the monetary of value of early stage firms is extremely difficult to determine. Option theory suggests that the participants make a tradeoff: paying to participate in the OIN allows them access to deal flow with future possibility of collaboration.

Finding 5. The Importance of an Industry Champion

USCAR, the industry consortium that coordinates pre-competitive research with the US Government, brings together fierce industry competitors in a collaborative environment. This presence of USCAR and its long term stability, all contribute to its instrumental value to the success of the first AutoVenture Forum. USCAR had extensive experience with cross-industry collaborations and already had the trust of the auto industry collective. Thus the AVF had only to gain the trust of USCAR to access all of the major USCAR participants. Also, USCAR is staffed by major OEM executives that participate with USCAR on a short term basis. This shared trust is what provides USCAR with enormous social capital or *gravitas*, as I mentioned earlier in the case study. I infer from my many interviews and personal experience that had USCAR not existed, the challenge of bringing together industry participants would have been extremely difficult.

Finding 6: Finding and Motivating Small, Early Stage Firms to Participate

The lead investigator identified this potential problem early on in the project. The case study uncovered some of the dynamics of the problem and also some solutions. To support quality deal flow, the hub firm must develop a way or method for finding and motivating early stage firms to participate in future events. The experiences of the

INSuM team during the formative stages of the first event strongly suggest that existing brokers and their channels into various types of regional and content-specific networks are crucial to finding these firms.

Of the firms that applied to the first OIN, nearly forty percent came from the traditional auto sector cluster states (Wisconsin, Illinois, Michigan, Ohio, and Western New York). But what this also suggests is the OIN must recruit nationally to find the best candidates. The firm that did complete an agreement was from *outside* the automotive cluster region.

Finding 7: Motivating the Supply Chain to Work with Entrepreneurs

The supply chain in the auto industry, the so-called Tier 1, 2 and 3 suppliers, become a key part of any future OIN. However, it is not clear from the first OIN how the tiered suppliers will be motivated to work with the higher risk and usually unknown startup firms. To some degree the OEMs must signal to the tiered suppliers that innovation is important and can be rewarded. But the historical poor relations between the US Auto OEMs and their suppliers as compared to Japanese firms could be a lingering obstacle to the OIN.

Conclusions and Recommendations for Further Research

Two areas of this research stand out as major goals for follow on research. First, additional case studies within the auto industry need to be completed to provide additional external validity to the findings of the first case. Conducting a case study outside of the industry may create validity problems as other industries may face

completely different industry dynamics. The second area of research, and equally important, is defining how an OIN can work with government in a collaborative environment. This could lead to some firms exiting the network but perhaps over time if the OIN is successful they could re-enter.

The importance of small, early stage companies to the Ion's value proposition needs more development. For the OIN to sustain itself, it must develop low cost and fast methods for finding and recruiting startup firms. There don't seem to be any major technical barriers but institutional barriers and "gatekeepers" certainly exist. Likewise, it is expected if the OIN is ongoing, a more robust and formalized method of screening and interviewing candidate firms will be needed.

The importance of OINs toward building a national competitive strategy for domestic industry needs to be explored. This extremely simple concept, leveraging of small entrepreneurial firms through collaboration and not venture capital investment, could create a competitive advantage over other nations for US firms.

APPENDICIES

APPENDIX A. The AutoVenture Forum Pilot

The AutoVenture Forum:

Testing the Feasibility of an Innovation Network for Sustainable Mobility (INSuM)
ASME, USCAR, and Clemson University

This prospectus describes a pilot application of *Network Innovation*, a breakthrough innovation process, in an arena of intense public scrutiny and private interest—the U.S. auto industry. The partners in this feasibility test include ASME, USCAR (the R&D consortium of the domestic-nameplate auto makers), and Clemson University. Success here will have national significance by enabling an innovation process that offers lower cost, faster cycle time, and wider access to technology.

We organize this prospectus as follows:

- Part I summarizes the motivation for the *AutoVenture Forum*.
- Part II explains the results that can be anticipated.
- Part III describes the preliminary plan for the *AutoVenture Forum* in greater depth.
- The APPENDIX provides background information on the network innovation project, which we call the *Innovation Network for Sustainable Mobility* (INSuM).¹

PART I – THE AUTOVENTURE FORUM IN SUMMARY

The traditional innovation process that has served the auto industry well for 100 years is falling under increasing stress:

- Public concerns with climate change require decisive reductions in the greenhouse gasses emitted by road vehicles;
- Volatility in the price of motor fuels leads to rapid shifts in the type of vehicles preferred by customers; and,
- Intense international competition requires faster, less costly innovation cycles.

Clemson University, USCAR, and ASME are testing the feasibility of an open-source innovation network to supplement the more internally-focused process now in place. The core idea is to enable collaboration among entrepreneurs, corporate innovators, technologists, investors, and customers. The network could speed the transition to sustainable mobility by linking the

¹ Clemson is developing the network innovation concept under a grant from the Department of Energy. For further information, please contact: David Bodde, 864-508-0571, bodde@clemson.edu; or Robert Leitner, 864-656-2267, rleitne@clemson.edu.

innovative capacity of entrepreneurs with the technology base, systems integration, manufacturing, and market channels of the auto industry, as described in the Appendix.

The first pilot test of the network innovation model will be a project called the *AutoVenture Forum*. This forum will directly match selected entrepreneurial ventures with auto industry incumbents with the intent to create superior business opportunities for all—partnerships, investment opportunities, and/or customer relationships. Based on the lessons learned from this pilot test, we anticipate the *AutoVenture Forum* would become the anchor service for the mature innovation network.

ASME, USCAR, and Clemson University are designing and organizing two pilot *AutoVenture Forums*, one to be held in early 2010 and a second in the late spring. These would be held at Clemson’s International Center for Automotive Research (CU-ICAR), a newly-built research laboratory with excellent conference facilities located in Greenville, South Carolina.² In addition, a third lessons-learned forum would be held, either at the location of ASME or of USCAR. Its purpose would be to capture the lessons learned and feed them into a larger proposal for ongoing support from the Department of Energy and from the U.S. auto industry.

PART II – ANTICIPATED RESULTS

Taken together, we expect these two trials to validate the basic network goal of connecting entrepreneurial companies with opportunities in the emerging auto industry. In addition, we look for concrete economic results—partnerships, joint R&D, sales, investment, and so forth—even from these pilot forums.

The lessons learned from these first pilot tests of the *AutoVenture Forum* will be captured and analyzed through:

- Follow-up questionnaires and interviews with the industry participants.
- Follow-up questionnaires and interviews with entrepreneur participants and with their investors.
- Observations of colleagues at participating companies, ASME, USCAR, and Clemson University.
- A lessons-learned meeting of the key participants.

A third meeting of the partners, together with selected invitees, will be held in the late summer of 2010 to analyze the results. From this meeting will come a set of proposals to the Department of Energy (funder of the original Clemson grant) and to the auto industry to support the Incubation Phase of the project, which we now imagine to occupy three years. During this phase, the project team will introduce additional services, especially those that enable entrepreneurs without

² For more about CU-ICAR, please go to: <http://www.clemson.edu/centers-institutes/cu-icar/>

professional investment support to build their ventures to the maturity required for participation in the forum.

To the extent that this pilot test confirms its value, the *AutoVenture Forum* will become a self-sustaining anchor-activity of the network innovation project.

PART III – PRELIMINARY PLAN FOR THE *AUTOVENTURE FOURM*

The *AutoVenture Forum* will provide a neutral venue for structured public discussions and unstructured private conversations. The participants on either side include: (a) new ventures relevant to the automotive transition; and (b) innovators in established auto-related companies.

By “auto-related companies,” we mean the OEM, key suppliers to the OEM, and after-market suppliers. Participating auto-related companies would begin the process by identifying general areas in which they would be interested in hearing of opportunities offered by entrepreneurs.

The entrepreneurial companies will be nominated by their venture capital investors or by a responsible support agency. The sponsors will also be invited to accompany their new ventures to the Forum. This nomination process ensures that the entrepreneurial companies have been vetted by interested and skilled analysts and so are deal-ready. Thus, the participating auto companies can expect immediate opportunities for product or service purchases, joint ventures, or investment. Nominations would be screened for relevance, maturity, and likelihood of success. Eight will be chosen for each of two trials of the *AutoVenture Forum*.

For each forum, the structured discussions would be held in a panel format, as shown in the draft agenda below. Representatives of the incumbent auto-related companies would form the panels. Each new venture would have 25 minutes before a panel: 15 minutes of presentation, and 10 minutes of feedback from the panel members. (Note that 5 minutes are allowed for transition between presentations, so that 2 presentations per hour can be held.)

In addition to the formal panel discussions, ample opportunity for private conversation would be provided. Each entrepreneurial company would be given a private meeting area, and time would be set aside especially for these meetings.

Prototype Meeting Agenda

08:30 – 09:15 Plenary Session

- Welcome speaker
- Explanation of rules of engagement

09:30 – 11:30 First Forum panel (4 new ventures)

11:30 – 13:00 Lunch and informal meetings

13:00 – 15:00 Second Forum panel (4 new ventures)

15:00 – 17:30 Informal meetings -- Tours of CU-ICAR facilities for those interested

18:00 – 20:30 Cocktail reception, dinner, and evening event (informal meetings as needed)

Two-Forum Logic and the Pathway to Sustainable Mobility

The transition from what we drive today to fully sustainable road vehicles must proceed through several stages. The pathway to sustainability begins with improvements to the current internal combustion engines and fuels, progresses through hybrid and plug-in hybrid electric vehicles, and culminates in all-electric or hydrogen fuel cell vehicles. The two pilot tests of the *AutoVenture Forum* would support this pathway.

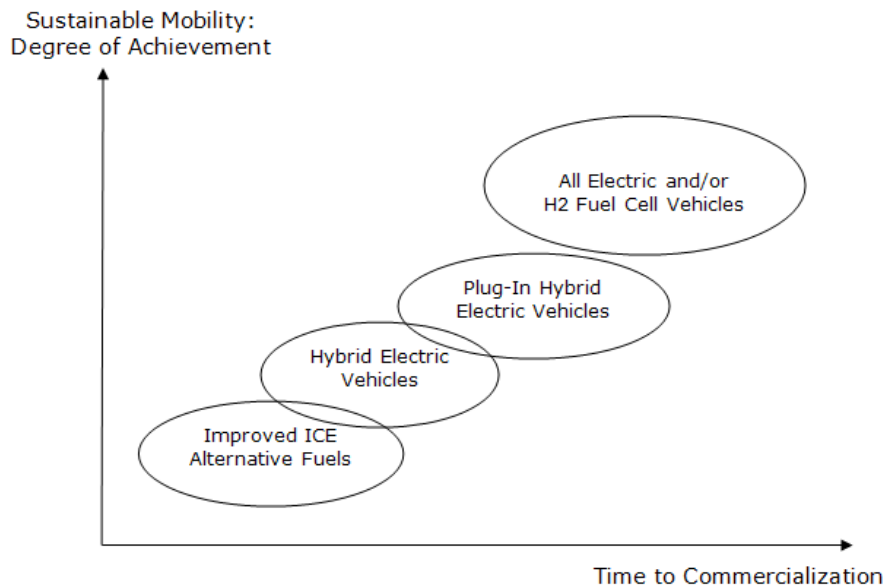


Figure 1 – Pathway to Sustainable Mobility
Source: U.S. Department of Energy

First Forum

The first *AutoVenture Forum* would focus on near-term technologies and opportunities. Because of that focus, this forum would seek venture capital backed companies offering products and services relevant to the next generation of ICE, hybrid, and battery vehicles. The first forum would be offered in early 2010.

Second Forum

In contrast, the second forum would focus on advanced technologies or business models³ that offer longer term payoff. Consider, for example, the opportunities that increasingly dwell at the convergence of the three distinct business models shown in Figure 2 below:

- Those of the auto companies, now requiring innovation by suppliers at all tiers, but able to benefit from systematic contact with entrepreneurs and new ventures;
- Those of the energy companies, traditionally commodity energy providers, but now facing competition from “smart” electricity; and,
- Those of the information and communication companies, offering smart devices and systems that manage electric energy onboard vehicles, among energy-using devices, and within smart grids⁴.

Entrepreneurial companies operating in that convergence would be among those invited to the second forum.

³ By “business model” we mean the formal explanation of the forces behind a company’s present and anticipated success--how the firm will create value for its customers and the public, and how it will capture enough of that value to provide a return for its investors.

⁴ The “information and communications” business model includes Google, which announced its entry into the micro-grid market in February of 2009. AT&T, Verizon, and Microsoft followed later that year with similar announcements.

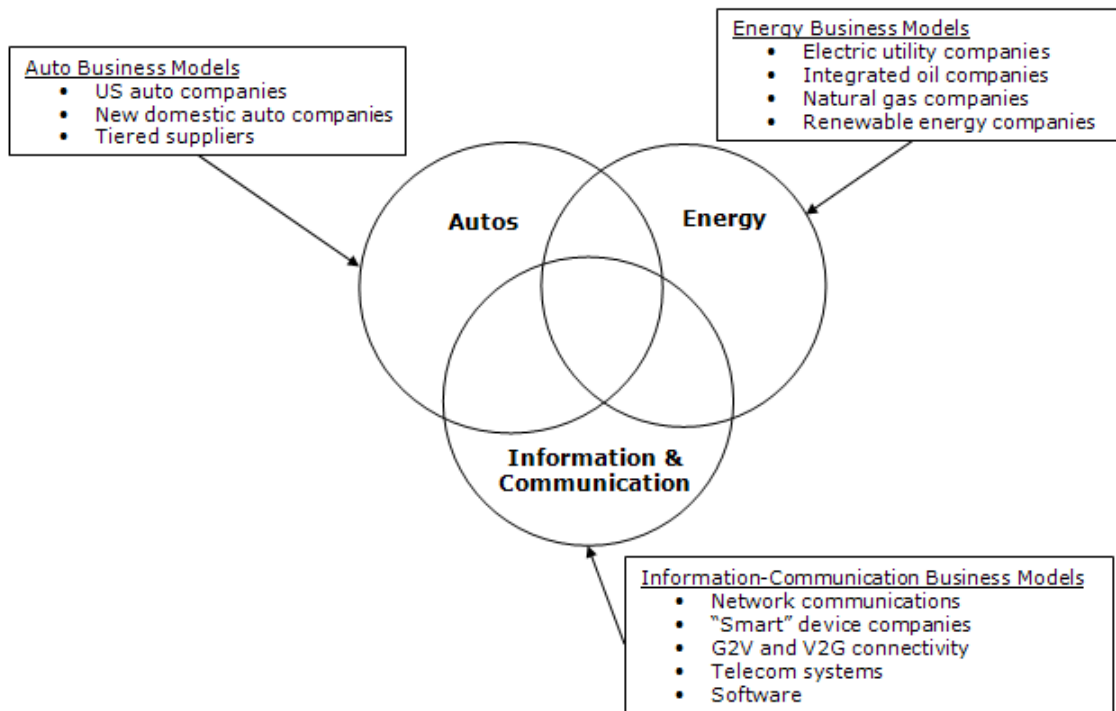


Figure 2 - Convergence and Opportunity

Venture companies participating in the second *AutoVenture Forum* might or might not be supported by professional venture investors, but all would be vetted by some external agency and by the project team. The second forum would be held in the Spring of 2010.

A third wrap-up meeting of the partners, together with selected invitees, will be held in the summer of 2010 to analyze the results. From this meeting will come a set of proposals to the Department of Energy (funder of the original Clemson grant) and to the auto industry to support the Incubation Phase of the project, which we now imagine to occupy three years. During this phase, the project team will introduce additional services, especially those that enable entrepreneurs without professional investment support to build their ventures to the maturity required for participation in the forum.

Beyond the Incubation Phase, we anticipate that the network innovation model will become fully self-sustaining by providing value commensurate with its cost to operate.

APPENDIX B. THE INSUM PROPOSAL

Innovation Network for Sustainable Mobility:
Accelerating the Transition in Autos and Energy

INSuM Project Team
Clemson University⁵

We propose a fundamentally different innovation process for the transition to sustainable mobility—an open-source innovation network that would enable collaboration among entrepreneurs, corporate innovators, technologists, investors, and customers independent of their location. The network could speed the sustainability transition by connecting the innovative capacity of entrepreneurs with the systems integration, manufacturing, and market channels of the industry incumbents.

We are now seeking strategic partners to join in designing and implementing this innovation process, which we call the *Innovation Network for Sustainable Mobility* (INSuM). With startup funding from a Department of Energy grant, INSuM will link entrepreneurs and industry incumbents through high-value services such as market access, technology demonstration and validation, rapid prototyping, investment capital, and other services described in Appendix A.

As the INSuM process grows in scope and capacity, we can expect:

- Job creation through the success of new ventures nationwide;
- A more innovative and economically competitive auto sector; and,
- A more rapid and efficient transition to sustainable mobility for the auto and its fueling infrastructure.

THE TRANSITION TO SUSTAINABLE MOBILITY

We use the term “sustainable mobility” to include three essential goals:

- Improving national and economic security by depending less on oil;
- Reducing the environmental footprint of road transportation;
- Building an economic and profitable auto sector with the help of more agile innovation processes.

⁵ Concept developed at Clemson University under a two-year grant from the U.S. Department of Energy. For further information, please contact: Dr. David Bodde, 864-508-0571, bodde@clemson.edu; or Robert Leitner, 864-656-2267, rleitne@clemson.edu.

Achieving these goals requires a patient revolution—*patient* because their full realization will be marked in decades, not in years; a *revolution* in that the current infrastructure of autos and fuels, which has served well for over 100 years, must give way to something else. The process of inventing that something else can benefit from the systematic engagement of entrepreneurs and innovators in the United States and around the world.

WHY ENTREPRENEURS?

Revolutionary technologies from steam to microelectronics have been launched by entrepreneurs and not by industry incumbents. But to achieve their full impact, all these technologies eventually made the transition to large, integrated systems—Edison’s Menlo Park laboratory became General Electric, the Bell Telephone Company became AT&T, Bill Gates’ startup became Microsoft, and so forth. Our thesis holds that the urgent transition required for sustainable mobility can be accomplished more effectively if the innovative technologies of the new, entrepreneurial companies enjoy better opportunities to link with the systems capabilities of the industry incumbents.

THE OPPORTUNITY

Entrepreneurs are especially active at the interface among the traditional business models for auto companies and energy companies because many attractive opportunities to accelerate the pace of change reside there. New technologies and business concepts now offer compelling opportunities as three traditional business models,⁶ formerly distinct, converge around the electric drivetrain vehicle⁷. These traditional business models (illustrated in Figure 1, following page) include:

- Those of the auto companies, once vertically integrated, now requiring innovation by suppliers at all tiers, but still lacking systematic connections with entrepreneurs and new ventures;
- Those of the information and communication companies, offering smart devices and systems that manage electric energy onboard vehicles, among energy-using devices, and within smart grids⁸; and,

⁶ By “business model” we mean the formal explanation of the forces behind a company’s present and anticipated success. It is the shared story of how the firm will create value for its customers and the public, and how it will capture enough of that value to provide a return for its investors.

⁷ Within the term “electric drivetrain vehicle” we include hybrid electric vehicles, plug-in hybrid electric vehicles, hydrogen fuel cell vehicles, and all-electric vehicles. Each of these can be considered a mobile infrastructure of electronic systems that provide motive power, information, navigation, entertainment, and similar services.

⁸ For example, the “information and communications” business model includes companies like Google, which in February of 2009 announced its entry into the micro-grid market, connecting energy-using devices to each other, to electric drivetrain vehicles, and to distributed sources of electric generation. AT&T and Verizon followed with similar new-ventures announcements in March of 2009.

- Those of the energy companies, traditionally commodity energy providers, but increasingly facing competition from “smart” electricity and renewable electricity generated from distributed sources.

In isolation, the current business models of auto companies, energy companies, and information/communication companies cannot take full advantage of the opportunities at the intersection of these domains. To fully succeed, corporate innovators need to draw upon the worldwide entrepreneurial community, the abundance of new ventures funded by professional investors and offering creative business models and innovative technologies.

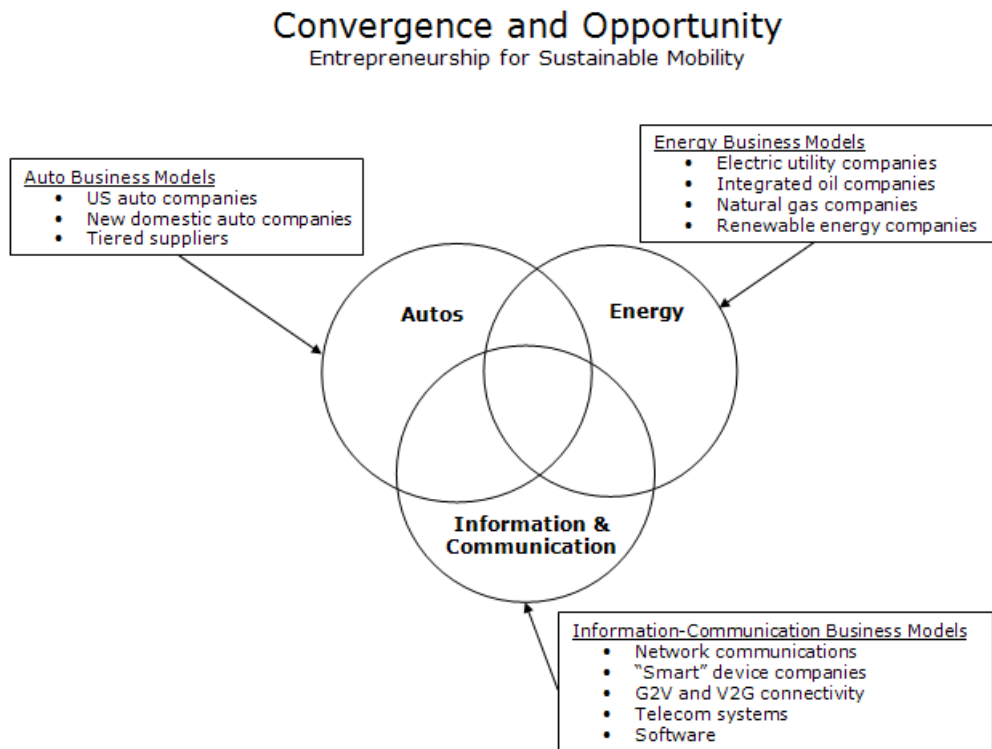


Figure 1

Within this convergence of business models can be found game-changing opportunities that would accelerate the pace of change. For example, consumers could realize more value from their plug-in hybrid or all-electric vehicles if they had the opportunity to recharge at any place and time. That would extend the electric range of these vehicles independent of the pace of battery improvements. Further, the energy supplied to the recharging stations could be derived, at least in part, from renewable sources. And because the renewable energy could be stored on vehicles at the value of transportation fuel rather than the price of grid electricity, many electric utility companies would find an incentive to meet their renewable portfolio requirements in

vehicle charging. Thus, any parking spot so equipped could become a marketplace where vehicles exchange electric energy with each other, with the grid, and with local renewable electric generation.

A network process can bypass the limitations of vertically integrated innovation models to realize opportunities like this. And in doing so, network innovation could accelerate the transition to sustainable mobility.

ORGANIZATION AND OPERATION

The Innovation Network for Sustainable Mobility (INSuM) serves as a bridge between the innovative capacity of entrepreneurial ventures and the systems integration, manufacturing capacity, and market channels of the industry incumbents. Experience gained in other open-innovation processes suggests that INSuM can execute this mission most effectively by operating under the following principles:

1. Neutrality INSuM must remain pre-competitive, a good-faith broker for all partners. It must be a catalyst for opportunity, but not become involved in deals between partners. Here, fact and perception must align well.
2. Leverage INSuM should reinvent nothing, but rather adapt success from experiences gained elsewhere.
3. Learning The first business model for INSuM is unlikely to get everything right—thus INSuM must learn from its own experience and adapt effectively.
4. Partnership The value of a network is proportional to the number of active members. Thus, INSuM should attract a variety of participants and remain open to new members whose presence can add value.
5. Service Designing and delivering useful, cost-effective services will prove essential to attract entrepreneurial ventures. A healthy “deal flow” of partnering opportunities provides the greatest value for the industry participants.

Figure 2, on the following page, illustrates how INSuM could be organized. The network would contain four basic components: (a) a Management and Operations Group to organize and maintain the network and its services; (b) a set of state and local entrepreneur support agencies as partners; (c) a set of industry partners; and (d) a set of specialized service providers, who provide specific services upon request, but are not considered partners in the INSuM network.

Management and Operations Group

INSuM will require leadership, administrative, and governance functions for the network to operate and maintain its services. Most fundamentally, the management and operations function would not itself provide most entrepreneurial services, but rather would seek out the most qualified providers nationwide. (Appendix A, below, describes the complete set of service packages.) In cases offering exceptional opportunity, INSuM might provide funds to procure the needed services. In addition, the management team would nurture and refresh the network itself, and establish and maintain a brand identity for the packaged services.

Because the management group would not provide most services, it could remain small, perhaps limited to 20 people when the network fully matures. Limited size would minimize overhead expenses and leave most funds for projects and outreach. Nevertheless, INSuM will need a source of revenue to exist, most likely an annual subscription from the industrial partners with some contributions from the entrepreneur partners as well. In addition, government support would be sought in due recognition of the public mission of INSuM. The management group would operate the INSuM under a Board of Directors and a governance process to be devised with the partner and supporting institutions.

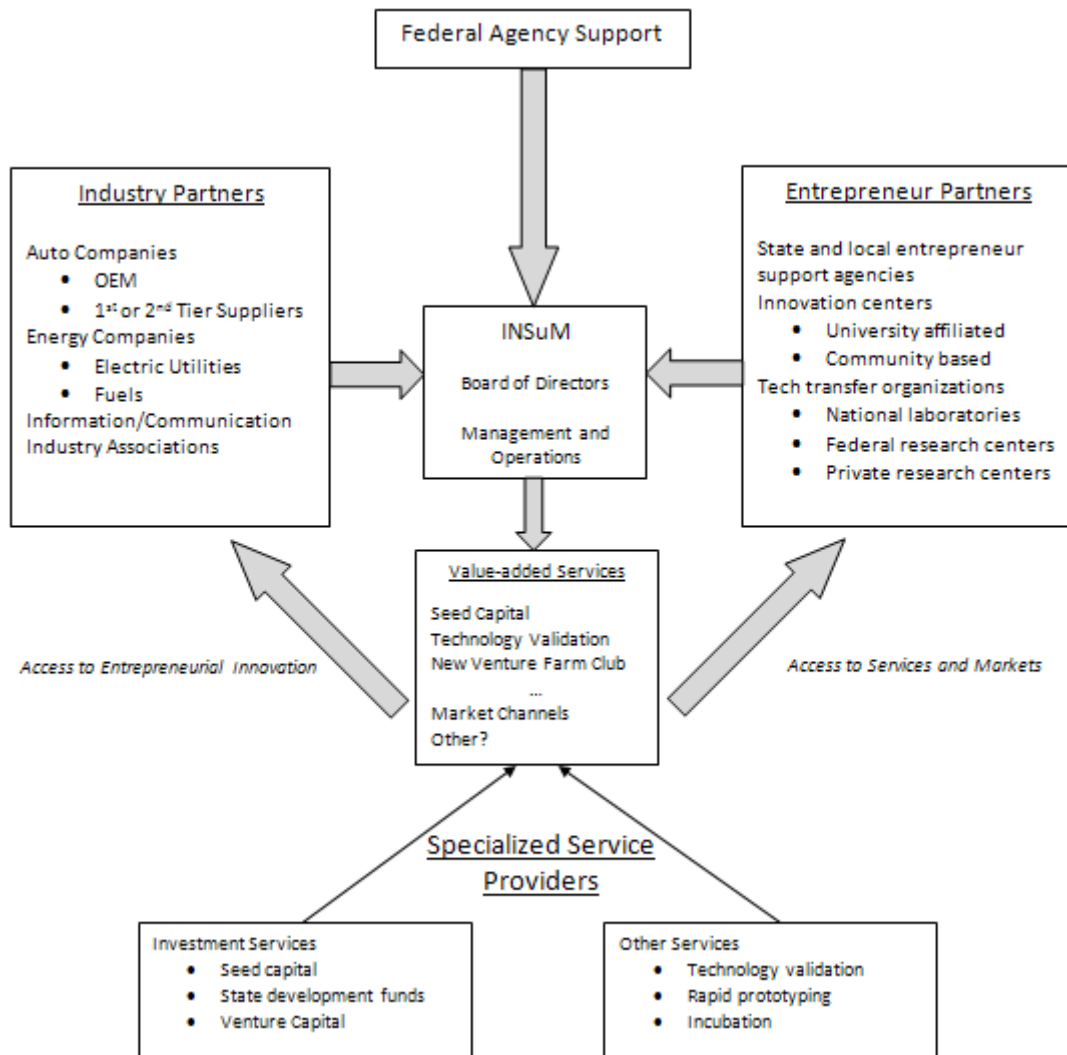


Figure 2 – INSuM Network and Organization

Entrepreneur Partners

INSuM would secure the “deal flow” needed for open-source innovation through partnership with state and local entrepreneur support groups. That channel would serve two primary purposes: (a) ease the administrative burden of maintaining contact with new ventures around the nation; and (b) provide some first-level validation mechanism for the quality and maturity of the new venture.

In return, the entrepreneur support agencies would gain an important outlet for their participating enterprises, and hence stronger economic development opportunities. They would be expected to contribute something to INSuM support, as free goods tend to be valued at just that price.

Industry Partners

Industrial partners could include energy companies, auto companies (and suppliers), and information/communication companies. Equally important, associations of companies participating in the sustainable mobility market would be invited as partners. These partners would gain timely, cost-effective access to a wider range of technologies, teaming opportunities with entrepreneurial ventures, and investment opportunities—the well demonstrated benefits of an open-source innovation process. (See Appendix B, also below) Industry partners would provide financial support for the INSuM network.

APPENDIX C. SERVICES FOR NETWORK INNOVATION

COMPONENT SERVICES FOR NETWORK INNOVATION

The value of an open-innovation network depends on the number and quality of its participants. The principal challenge for INSuM will be to attract a high quality deal flow of entrepreneurs and new ventures. To achieve this, INSuM will develop and market a set of services to provide entrepreneurs with a superior opportunity to build their enterprises while serving the transition to sustainable mobility.⁹

As a practical matter, most of these services would probably be performed by specialized support organizations participating in the innovation network, thus taking full advantage of unique competencies and investments already in place. For example, vehicle-grid compatibility might be tested through the Electric Power Research Institute (EPRI), and the effect of an innovation on the overall performance of the vehicle system at Argonne National Laboratory. If a venture capital service is initiated, it might be operated by an entirely separate entity, governed but not operated by INSuM.

Technology and Market Validation

Neither seed capital investors (also termed “angel” investors) nor venture capitalists have demonstrated an enthusiasm for funding technology development projects. Hence, entrepreneurs with advanced technologies at the proof-of-concept stage find it difficult to secure the resources needed for demonstration or market research. Recent evidence shows that proof-of-concept services can accelerate the pace of innovation by offering third-party confirmation of the performance of the underlying technology or of the market demand.¹⁰

To meet this need, technology and/or market validation could be offered through specialized laboratories located throughout the network of partner institutions. A source of funding would be needed to support this service.

Systems Validation

In addition to validating the stand-alone characteristics of component innovations, their performance could be estimated within the larger context of the complex geometry and functions of contemporary road vehicles. Such services would be offered through a variety of partner institutions, including Argonne National Laboratory (hardware-in-the-loop), Oak Ridge National Laboratory, or Clemson University’s International Center for Automotive Research.

⁹ *Transitions to Alternative Transportation Technologies: A Focus on Hydrogen*. Committee on Assessment of Resource Needs for Development of Fuel Cell and Hydrogen Technology, National Academy Press, National Academy of Sciences, Washington, D.C. August 2008.

¹⁰ See, for example, *Proof of Concept Centers: Accelerating the Commercialization of University Innovation*, Ewing Marion Kauffman Foundation, January 2008.

In addition, some special demonstration facilities might be constructed—for example a facility to explore alternatives for refueling electric vehicles. Rapid prototyping for whole-vehicle test and demonstration could become an essential validation service. As above, a source of funding would be required to develop this capability.

Channels to Market

Incumbent companies could seek specific product offerings, technology partners, and/or business partners through the INSuM network. This could provide an important channel to market for the entrepreneur members and significantly increase the value of their participation. Similarly, new enterprises could market their solutions to the industry through the INSuM.

Solutions Network

The pace of innovation could be accelerated if innovators and entrepreneurs could gain access to a wider pool of technology solutions. A “solutions network” could accelerate the innovation cycle of auto, fuels, and infrastructure companies by posting technology needs for which entrepreneurs and independent technologists can propose solutions, presumably with the expectation of some economic reward.

In other industries (computers and life sciences, for example) prizes offered by individual companies for the solution to specific technology challenges have proven effective in accelerating innovation. Offering these prizes through a neutral third-party like INSuM could provide a wider pool of participants, including members of the INSuM partnership itself.

Early Stage Seed Capital

Investment for the early stage company is like blood for the human body—there are not many good substitutes for it. However, venture capital investors have tended to migrate away from early-stage companies to focus on more mature investments. Even some Angel networks have drifted toward later-stage investment. Seed capital could be offered as another service of INSuM in consonance with the services above. This could be offered through established investment organizations or perhaps through a specially constituted venture finance arm operating under the governance and charter of INSuM. Investors could include the incumbent auto/fuels/infrastructure companies as well as independent investors.

However organized, an early-stage venture investment fund could support the mission of INSuM in several ways:

- Stimulate innovation for sustainable mobility, much as the Small Business Innovation Research (SBIR) program does for mission-agencies of the federal government;
- Provide a window on new technology developments and on emerging threats and opportunities for the investment partners;
- By including entrepreneurial ventures, broaden and deepen the supplier base and diversify the supply chain;
- Leverage the venture investment resources of the INSuM partners; and,

- Provide an attractive return to the investors in the fund.

A New Venture Farm Club

Few baseball players enter the major leagues directly, but rather improve their skills with a few years in a “farm system.” Similarly, an INSuM farm system could begin preparing entrepreneurs well before they are ready for professional venture investment.

Numerous models for this can be found. For example, the *NextStart*¹¹ program in upstate South Carolina provides entrepreneurs with mentors, technical assistance, business plan development, connections with market opportunities and with other entrepreneurs, and limited funding (\$10,000 limit). The core idea is to prepare new ventures to compete effectively for first-stage investment or for proof-of-concept funding from the federal SBIR program. Thus, INSuM could provide the “farm system” for the seed capital fund discussed previously.

The farm club concept might be adapted to sustainable mobility in partnership with institutions of special competency like the Ewing Marion Kauffman Foundation, which focuses on improving methods for entrepreneurial support.

Center for Lessons Learned

Much is being learned throughout the auto/fuels sector about innovation in the complex business environment of the automotive transition. But these lessons are neither systematically captured nor widely disseminated. A networked “Center for Lessons Learned” could achieve this. In addition, it could collect data on the performance of vehicles and fuels in the hands of customers or in demonstration fleets.

Lessons from the entrepreneurial sector could become especially valuable for public policy development. The American economy draws strength from its ability to experiment, and entrepreneurial startup companies become the *drosophila* of this economic laboratory. Real-life experimentation has proven effective in industries like biotechnology and software. There, dozens of business models might succeed, and no one can know in advance which will and which will not. Entrepreneurs, investors, and participating companies could draw benefit from the networked delivery of lessons learned from the auto-fuels markets.

Workforce Development

A skilled workforce is essential to any technology revolution. INSuM partners, working with community colleges and technical schools could help ensure that the relevant technical skills become available on a timely basis.

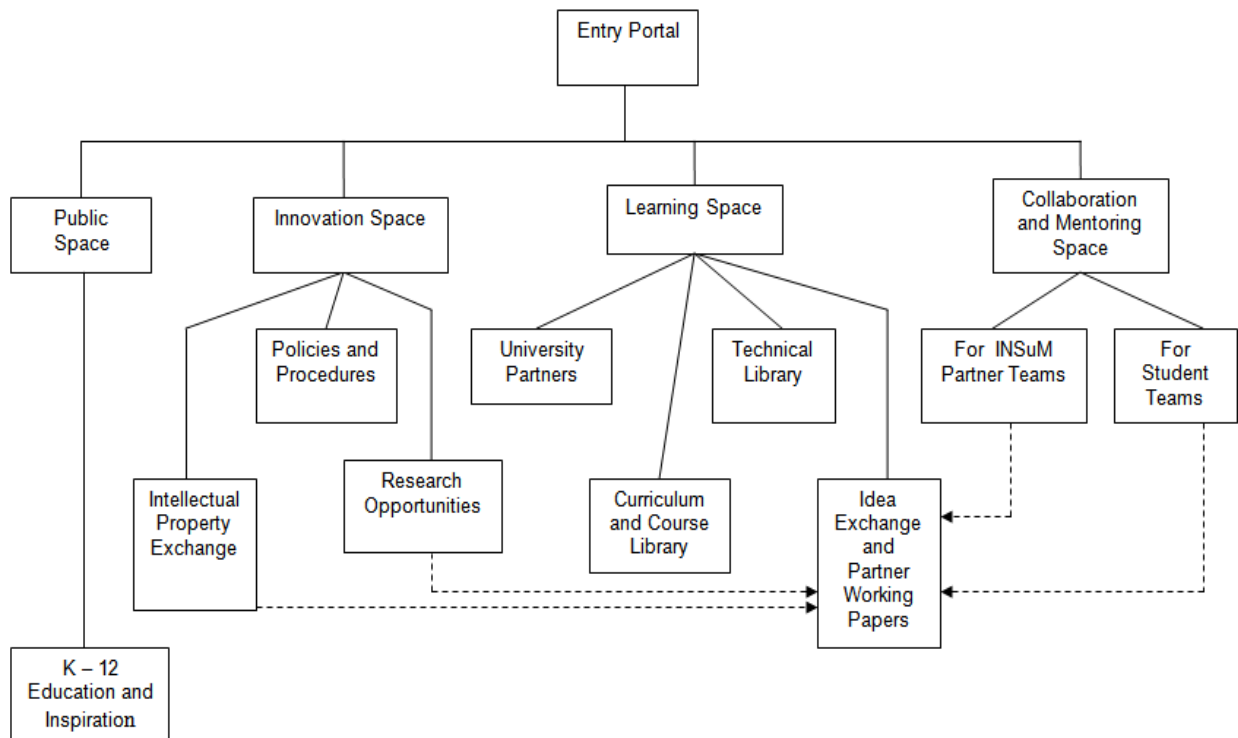
Internet-Enabled Working/Collaboration Space

Open-architecture collaboration might be implemented in part through an Internet-based platform. Three operating characteristics could distinguish this open-architecture platform:

¹¹ Full description available at: <http://nextstart.org>

- Offering synchronous or asynchronous collaboration and communication, thus helping the innovation process depend less on geographic proximity;
- Enabling learning and collaborative research by partner companies and institutions, either on a non-proprietary or a secure, proprietary basis as required; and,
- Growing in scope and capacity as the open-architecture network accumulates the experience and learning of its members, thus creating a virtuous cycle of use and value.

In addition to the generally open collaborations envisioned here, the internet platform will need private spaces where proprietary information can be discussed. These must be protected with the vigilance and security now provided for financial transactions, a function of either the management and operations group or perhaps some third party. The figure below sets out a preliminary illustration of some of the elements that might be included within a working/collaboration space.



APPENDIX D. THE NETWORK INNOVATION PROCESS

NETWORK INNOVATION

A “network innovation process” would not replace the current RD&D processes of the established industry. Instead, it would supplement those business processes by providing access to a wider field of advanced technologies and innovative ideas, especially those arising from outside the domain of traditional business models. Indeed, the most attractive opportunities to accelerate the pace of change reside at the interface among the traditional business models for auto companies, intelligence companies, and energy companies. In that business environment, competitive success requires a wider field of vision than vertically integrated business models can afford.

Network innovation works through intermediate markets, a process in which networks of companies—some sources of technology ideas, some market ideas, some manufacturing, some intellectual property, and so forth—participate in value creation and value capture.¹² In the auto/energy transition, a network-enabled innovation process could offset many of the inadequacies of the current practice and become the industry standard for complex, advanced-technology projects—those with high risk arising from multiple participants, untried technologies, and uncertain consumer preferences. These networks can provide a highly effective supplement to traditional RD&D processes, and in some cases have changed the basic character of vertically integrated innovation.

Consider computers and pharmaceuticals, for example, which have seen intermediate markets emerge to fundamentally change the traditional business models for innovation. The computer industry has become progressively less integrated since the 1960s. Specialty firms now push the frontiers of research, innovation, and manufacturing for the chips, the chip fabrication plants, displays, games, and so forth. Thus, the computer industry has become more of a network and less a competition among self-sufficient, integrated companies.

The network we propose would provide a platform for a national, perhaps global, open innovation process. Incumbent companies would gain a more rapid cycle time for innovation,¹³ and entrepreneurs would gain access to value-added services tailored to sustainable mobility.

¹² Ashish Arora, Andrea Fosfuri, and Alfonso Gambardella *The Economics of Innovation and Corporate Strategy*, MIT Press, Cambridge, Massachusetts, 2001.

¹³ Gary P. Pisano and Roberto Verganti “Which Kind of Collaboration is Right for You?” *Harvard Business Review*, December 2008, pp. 78-86.

APPENDIX E. LETTER TO INTERVIEWEES

Information about Being in a Research Study

Clemson University

8 March 2011

**The AutoVenture Forum: how open innovation networks can accelerate
innovation**

Description of the Study and Your Part in It

Dr. David Bodde with John Skardon are inviting you to take part in a research study. Dr. Bodde is Professor and Senior Fellow at Clemson University. John Skardon is a Phd student in policy studies at Clemson University, running this study with the help of Dr. Bodde. The purpose of this research is to investigate how the AutoVenture Forum, as an example of an open innovation network, can accelerate the rate of innovation within an industry.

Your part in the study will be to respond to questions from Mr. Skardon regarding the recent AutoVenture Forum held on September 22, 2010.

It will take you about 30-45 minutes to be in this study.

Risks and Discomforts

We do not know of any risks or discomforts to you in this research study.

Possible Benefits

We expect that you may experience some benefits from participation in this survey.

Benefits can include: a) a broader understanding of how open innovation may be implemented at the company, region or industry level, b) a better understanding of the potential benefits and value propositions that may accrue to participants in subsequent forums, and c) new ideas on collaboration and open business models for your organization. We also intend to publish a summary of the survey to the participants.

Protection of Privacy and Confidentiality

We will do everything we can to protect your privacy and confidentiality. All participants and their responses to the survey will be assigned an alphanumeric code that is kept solely by the principal investigators. No individually identifiable comments or answers to specific questions will appear in any publication. We will not tell anybody outside of the research team that you were in this study or what information we collected about you in particular.

Choosing to Be in the Study

You do not have to be in this study. You may choose not to take part and you may choose to stop taking part at any time. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study.

Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact Dr. David Bodde at Clemson University at 864-508-0571. If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-6460 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC's toll-free number, 866-297-3071.

A copy of this form will be given to you.

APPENDIX F. THE INTERVIEW INSTRUMENT

The AutoVenture Forum: how open innovation networks can accelerate

Innovation

Survey for organizers, participants

John Skardon

Clemson University

DO NOT COPY | DO NOT DISTRIBUTE

Contact Process

Contact attendee via phone. Leave message or explain to attendee the purpose of the call, confirm a date and time for the interview.

Follow-up with email and letter

Sections

Applicants who submitted documents but were not selected to present

Applicants who submitted documents and were selected to present

Auto Industry Companies and Suppliers

Government attendees

All other attendees

READ TO ALL INTERVIEWEES

Good (morning/day). My name is John Skardon. I am a doctoral student at Clemson University. I am calling about an email you may receive from me concerning the AutoVenture Forum: an investment conference accelerating innovation in the automotive industry that was conducted in September 2010 In Detroit. The purpose of this call is to follow-up on the conference and ask a few questions about the event. This data is being collected as part of my Phd program. No identifiable information about you or your organization will appear in any public documents. However I will make available to you, a summary of the interviews that I conducted as part of my research. May we continue? I would prefer to record this conversation so that I may accurately transcribe it later. Is that acceptable to you? No electronic copy of the recording will be made available to any outside person or organization except my dissertation advisor, Dr. David Bodde. I can provide you with a copy of the recording if you would like to have one for your records.

If the interviewee says “NO”, then go the section and transcribe manually. If the interviewee says “YES”, then turn on the VOIP recorder and begin the interview.

This survey will take between fifteen and thirty minutes of your time. We can skip any question that you do not want to answer.

APPENDIX G. SAMPLE QUESTIONNAIRE USED IN SURVEY

1. SKIP: Confirm that the role at the event was either presenter or company representative.
2. How important were your personal or professional contacts or membership in organizations in learning about the AVF or influencing your decision to attend?
3. Is your company located close, within 100 miles or so, of a major university or automotive facility? Do you have business relationships with either?
4. Do you have any other university or research lab associations that are very important to your business?
5. How do plan to leverage your intellectual property, such as patents and proprietary know-how? Have you considered licensing your property or acquiring licenses to other property that could strengthen your company's business model?
6. Was your participation in the AVF forum valuable?
 - a. Can you provide some specific examples?
7. What were your costs of participation in the AVF? What were the benefits?
8. Overall, what was the primary value you/your company gained from presenting and attending the event?
9. What problems did you encounter in explaining or discussing your company's value proposition to the audience during the breakout sessions?

10. What kind of new relationships did you form at the event? Of these relationships, which have been the most valuable to your company? Why?
11. Since your presentation at the AVF, please describe any interactions you have had with major auto manufacturers or their suppliers.
12. What challenges and opportunities do you see in further developing a new business relationship with the auto industry?
13. How could the AVF staff facilitate your relationships with the auto industry beyond the investment forum? For example, should the AVF offer a “technology validation” service?
14. Apart from the auto industry representatives, the audience also contained a number of hand-selected venture capitalists, members of academia and members of state and federal agencies. Did the presence of any of these non-automotive industry attendees create any concern during your presentation or follow-on discussions?
15. Assume that the AVF becomes a formal organization that connects entrepreneurial startups and the auto industry and you have been invited to join:
 - a. What kind of institution should manage and run the AVF? For example: USCAR, or a for-profit intermediary such as a NineSigma? Other ideas?
 - b. How would you define the value of participation for your company?
 - c. What factors would encourage you to join?
 - d. What factors would cause you not to join?
 - e. Who else should be allowed to join the network?

- f. How should the cost of operating the network be paid?
- g. What kind of rules should be in place?
- h. Who should enforce those rules?
- i. Government (state and federal) see innovation as a way solve “social problems” such as reducing the number of car crashes or increasing employment through commercialization of new technologies. If government agencies were involved in a “formal” network version of the AVF, what should their role be?
- j. If you see a role for government agencies, is there a type or specific agency that should or should not be involved?

16.If another event in the automotive sector is conducted, will you be interested in participating?

17.May we contact you later for follow-up questions if our conversations with other attendees yield new insights?

Thank you for your time

STOP

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