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Innovation, Production, and Sustainable Job Creation: Reviving U.S. Prosperity

America's Two Systems of Innovation: Recommendations for Policy Changes to Support Innovation, Production and Job Creation

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I. Introduction

A strong bipartisan consensus is a rare Washington sighting, but there is one on the urgent need to promote innovation. Business leaders and scholars alike worry that our current rate of innovation is not sufficient to keep the economy prosperous. Furthermore, high levels of U.S. unemployment raise unsettling questions about whether our innovation system is still primed to create and maintain new jobs for Americans within their own country.

Innovation is the key to America's competitiveness. However, innovation needs to be understood more broadly than it typically has been. Conventional conversations about innovation focus on novel breakthrough developments that give rise to "game-changing" technology. This kind of innovation characterized the American economy for the past century and has generated enormous wealth and value for the nation. Nevertheless, the globalization of design, production, sophisticated manufacturing, and distribution requires a new approach to a second form of innovation—in processes and production, as well incremental product innovation—in order to avoid the risk of losing jobs and industrial capabilities essential to the competitiveness of the U.S. economy.

We argue that a strategy for manufacturing products and production innovation must recognize the growing interdependence of services and manufacturing in the new global landscape.[1] Such a strategy should focus on four building blocks critical to the fate of individual American firms. These form the foundation to address both market mechanisms and the building of social capital, a critical dimension of innovation systems. The four are:

1. Shared production assets: firms need to fund and use assets held in common by a variety of contractual and institutional mechanisms.
2. Effective innovation network structures: markets, contracts, and firms no longer provide an adequate "glue" for effectively linking together pools of innovators.

1 Both manufacturing and services are vital for jobs. A growing share of the manufactured products in which the U.S. has potential advantages is heavily intertwined with services (both in process innovation and in the final product package). Moreover, services themselves are an important part of the long-term picture for good wage jobs in America. We are interested in finding formulas to maximize innovation in a way that enhances prospects for all jobs in America.

3. Flexible business models: restructuring the traditional definitions of supply and demand functions in markets is often as important as an innovative product.
4. Specialized financial institutions: risk assessment capacity and lending/investment models appropriate to different types of innovation are necessary.

We believe that the American policy model for supporting novel product innovation still largely gets these factors right. In contrast, policies for production and incremental product and process innovation have not provided these building blocks successfully. We base our conclusions on a study undertaken by the CONNECT Innovation Institute on how to promote both forms of innovation while strengthening the nation's employment base and maximizing the creation of U.S. jobs from our own innovations. We searched for answers using a two-fold strategy. In the first track, the Institute commissioned white papers from leading scholars of U.S. innovation practices to reveal and examine the issues. From these papers, we have synthesized some preliminary conclusions about both the direction and mix of reforms in innovation policies. In the second track, the Institute has engaged with a group of distinguished practitioners of innovation to synthesize their suggestions on how to improve the American capacity for innovation.

This paper has four parts: Section One identifies the primary forms of innovation. These distinctions allow us to show that the "conventional model" for U.S. innovation, which anchors the discussion of most policy makers and market participants, focuses almost exclusively on only one aspect of innovation. Section Two lays out several challenges that the conventional model of innovation largely neglects with regard to incremental product and process innovation. Section Three focuses on our four building blocks and offers suggestions on how policy could close those gaps and revitalize U.S. innovation in a way that would maximize U.S. job growth and sustainability. Section Four returns to the "conventional model" and uses the recommendations of our panel of practitioners to suggest updates to bring this model into the 21st century.

To tip our hand, we believe that the American economy, and its institutional structures, must adapt to the increasing globalization of the U.S. economy (a steadily rising share of gross domestic product [GDP] is attributable to trade and foreign direct investment) and ever growing, globally fragmented production of goods and services. There are two distinct, although sometimes interrelated, sets of challenges for American innovation. Whatever our fears are about rising foreign competition, the U.S. innovation system is still superb at novel-product/technology patentable (and trade secret-laden) innovation. Nonetheless, we argue in Section Four that it is highly prudent to shore up this leadership by adjusting the "conventional model."

In contrast, the research for this investigation shows that the focus of concern should be the growing inability of the U.S. innovation system to orchestrate the move from a novel-product-innovation centric approach to novel-production located in the U.S., as well as on generating sufficient innovation in products (and production) that are not high value-added items with novel properties. We call this latter track "process and incremental product innovation." Both of these shortfalls occur, we believe, because of weaknesses in our system of process and incremental product innovation. As Nate Rosenberg has clearly shown, process and incremental innovation are the true unsung heroes of economic growth.2 Therefore, we should be greatly concerned that:

a. High value-added innovations are no longer yielding the production and job base for America we assumed that they would.
b. The supply base of small and medium firms for middle value-added products which could benefit from supply chain factors is both dwindling and not truly innovative.

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2 Rosenberg, Nathan. 1983. Inside the Black Box: Technology and Economics. Cambridge: University of Cambridge Press; Rosenberg, Nathan and L.E. Birdzell Jr. 1986. How the West Grew Rich: The Economic Transformation of the Industrial World. New York: Basic Books.

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c. The changing mix of skills necessary for production and incremental product innovation in the small and medium enterprises (SME) supplier base falls outside of the range of core skills in traditional production shops.

d. Our system of financing innovation has become increasingly fragmented, focusing on specific financial vehicles (i.e., venture financing), which in turn specialize primarily in just one kind of innovation or one specific set of companies, and then necessitate a financial exit within a relatively short time frame.

Even if the U.S. does everything right, a substantial amount of production, whether of goods or services, will not be located in the U.S. Offshoring and outsourcing will continue to offer tremendous benefits to U.S. corporations and consumers.[3] We live in a global economy for both supply and demand. However, even taking this to account, less sophisticated production—and significantly fewer good jobs—exist in the U.S. than is possible due to structural flaws in our innovation system, particularly with regard to process and second-generation product innovations. These structural failures have long-term negative consequences for our economic prosperity, our ability to create jobs, our trade deficit, and the capability of American corporations to secure continuous competitive advantages, based on innovations that they themselves pioneered.

II. Innovation and the Conventional U.S. Policy Model

The Types of Innovation

Current American innovation policy is predominantly rooted in a skewed picture of innovation. Too often we associate innovation solely with the creation of novel products or technologies —the first lasers, mobile phones, or protease inhibitors. This emphasis confuses the act of invention with innovation. Innovation encompasses a whole array of activities that transform ideas in novel or better products and services that are actually sold and bought in the market.[4]

In a simplified form, we can think about innovation as occurring in two stages during the creation of products and services. First, there is the *novel product/technology innovation*, which covers the act of coming up with new products, such as the iPad, the first word processor, or new services such as Facebook (for social utility) and Quicken (for tax preparation). It is important to note that there is a growing interdependence between innovation in hardware and services—the iPhone gets much of its value because of complementary service innovations (mobile broadband, Apple's apps store, and iTunes). Second, *process and incremental innovation* applies to improvements in how goods or services are designed, produced, distributed, and serviced, including significant enhancements to "novel" products. It is here that the major impact on economic growth happens. It was not the act of inventing the internal combustion engine that in itself changed modern society—it was the wave of following innovations that both improved and put to use this innovation throughout the economy which ensured that impact. Some industries are less about rapid product innovation and more about continuous process improvements that alter cost and performance capabilities: think cars, refrigerators, or indeed, the last decade's personal computing. The argument about German manufacturing success gives special weight to its strength in precisely this kind of innovation. There are other kinds of innovation, not discussed here.[5]

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3 Furthermore, knowledge is a global good. Accordingly, innovation in other countries can powerfully benefit the U.S.

4 Innovation always implies a measure of added risk. But the level, type, and time frames of risk vary according to the type of innovation. Different financial institutions excel at mastering different forms of risk.

5 Product adaptation, as in the redefining of product characteristics to meet a specific market's needs (e.g., cheap reliable CT machines to be used in rural Asia) is a third major type of innovation. While important on a global scale, since most of this adaptation by its very nature needs to be done in specific regional context (often by multinational firms), we shall leave it outside

Substantial continuity or slow turnover in fundamental end products does not mean that considerable innovation is missing, more likely than not, it means the opposite. A former head of R&D of a global consumer products company pointed out to us that major consumer brands may seem in their essence more or less the same over time, but continually innovate significantly in the process technology underlying them.[6] Moreover, basic scientific research is also essential for both product and incremental and process innovation—the main difference is in the ways producers of science (such as universities and research institutes) and users of science (companies and entrepreneurs) interact to commercialize knowledge. We believe that the current U.S. system has hampered this relationship with regard to incremental and process innovation, which used to be one of the core strengths of American corporations.[7]

Innovation frequently implies more than changes in products or processes. It often requires major changes in business models that upset expectations about how markets work, and to whom a new set of products is aimed. Henry Ford's model T represented a perfect example of melding both process innovation and a business model innovation, perfecting the idea of mass production together with the mold breaking business model of pricing cars for all working households and paying Ford's employees enough so they become leading users of their own products. Similarly, Apple made the iPod into a breakthrough success because of product innovation and a business model revolution. The product was a slick hardware/software/service combination of the iPod and its music store. The new business model inverted the conventional wisdom on how to price. Instead of pricing the hardware as a cheap commodity and charging a premium for content Apple did just the opposite, the iPods were expensive and songs cheap, thereby turning songs once again into a product that customers were willing to buy (rather than rip them off from the web).[8] With the increasing global fragmentation of production, we need to pay careful attention to the role of business model innovation, the necessary inter-firm and inter-organization collaborations (as well as financial needs), as inputs to successful product and process innovation. Some of our suggestions for improving process innovation imply changes in business models.

The Conventional Policy Model and Novel Product Innovation

In the U.S., a unique "conventional policy model" about how to support innovation emerged from trial and error to dominate policy thinking beginning in the1970s. Overall, U.S. innovation policy is viewed as market conforming, i.e., policies and innovation institutions remove barriers and tweak the rewards to be gained in an effort to allow market mechanisms to complement actors that (under these tweaked conditions) are willing and able to undertake the types of risks and reap the rewards necessary to generate change.[9] In addition, this model is still based on a worldview which sees an individual firm as the main loci of all activities that need to be

our discussion.

6 Breznitz, Dan and Michael Murphree. 2011. Run of the Red Queen: Government, Innovation, Globalization, and Economic Growth in China. New Haven, CN: Yale University Press.

7 Accordingly, we are skeptical that, as David Brooks has speculated, innovation has peaked and therefore job creation stagnates. We think that a particular form of innovation lags and this hurts employment. We agree with Brooks that the solution rests in both reforms of market and social institutions. David Brooks, Where Are the Jobs?, New York Times, October 7, 2011, p. A23. On the need to revamp policy in this area also see Ezell, J. Stephen, and Atkinson, D. Robert. 2011 The Case for a National Manufacturing Strategy. The Information Technology and Innovation Foundation, DC, Washington.

8 On the iPod, see Huberty, Mark. 2012. The Dissolution of Sectors: Do Politics and Sectors Still Go Together? Chapter 7 in John Zysman and Dan Breznitz (eds). Can Wealthy Nations Stay Rich? Forthcoming. Oxford University Press.

9 See Arrow's seminal paper, Arrow, J. Kenneth. 1962. "Economic Welfare and the Allocation of Resources for Invention." Pp. 609-625 in The Rate and Direction of Inventive Activity: Economic and Social Factors, edited by R. R. Nelson. Princeton, NJ: Princeton University Press. Josh Whitford's paper for this project – Network failures and innovation in the New Old Economy – makes a similar point although he casts the notion more narrowly as a focus on market failures.

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carried out in order to produce a product and transform novel innovation into specific products. As such, some of its basic assumptions no longer conform to the global reality of fragmented production.

Coming out of World War II, a significant part of U.S. research spending and technology production was built around large enterprises doing complex innovations in both novel product and process and incremental product change; many of these enterprises work in both the defense and civilian markets (Boeing and GE, for example). These major firms had enormous financial and human capital resources including (as William Lazonick argues in his award winning book) a substantial pool of "patient capital" for innovation that could be invested without expectations for rapid returns.[10] Many of their calculations dealt with tax policy (such as corporate income tax and the R&D tax credit) and policies influencing human resources (whether workplace rules or immigration policies for skilled researchers). Significantly, to an extent unimaginable today, they were highly vertically integrated. Thus, they "internalized" the tending of networking among their various specialist groups in different phases of design and production and they also internalized many of the financial risk management functions for innovation.

Since the major corporate restructurings of the 1970s and 1980s, vertical and horizontal integration has sharply declined in large firms in order to focus more keenly on "core competencies." This set of changes opened the way to a new landscape for innovation where a great deal of innovation is driven by new entrants (especially those that take off into rapid growth) that are focused on specific stages on production. This significant change was enabled, and in turn strengthened, the development of a new set of arrangements for financing and networking the fragmented ecosystem of the entrepreneurial model of innovation that has emerged.

The "conventional model" for technology policy in the U.S. since the corporate restructurings has tilted sharply towards novel product innovation. Although there are strong national policy components, the "conventional model" especially focuses on the intersection of the national with the regional in the form of technology clusters because universities are critical to both knowledge creation and human resource capital, building models on which clusters thrive.[11] Moreover, an essential part of this revised model is the new laws and regulations that allowed and incentivized the creation of new financial vehicles, such as venture capital (VC), and the creation of new markets to allow the realization of financial gains on such investments within a short time span (such as NASDAQ). Regional technology clusters also worked hard to develop an ecosystem of professional support services for these specialized firms (e.g., law and accounting firms that could handle their unique problems). The great success of this technology start-ups-based model and the immense financial gains that accrued to both founders and financiers quickly made it the focus of policy discussions. New industrial clusters growing around emerging sets of technologies have become the policy mantra.[12] Serving the San Diego region, CONNECT represents one of the most successful cluster strategies in the U.S. The regional anchors, and supporting federal measures, made this "conventional model" politically viable in both "blue" and "red" states.

At its core, a successful technology cluster for novel product innovation addresses the challenges of both market failures and social/informational networking. Courting a committed base of venture capitalists attuned to the region, nurturing an angel investment community for the earliest stages of funding, and (in recent years) promoting incubators that lower costs and identify prospects for early investors are all activities in these clusters to address the costs associated with searching for finance when it is not a part of the innovation system (via

10 Lazonick, William. 2009. Sustainable Prosperity in the New Economy? Business Organization and High-Tech Employment in the United States. W.E. Upjohn Institute.

11 Florida, Richard L. and Martin Kenney. 1988. "Venture Capital-Financed Innovation and Technological Change in the U.S.A." Research Policy 17:119-137

12 Even traditional technology/engineering giants now make decisions about where to innovate and produce based on a larger ecosystem of supplier firms with which they work and their engagement with the innovation system of technology clusters.

vertical and horizontal integration within a firm). Significantly, common economic assets for new firms (such as expensive mass spectrometers) are often created; for example, an anchor university might rent use of its advanced lab equipment to the cluster's firms. And, most vitally, the clusters provide networking institutions for high-end technology specialists so that people circulated freely and knowledge was shared via countless varieties of events.

As cluster leaders routinely acknowledge, people are arguably the most important asset for novel product innovation industries. The clusters provide a social institutional solution for the loss through the 1960s of networks nested in vertically and horizontally integrated firms Research in economic sociology and geography has underscored that strong social networks, abetted by formal and informal institutions, are essential to the circulation of knowledge and people, and the resultant building of trust, that make for the most successful clusters, those that can adapt swiftly and repeatedly to new circumstances. One classic study attributed the divergent paths of the California and Massachusetts information industries primarily to the difference in their social institutional networks.[13]

As a backdrop to regional clusters, there are vital national policies which fund basic and some forms of applied research and development (R&D); fund the training of skilled researchers and engineers; protect the intellectual property that is central to ventures pushing novel technologies; and enforce competition rules that keep markets open to newcomers.

This conventional model has served the U.S. well for novel product innovation.[14] We argue that it will continue to do so thanks to four basic strengths:

1. Basic R&D and research universities—not only does the U.S. remain the dominant science research power, it has a great regional spread of specialized strengths because of its highly competitive system of research universities.
2. The U.S. is still the best place for early commercialization of new ideas—only Israel is a reasonable second. The strengths of the U.S. include strong rule of law, relatively easy entry into markets, and a deep market of entrepreneurs and professional services.
3. Hidden U.S. strengths include sophisticated user base that coinvents and flexible value and business propositions—where you make your money and how you do so can be surprising and innovative.
4. The U.S. has the world's best system for mobilizing financial resources for ideas, from small initial investment to "almost large," promising start-ups can, within their first few years of operation, attract $200-400 million dollars without this being seen as an anomaly.

Still, even for novel-product innovation—as the panel of CONNECT practitioners have noted—there is a need for updating the model, especially in light of rising international competition and the increasing global fragmentation of production and innovation. In particular, the panel expressed worries about financial incentives, including the tilt in U.S. government funding for basic and applied research. Section Four of this paper summarizes some of the solutions that they recommend to update the model.

III. The American Economy's Unfinished Adaptation to New Global Realities: the Faltering of Incremental Product and Process Innovation

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13 Saxenian, Annalee. 1994 Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Harvard University Press.

14 Adam Segal, Advantage, Norton, 2011. Peter Cowhey and Jonathan Aronson with Don Abelson, Transforming Global Information and Communication Markets, MIT Press, 2009, Chapter 5. Dan Breznitz and Mike Murphee, The Run of the Red Queen, Yale University Press, 2010.

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Even if the U.S. retains its leadership in novel product innovation, U.S. leadership in second generation, incremental, and process innovation is in deep trouble. Process innovation is both an input to product innovation, especially incremental innovation, and a key to maintaining the highest feasible level of production activities, and hence, employment opportunities, in the U.S.[15] The failure to get process and incremental innovation policies right weakens the employment benefits made possible by novel product innovation. In some cases, as Erica Fuchs' paper shows in both more traditional industries such as automobile and high-tech industries such as optoelectronics, these failures critically weaken the long-term ability to sustain novel product innovation.[16] Thus, we must address the task of fixing these gaps in order to ensure our continuous economic prosperity, ability to create jobs, decrease our trade deficit, and enhance the capability of American firms to secure continuous competitive advantages, based on innovations pioneered by Americans.[17]

Our main recommendations are based on two observations.

First, the way in which products and services are now produced has significantly changed in the last two decades, yet the main assumptions underlying the model remained the same. We now live in a world of increasingly fragmented production. Activities along the production networks are done by companies specializing in narrower set of activities, from high level R&D, to design, manufacturing, and assembly. The innovation and financial needs of companies in different stages along this network are significantly varied; this fragmentation leads to the necessity of establishing new ways to collaborate across companies and across different modes of operation. We live in a world of networks between companies and organizations, not a world of working internally within one company. Therefore, we must develop and implement policies whose aims are to solve semi-public good supply problems, such as shared production facilities, training, and codevelopment of non-patentable innovation. The supply of these semi-public goods has become a critical issue in the most advanced high-tech industries, where, for example, in both optoelectronics and biopharmaceuticals, production facilities are usually not firm specific, and hence, no sole U.S. firm, especially young firms with limited revenues, can (or should) invest in building the latest, most advanced production facilities by itself.[18] *Accordingly, the need to fix network failures, and not focus solely on market failures, is growing daily due to the changes in the global production system.*

Second, however unintentional, a combination of incentives discourages large capital investment in production and production innovation in the U.S. This mix includes the growing focus of the conventional model on start-ups and novel product innovation; the current financial constraints under which U.S. public companies operate; and the character of financial vehicles open to private companies. Together, these factors make it hard

15 This point was forcefully made by John Zysman and Stephen Cohen previously in 1987 (Manufacturing Matters: The Myth of the Post-Industrial Economy, Basic Books). Lately it has been strengthened and shown to be even more potent today by multiple studies, for example: see the Stephen Ezell and Robert Atkinson, ibid; Suzanne Berger, Why Manufacturing Matters? (Technology Review, July 1st 2011); The Council on Competitiveness, 2011, Make: An American Manufacturing Movement; and Helper, Susan, Krueger, Timothy and Wail Howard Wial. 2012. Why Does Manufacturing Matter? Which Manufacturing Matters? A Policy Framework. Brookings Instituttion.

16 Erica Fuchs, R.H. 2012. The Impact of Manufacturing Offshore on Technology Competitiveness: Implications for U.S. Policy. Connect Innovation Institute White Paper: Project on Production Innovation.

17 To repeat, globalization means that significant amounts of production and employment will be created and remain outside the U.S. But higher rates of incremental product innovation and process innovation can greatly improve American production and employment.

18 As a corollary, we note that these fragmented networks can misalign the interests of the state and the tax payers, who pay for innovation policy with the expectation of higher returns to their locale, and the interests of companies, which are increasingly global. See, Breznitz, Dan and Amos Zehavi. 2010. "The Limits of Capital: Transcending the Public Financier - Private Producer Split in Industrial R&D." Research Policy 39:301-312.

to take risks on long-term capital investments whose payouts are hard to reconcile with quarterly earnings expectations or investment models based on cashing out with very high returns in the medium-term (e.g., seven years or less). These constraints, coupled with the growth of foreign-based contract manufacturers, lead, even in the most advanced manufacturing of the most advanced niches of the high-technology industry, to more and more jobs in the U.S. never being created.

The result of this inability of the U.S economy to adapt has been a failure to develop the four building blocks essential to successful process and incremental product innovation in America:

1. SMEs suffer from inadequate common assets to complement firm-specific assets. The changing mix of skills necessary for production and incremental product innovation falls outside of the traditional core.
2. SMEs lack strong networking institutions to foster sharing of know-how and social capital. This system of innovation requires more than the circulation of smart people—context and craft-oriented innovations require more structured forms of networking.
3. The legal and regulatory systems do not block business model innovation, per se, but many SMEs depend on subcontracted work. Our studies indicate that the rules and practices for subcontracting in the U.S. do not foster innovation.[19]
4. The U.S. currently lacks financial institutions with the proper business models and sufficient risk assessment capabilities to analyze and invest in production SME firms.

Accordingly, our high-level recommendations of how we need to rethink innovation policy to strengthen these building blocks cluster into two major themes:

- <u>Moving from regional networks to regional platforms:</u> Innovation and production are now, more than ever, done via semi-public goods provisions, such as shared production assets. These are the critical issue in more traditional industries, such as metal or the automotive industry, where there is a constant need to spur and diffuse innovation across an array of many SMEs. Thus, by definition, the ability of the innovator to appropriate gains is limited. Shared assets can be truly shared facilities, that is, a facility that is owned jointly by a few companies under a variety of contractual forms, or a private, for-profit organization focused on production for other companies. A successful example of the latter is Hospira, currently the world leader in the production in injectable pharmaceuticals, which started life when Abbot Laboratories decided to spin-off it production division. Creating shared assets, including training of workers, may mean introducing new business models. And, as a corollary, there will be a need to increase the range of financial options for different combinations of risk/reward situations involving innovations. The VC model does not fit these situations and the predominant mix of American finance practices does not yield satisfactory alternatives. Creating new options that do not require large subsidies is essential.

- Finding solutions to network failures for incremental product and process innovation specialists: Sharing solutions within a supply network or introducing skills that are

19 The findings of our team members Susan Helper and Jenny Kuan in the automotive production sector, in which two of the Detroit three were recently saved from closure only by very large injection of public finance, are especially worrying, as they suggest that leading American corporations face significant problems in adapting their mode of relationship with U.S. SMEs to the changing reality of global production. Helper, Susan and Kuan, Jenny. 2012. Overcoming Collective Action Problems in the Automotive Supply Chain. Connect Innovation Institute White Paper: Project on Production Innovation.

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largely absent from a network will be critical. As a first step, this requires bridging the knowledge silos of different industries and technologies. For example, it is becoming apparent that in the U.S., similar to the case in Israel (where a specific program has been launched by the Chief Scientists to alleviate these issues), production companies lack the most crucial new skills in areas such as information and communication technologies ICT, where the most promise for production innovation lies. More ambitiously, the U.S. has to find an appropriate model of the industrial research systems that have worked so successfully in Germany, Taiwan and Korea.

Let us now delve deeper into the findings of our scholars and practitioners and use them to offer a concrete set of recommendation to solve the main issues.

To illustrate the challenges confronting America, consider the role of the U.S.in manufacturing. Contrary to popular belief, as late as 2009, the U.S. was still the world's largest manufacturing economy (about $1.6 trillion in output), producing 21 percent of global manufactured products. China was second at 15 percent and Japan was third at 12 percent. Moreover, allowing for impacts of recessions, the level of U.S. manufacturing output continued to rise steadily year after year. This output supported about 1 in 6 private sector jobs (18.6 million supported, of which 12 million are directly in manufacturing). Yet, as Helper, Krueger, and Wial show, the larger picture for manufacturing was not healthy. Employment is sagging for reasons that are not reducible to rising productivity or uncompetitive wages and benefits.[20] As Whitford notes, Germany has high wages and high productivity in manufacturing, yet manufacturing maintains a much larger role in its economy (20% of GDP versus about 11% in the U.S.).[21]

For our purposes, findings in three studies (Helper and Kaun; Reynolds; and Helper, Krueger, and Wial) are convenient starting points for a discussion of process and incremental product innovations.[22]

- High-wage, high value-added production is central to both Reynolds' and Helper, Krueger, and Wial's suggestions for strengthening the manufacturing employment base; biotech and advanced electronics production are exemplars of the possibilities for expanded production.
- In industries where various supply chain issues (costs and time of shipping) may allow for increasing somewhat lower value-added production,, a main obstacle is that only a minority of U.S. suppliers engage in significant process or incremental product innovation. This is in part because U.S. suppliers do not have the institutional system to support these activities.
- The composition of the value added in manufacturing is shifting. Most notably, the share of information value added (e.g., software and computing services) in manufacturing is rising rapidly, thus making these inputs more central to process and product innovation. This means that the necessary skills for production success in manufacturing are shifting.

Altogether, the papers for this project highlight several policy omissions that hinder process and incremental

20 National Association of Manufacturers, Manufacturing Strategy for Jobs and a Competitive America, January 2011; Ezell and Atkinson, ibid; Helper at el., ibid; The Council on Competitiveness, ibid.

21 Whitford, Josh. 2012. Network failures and innovation in the New Old Economy. Connect Innovation Institute White Paper: Project on Production Innovation.

22 Reynolds, Elisabeth B. 2012. Technology, Policy and Product Life Cycle: The Evolving Geography of Biomanufacturing. . Connect Innovation Institute White Paper: Project on Production Innovation; Helper and Kuan, ibid; Helper, Krueger, and Wial, ibid.

product innovation, and thereby harm employment prospects in the U.S. These gaps may also adversely affect the ability to do novel product innovation in some fields. Indeed, high value-added, high product innovation industries are no longer yielding the production and jobs base for America that we usually assumed.

The supply base of middle value-added firms which could benefit from supply chain factors has significant problems realizing its innovation potential. Due to globalization and the fragmentation of production, many leading manufacturing companies, such as the American car companies, have delegated more and more of the critical manufacturing, design, and innovation responsibilities for their own final product to their supplier base. This change means that in order to thrive, U.S. leading manufacturers rely on the vibrancy and innovations of their supplier network. However, in order to flourish, networks need to overcome significant issues of collective action and diminish free riding. (Free riding arises because other firms could benefit from the investment of another firm without contributing to the cost. Non-patentable innovations or even worker training, when workers can switch firms, are examples of situations ripe for free riding.) Therefore, it is alarming that Helper and Kuan find, in the largest survey ever conducted on innovation in the automotive supply sector, that such shirking is common place, and worse, that American suppliers view American car companies as the least trustworthy partners compared to their European or Asian competitors.

The network structure of the auto supply base in the U.S. has a distinct minority of firms that really routinize innovation as part and parcel of their business. There are many reasons, but three stand out: first, in order to excel in process, incremental, and product adaption innovation, we must have workers with specific skills. Today, firms find too little stability to invest heavily in skills individually and due to risks of free riding and shirking, they fail to overcome the collective action problems and sponsor inter-firm skill training. Second, in market niches where intellectual property rights (IP) do not count heavily in the value propositions, firms do not easily invest in innovation. Indeed, in these industries, some forms of IP protection (such as laws restricting labor from moving to firms in the same industry, as exist in Michigan) can even hinder the dissemination of new techniques. Third, it cannot be assumed that the supplier base for bigger, more innovative, anchor firms will benefit significantly from innovation. Helper and Kuan find that American car makers provide comparatively little "feeding" of the innovation function in the supply base. Just as significantly, Whitford demonstrates that the current ways of pooling expertise among SMEs are largely ineffective, especially in international comparison.

The changing mix of skills necessary for production and incremental product innovation in the SME supplier base falls outside of the range of core skills of traditional production shops. ICT applications are changing both production processes and opening the ways to more tailored incremental product innovations because they lower costs and allow for more functionalities, even in traditional products. Yet, ICT specialists and the new generation of design specialists who can apply ICT products or process *are not part of the core skills of traditional producers*. While some of the functions are available through outsourcing to specialist firms, the practical skills of even the designers depend heavily on the set of firms with whom they have worked previously.

The skills shortfall usually is addressed as matters of new/better job training/retraining or better infrastructure. But, if there is one thing that is clear, skill training does not suffice for the kind of learning necessary to embrace and successfully utilize major new sets of skills. And, while it is wise to make sure that broadband communications capacity at competitive prices is ubiquitous, a goal of many clusters, it is the skill of knowing how to deploy these resources to advantage that is equally critical. Market forces can help; nonetheless, we know that it can take considerable time to figure out how to seize the opportunities of new enabling technologies, like information and communication services.[23] In short, skills and knowledge emanating from

23 Paul David, The Computer and the Dynamo, Working Paper, Center for Economic Policy Research, Stanford University, 1995.

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new industries that can have significant impact on innovation in traditional industries are insulated in silos that prevent these assets from being diffused and utilized effectively.

As significant as these problems are for incremental product and process innovation, Reynolds paper shows that their adverse impact on on-shore U.S. production in the biopharma industry could also retard both novel product and incremental product innovation in the U.S. Specifically, as the technology somewhat matures, the industry can modularize production and reduce the high risk associated with biopharma production. Coupled with regulatory oversight slowly converging across national boundaries, companies start to shop for such incentives as favorable tax treatment (wages are not determinative of locational decisions in this industry). In addition, surplus production capacity has emerged in the industry, requiring consolidation of facilities. At the same time, the rise of contract manufacturing organizations (CMOs) outside of the U.S. that are backed by strong local state support has created a sophisticated group of offshore suppliers that reduce the need for U.S. companies to even engage in production. This leads to a sharp decrease of new production facilities breaking grounds in the U.S., while at the same time other high-wages advanced economies, such as Ireland, Denmark, and even Switzerland become major production hubs. The parallels to the U.S. electronics industry loom large. The question facing policy analysts is whether these CMOs are more like the "rote" CMOs in electronics like Hon Hai or more like the "creative" CMOs that contribute significantly to design and process innovation, like TSMC. If these CMOs are of the "creative' kind, then what can be done so these CMOs could emerge in the U.S.? Such higher end CMOs could help to cement U.S. dominance in the biotech industry and maximize its local job creation impact in a move that could enhance the possibility for new "niche" innovation that play to U.S. strengths identified by Reynolds.

Erica Fuchs lays out problems hindering process innovation crucial for production in the U.S. of both the most advanced optoelectronics as well as critical new innovations in the automotive industry. She demonstrates how, under current conditions, it is more profitable to produce using old technologies in China. In optoelectronics this led all publicly-traded U.S. firms to offshore their production to Chinese companies, leaving only privately-held startups to even advance the new technologies. At least as worrisome, Fuchs found a significant reduction of innovation in all the companies that offshored their production. This leads Fuchs to suggest that in advanced manufacturing the loss of production activities can, within an extremely short time span, lead to sharp reduction in the innovation capacities of firms. These findings are even more concerning because they were found to be replicated in the case of new material technologies for car production. Last but not least, these decisions of opting to produce using a less innovative, but more easily outsourced (thus requiring less financing) technology offshore also leads to a technology trajectory that works against U.S. leadership because the most advanced production technologies, where the U.S. has a sustained edge, never reach the market.

Had financing been available to many of the firms studied by Fuchs, they would have opted to push the innovative edge further and use the more advanced production technologies in the U.S. However, because this U.S. production strategy would be both more technically challenging (including the fact that some skills are now in scarce supply in the U.S.) and more capital consuming, all publicly-traded companies preferred not to invest in it. If, however, shared production facilities for co-use in the U.S. would have been built, all of them would have used them instead and developed products using the latest technology instead of offshoring.[24] This issue is more acute since startup financing does not easily cover the needs for such production.

Accordingly, Fuchs finds that private consideration looking at short time-frame financial concerns leads to

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24 Even if firms do opt to move advanced production to the U.S., we can anticipate hitches because the supply base of talent and infrastructure for some advanced production is now larger outside the U.S. than inside. See Charles Dughigg and Keith Bradsher, How the U.S. Lost Out on iPhone Work, New York Times, January 22, 2012, p. A1

a suboptimal solution for all in the industrial sector as well as a reduction in U.S. welfare. Both Fuchs and Reynolds strikingly show how one of the issues facing production in the U.S. is the mismatch between the financial model driving the startup of research intensive companies as well as technology-based publicly-listed companies, and the financial model conducive to driving long-term capital investment for production in the U.S.

Although the startup model for major product innovations clearly has done well, William Lazonick's work delineates the pressures on production process decisions created by the "financialization" of the U.S. corporate model.[25] To be clear, there is no such thing as a management strategy that does not carry risks about implementation. However, the particular risks of the current dominant model of "financialization" have special importance for our analysis of the prospects for production in the U.S.

As the "principal-agent' theory has made clear, any set of incentives for management by ownership carries risks of creating unintentional perverse incentives. Furthermore, measures designed to simplify the monitoring of management performance may themselves further distort management incentives. This is precisely what happened in response to problems in the prevailing conglomerate strategies of the 1960s that were revealed by the rise of the Japanese challenge. The reforms of the conglomerate model in corporate America led to a new set of financial strategies.

In theory, the "financialization model" focused on disciplining management to emphasize return to shareholders and the core competence of companies as a way of getting the company to stay focused on areas where they had sustainable advantages and renovate cost and product structures constantly. As a result, financial markets "monitored" publicly traded firms by emphasizing a rigorous focus on quarterly financial returns and investment in only the highest return alternatives. While certainly not impossible, massive spending on difficult, capital intensive investments with long-term paybacks had a much steeper threshold for approval under this approach. (As the chairman of a privately held manufacturing company with 3000 employees noted to us, his company can handle quarterly disruptions in earnings from challenges of new production projects with far less heartache than his counterparts who are publicly traded.) Additionally, the new metrics for measuring financial performance and return to shareholders, together with new financial regulations about how to account for minority investments in other firms, further tilted incentives toward the management of quarterly earnings performance through much expanded use of stock buybacks and other devices. Boards reinforced this pattern by emphasizing incentives for top managers that were more and more tightly woven around stock price. However, by so strongly incentivizing top managers to pay attention solely to the stock price, our financial system might have created a tendency to reinforce short-term financial engineering over long term strategic investment in productive facilities.

Even as the financialization model of publicly traded firms reshaped investment incentives for production, the papers in this project attest to the many virtues of the creative venture capital (VC) model excels for financing new companies with novel technology. However, the VC model is not well suited for financing expansion into large-scale production and process and incremental innovation. Companies specializing in different kinds of innovations have different financial needs. For example, the VC model is built on a high-risk, high-return limited timeframe model. A good VC aims to invest in a company with a completely new product or technology that can, within five years, offer financial returns on ownership stakes on the magnitude of hundred or more per dollar invested.[26] Most SMEs which focus on production innovation aim to increase the profitability of an already established revenue stream in an average of low double digits, and have no wish to sell ownership. However, in order to know whether their innovations can reach that profitability the investors needs to have the

25 Lazonick, Ibid.

26 For more on the VC model, see Gompers, Paul and Joshua Lerner. 1999. The Venture Capital Cycle Cambridge, Mass: The MIT Press; Florida and Kenney, op cit.

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deep knowledge of that industry and technology which VCs possess and American commercial banks do not. To connect the dots, then, the question is what would be a robust financial basis to confront this challenge (even for new technologies) if publicly traded firms face countervailing incentives for big production decisions.

In sum, many of these suppliers suffer from significant issues of access to resources, not only in terms of skills, but also in terms of finance. Currently there are few specialized financial organizations in the U.S. with both the business model and the necessary skills to invest profitability in process and incremental innovation. This issue is further augmented since the optimal social outcome would be for these innovations to be diffused widely and rapidly throughout the supplier network, minimizing the appropriability of innovation.

Accordingly, in the next section of the paper we suggest that under the current conditions, innovation and education in manufacturing should be treated similarly to agriculture, where there is no assumption that the final agents—farmers—would either innovate or supply training and skills by themselves. Such a view calls for a very different role for public research institutions and significant changes in university-industry relations. Indeed, when we look at the most successful international production innovators, Germany, Japan, Taiwan, the Nordic countries, South Korea, and to a certain degree China, we see that all of them have an extensive role for public research institutions that take on most of the actual R&D and diffuse the results throughout the industry. For example, the success of German manufacturing cannot be understood without the growth of its Fruanhofer institute, the same way that Taiwan's rise to become the epicenter of global semiconductors production cannot be understood without the activities of the Industrial Technology Research Institute (ITRI) since the mid-1970s.

IV. Moving Toward Solutions: Process and Incremental Product Innovation

Our approach to revving up the innovation system in the U.S. assumes two constraints on the available policy choices.

The first constraint is our divided system of power and the key role of federalism. These mean that even if someone thought it to be wise—we certainly do ***not*** think so—a centralized top-down industrial policy a la Japan or South Korea is impossible. The strategies of East Asian states in various stages of their rise to power are frankly not available in the U.S. In contrast, the importance of competition policy in U.S. economic policy reflects this same fragmentation of power, as dominance by any market player surely upsets firms in other regions of the country.[27]

The second constraint is that the fragmentation of the U.S. system of governance reinforces the natural tendency to have a wide spread of performance capabilities among agencies and administrative domains. The ability to execute policies to nurture innovation varies very substantially. For example, the implementation of labor retraining policies should be expected to show enormous variability across the country.

In light of these constraints we focus on changes in policy for enhancing process and incremental product innovation that are consistent with strong market competition among firms, seek to expand the range of financial tools and organizational/business models available to firms, and to increase collective capabilities through coordination of actors by a variety of mechanisms. We emphasize the role of regional clusters because they are best able to build on the results of a fruitful exercise in federalism where local, state, and national authorities have cooperated in the past.[28] Moreover, as Willie Sutton best put it, they are where the money is—in

27 See Cowhey and Aronson, Ibid. Chapter One. These political factors can seduce competition policy into protecting competitors, not consumers. But they also lend potency to the competition commitment over time.

28 J. Sallet, E. Paisley and J. Masterman, The Geography of Innovation, Progress of Science, September 2009, argue that overall federal support for clusters has been too disjointed to be fully effective. We have no quarrel with the optimality argument, but we want to focus on specific gaps in the innovation effort.

this case, the source of knowledge, people, cooperation, and facilities that are critical to driving innovation. At the same time, a reformulated strategy built on regional anchors with federal support opens the way again for bipartisan political support. Finally, we take seriously the lesson from the conventional model for novel product innovation—creating social capital is an essential complement to effective market institutions.

Regional Platforms

The first policy shift is *to go beyond regional clusters to regional platforms* As noted earlier, clusters, where firms are locally embedded and networks are thriving, allow the industrial community engaged in novel product innovation as a whole to continuously excel. Some of their success comes with regard to efforts to address market challenges, such as increasing financial options for innovation to promoting shared use of critical (expensive) scientific infrastructure for smaller firms. Just as importantly, they built social network institutions that promote trust, fine-grained information transfer, and joint problem solving.[29] In short, clusters organize regions as networking and information systems to enhance their density of interconnection, flow of human capital, and transfer of knowledge—networking, facilitating business contacts (trade centers)—thus, making it easier to match ideas to financiers (and other support services) and providing specific informational sessions.

Platforms are the logical next step beyond clusters as we focus on process and incremental product innovation. Their aim would be to solve specific and acute problems of semi-public good supply and network failure that our authors have identified. They do so by ***creating particular regional assets that are common and shared by all companies in an industry.*** Hence, platforms alleviate the free riding and collective action problems, supply the missing critical resources, change the risk and profitability calculation of firms before they opt to offshore production, and enhance the conversion of ideas on production and further incremental product innovation within the U.S. Furthermore, successful platforms can serve as the seeds of new production-focused American companies that can successfully compete with the best (and sometimes state-supported) foreign CMOs. Promoting these platforms would specifically acknowledge that process and incremental product innovation, both critical to production capabilities, may require something more than the circulation of people and tapping a common research base. Instead, as the biopharma case suggests, the goal should be the creation of common assets vital to production. How best to do this is not a question that can be answered based on our research to date. We expect significant variations in the answer depending on particular industrial structures, but we can illustrate three kinds of options that could be considered. These options may be complementary in some cases.

A first option would be to more carefully look at the record of contract manufacturing organizations (CMOs) in other countries. While low end contractors, specializing in the lowest cost fulfillment of comprehensively blueprinted orders, do not seem to be a relevant option, the example of TMSC, or the CMOs activities of Samsung, one of the world's most admired companies for its innovation-based growth strategy, deserves careful consideration. What are the obstacles to the growth of such organizations in the U.S. if labor costs are not the controlling factor? And what are the obstacles to repurposing existing production capacity, for example current pharma and biopharma facilities, into CMOs instead of closure when their controlling companies, such as Pfizer, opt out of production? As one CONNECT executive has pointed out, the surplus capacity in biotech production capacity need not be a deadweight loss. Instead this capacity could be the basis for regional shared facilities that can grow into highly successful and profitable CMOs attuned to the specializations of a regional innovation cluster.[30]

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29 Breznitz, Dan and Taylor, Mollie. 2011. California Dreaming? Cross-Cluster Embeddedness and the Systematic Non-Emergence of the 'Next Silicon Valley.' Paper Presented in the Academy of Management Annual Meeting, San Antonio, TX, Aug 2011.

30 Duane Roth and Pedro Cuatrecasas, The Distributed Partnering Model for Drug Discovery and Development, Kauffman Foundation, January 2010.

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A second option is to increase the specialized industry-training regional training schemes. Here a perfect example is North Carolina's research triangle, where unique industry-university collaboration around the specialized training of workers for advanced biotech production is widely attributed as one of the keystones of the region's tremendous success. Funding for such endeavors comes from both public and private sources (again alleviating some of the collective action problems), and is administrated by local government working together with industry and the local university system to identify the specific needs and unique strengths of their region.[31]

A third group of options would address the financial options for firms specializing in incremental and process innovations, especially smaller ones. One approach might be to create new public-private investment banks for specialized purposes. The goal would be to operate by converting relatively inefficient state subsidy (or other expenditure) streams into more leveraged banking schemes for production and product innovation. One of the new pioneers of this approach is the Connecticut Clean Energy Finance and Investment Authority (CEFIA) that has converted a subsidy fund collected by state utility customers to a public investment bank for clean energy projects. Such banks, assuming that they can overcome politicized targeting of their funding and risk assessment practices, could easily be targeted toward regional cluster platforms.[32] A strong benefit of this approach is that it might also be helpful for novel product innovation.

A broader approach on finance would be to institute changes in deferral regulation and taxation that can have fast and significant impact, whereas, the current taxation and regulation regime incentivizes public companies, both large and small, not to invest in production activities in the U.S. *We strongly believe that the best job creation agents in the American economy are private companies. It is, therefore, of extreme concern, suggesting a serious policy failure, that currently during this time of great recession, the best American corporations, such as Apple, sit atop the largest piles of cash in corporate America history.* It would behoove federal policy makers to think about ways in which changes in taxation, and perhaps some matching funds, would tilt companies calculation about return on investment (ROI) and risk, just low enough for them to invest in the U.S. and not view this as an action against the best interests of their shareholders.[33]

On the other side of the same coin, since it is now becoming obvious that privately-held (that is not publicly-listed companies) are more positively disposed toward investment in production, but their access to capital is limited, a set of new regulations and changes in taxation that would make such investment more profitable to financers, and maybe spur the re-creation of specialized investment companies, is also long overdue.

Network Solutions

The second policy approach is to create new forms of regional networks specializing in "network solutions" to upgrade capabilities for process and incremental product innovation. As our authors showed, there are two significant issues with production innovation. First, much of this innovation is not protectable under the current intellectual property regimes. Second, a crucial issue is to ensure the most rapid diffusion and widest sharing of new innovation across the supplier base network. This combination of issues creates a perverse outcome. Lacking the ability to appropriate investment many of the SMEs, which are the core of the supply base, underinvest in innovation. A solution to this, however, cannot be solely the strengthening of IPR, since this would lead to a less rapid and wide diffusion of incremental and production innovation.

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31 Southern Growth Policies Board, Innovation with a Southern Accent, 2006 Report.

32 For details, see: www.ctcleanenergy.com/board.html

33 Ezell, Stephen J. and Atkinson, D. Robert. 2010. The Good, the Bad, and The Ugly (and the Self-Destructive) of Innovation Policy, The Information Technology and Innovation Foundation, Washington, DC.

Some of the current solutions for information sharing can even make the problem worse. Detailed studies of innovation in process and incremental product industries, such as those summarized in Whitford's paper, indicate that traditional systems of sharing information often do not effectively lead to detailed problem solving and, worse yet, can lock firms into relatively narrow circles of expertise and transaction contacts. To upgrade the capacities of SMEs in, for example, low R&D intensive industries such as metal-bashing, it is important to build bridges across industry segments.

Therefore, we have a dual set of recommendations, one to maximize information sharing, collective action, and negate network failures, and the second, to deal with the need for production innovation, at least in some industries, by treating it as a semi-public good.

The first way to implement "networked solution" systems is to create problem solving teams that draw expertise from different segments of the supply chain. Other experiments with this approach have proven very successful. These efforts have the following characteristics: a) they bridge traditional segments within an industry, thereby maximizing networking contacts; b) they bridge between traditional industries, and new technologies and the skills needed to operate them, hence, infusing these industries with new knowledge, ideas, and the skills to act upon them; c) they are governed by multi-stakeholder boards, including government officials, so as to drive responsiveness to new group demands; and, d) they focus on solving problems and creating technical capabilities (such as lab testing for quality) for the network through engagement of members of many organizations in the network. In the words of McDermott et al, such networks can "…. provide firms with a new scale and scope of diverse services and foster new learning relationships between firms from previously isolated producer communities."[34]

The regional base for such organizations plays an important role in their potential success because they can develop informal transactional mechanisms that are more effective than standard contracts and rules when dealing with the kinds of uncertainty that characterize efforts at innovation.[35] They can also provide important feedback to government institutions whose programs, especially in job training, are crucial to regional clusters. For example, these networks might reveal the merits (or demerits) of one proposal for expanding and renaming the Manufacturing Extension Partnership (MEP) as the Innovation and Productivity Extension Partnership (IPEP).[36] The MEP program has enhanced process innovation in SME manufacturers. Should it now also encompass service companies as well as manufacturing companies, given the interdependence of services and manufacturing? Rather than decide this top-down from Washington, such ideas could emerge from regional networks.[37]

A second prong of "networked solution" institutions will cross-over with the creation of platform capabilities. Solving many production process problems through collaboration may lead to collective investments, perhaps through co-op systems, in certain kinds of capabilities. For example, most SMEs have limited capacity for original

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34 G. McDermott, R.A. Corredoira, and G. Kruse, Public-Private Institutions as Catalysts of Upgrading in Emerging Markets, Academy of Management Journal, Vol. 52, 2009, p. 1292. We note that such networks do not replace existing organizations. They link together their capacities and their participants in new ways that induce different forms of learning and cooperation. J. Rauch and J. Watson use economic models to make similar points about the benefits of bridging in networks, Kauffman Foundation.

35 R. Gilson, C. Sabel, and R Scott, Contract, Uncertainty and Innovation in Kauffman Foundation, Rules for Growth, 2011, make the case that flexible problem solving under uncertainty, a key element of innovation, is easier in communities that can develop normative mechanisms (including reciprocity practices) to complement formal contracts.

36 K.P. Jarboe, Rethinking Innovation Policy, April 1, 2011, Athena Alliance, Washington, D.C.

37 We note that this notion of networked solutions is starting to stir, but not in the full form that we envision. According to the Southern Growth Policies Board, regional clusters should look to examples such as the " Integrated Manufacturing Technology Initiative (IMTI) – IMTI is a nonprofit member based organization bringing together industry, academic and government entities to support and strengthen the nation's manufacturing community. A partnership combining the knowledge and expertise of public and private organizations, IMTI includes five federal agencies and leading companies such as Rockwell Collins and Procter & Gamble." Southern Growth Policies Board, Innovation with a Southern Accent, 2006, p. 43.

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applications of ICT customized to their needs or in design innovations.[38] While there are many firms offering to provide these inputs as outsourced activities, the specialist suppliers are often drawing from a relatively small pool of relevant experiences. Providing a central node for comparing ICT and design ideas, and even generating new ones relevant to the cluster, could be powerful. We would strongly encourage both the federal and state government to open and quickly expand programs such as the traditional industries program of the Israeli Chief Scientist. Here, we would specifically emphasize the part of the program that aims to match graduate students from various high-technology disciplines with production SMEs. Special attention should be given to how to incentivize both actors (i.e., students and manager/owners of companies) so these internships in companies would lead to both projects with innovative outcomes, and, at least as importantly, routinization of innovation activities in these SMEs and the embeddedness of new domains of knowledge (such as ICT) within them.[39]

Our third prong of networked solutions is to embrace public funding for a R&D system aimed at supporting production (of goods and services) that emphasizes the networking benefits of R&D. There is a long infertile debate in the U.S. over whether "market failure" for research is large enough to justify public funding for applied research centers tied to industries. (There is agreement that an individual firm may not capture all of the returns from research and therefore under-invest in this knowledge creation. But there is disagreement about the size of this disincentive.) This debate over the size of the market failure ignores the proven record of such research efforts, properly defined, in promoting the networking of knowledge and innovation among smaller firms. Yet this is precisely the challenge at hand.
To recap the findings of our research papers, there is a low level of innovation in American production SMEs, anchor American production firms (such as automakers) do not continuously invest in infusion the supply base with innovation, and many SMEs have a limited capability and resources to engage in innovation. Moreover, such innovation as takes place usually diffuses slowly in this environment, slower than much of the knowledge generated in novel product technology clusters. (In these clusters, proprietary technology stays secret but lots of know-how spreads rapidly.)

These facts have led some analysts to suggest that the U.S. would do well to look at how other countries have utilized various public research institutes to solve those issues. The examples are many, from the Korean research institutions, to the currently idolized German Fraunhofer institutes network and the Taiwanese ITRI. These public research institutes have a similar design: their specialized departments (or sub-institutes) focus on particular industrial niches and set of technologies, develop long-term relationships with industry, and establish a division of labor, where with the pooling of private resources, coupled with infusion of public funding, the institute concentrate on the core and continuous production R&D, and diffuse the results widely to industry, which in turn focuses mostly on final development and implementation of these technologies.[40]

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38 There are proposals to resolve process innovation by creating pre-commercial production prototypes in the tradition of Sematech. Whatever their merits, our proposal heads exactly in the opposite direction: it advocates networked institutions for applied problem solving.

39 This could also allow new ways of linking producer know-how with university expertise. Some propose enabling the National Science Foundation's (NSF) Engineering Research Centers program to support the creation of Design Research Centers as well as promote research and teaching of integrated design. How much more powerful would such Centers be if linked to regional design cooperatives?

40 In order to excel in continuous incremental innovation, a system of specialized banks, with deep knowledge of the industry, handling mid-risk, but very long time horizons, such as the German hausbanken can be very advantageous. Elisa Ughetto , Industrial districts and financial constraints to innovation, International Review of Applied Economics Vol. 23, No. 5, September 2009, 597–624; Vijay Govindarajan and Chris Trimble, The Other Side of Innovation: Solving the Execution Challenge (Harvard Business Review); on the German model, see: http://www.eib.org/attachments/efs/eibpapers/eibpapers_2003_v08_n02/eibpapers_2003_v08_n02_a03_en.pdf . On ITRI, Breznitz, Dan. 2007. Innovation and the State. New Haven, CT, Yale University Press, and Breznitz, Dan. 2005. Development, Flexibility, and R&D Performance in the Taiwanese IT industry – Capability Creation and the Effects of State-Industry Co-Evolution." *Industrial and Corporate Change,* Vol. 14 (1): 153-187.

However, while we value the logic of these proposals, we are skeptical about the feasibility of successfully transplanting institutions that owe much of their success to the fact they work in an extremely different institutional environment to the U.S. Nonetheless, we in America have already developed a set of institutions to solve exactly such issues in another sector of the economy. Not only that, but our solution proved to be extremely successful in spurring and guaranteeing American superiority in innovation and production, as well as being responsible for the ushering of a technological revolution that did more than any other to improve the life and the lots of the majority of humanity in the last century. We are, of course, referring to the infrastructure of agriculture research in the U.S. In agriculture the assumption was uncannily similar to the finding of our authors in many low and mid-tech industries; while these industries are essential to American prosperity, we should not assume that the actors (similarly to farmers) can conduct the necessary innovation, or even independently acquire the skills, to continuously excel in the market. Indeed, as both the Fraunhofer and ITRI shows, other countries certainly stopped assuming this many years ago. Hence, a program for production innovation built around the organizational logic of agriculture research in the U.S., devised along regional specialization, and sponsored both at the state and the federal levels seems to us a much better fit for the U.S. than a centralized research institute, whose success relies on the existence of environmental conditions and supporting organizations that the U.S. does not, nor necessarily ever wish to, possess.[41]

The creation of national and regional innovation information systems could be an important tool for such "extension" systems. In their simplest forms such systems can resemble the technological roadmaps that proved so useful to coordinate investment and spur innovation in many domains, such as semiconductors. In their more expansive forms we are thinking of information mechanisms that involve real costs of participation for those that engage in the exercise in order to improve the quality of the information.[42] We do not expect the U.S. government to fund a comprehensive technology effort in many areas, nor to fund comprehensive efforts to upgrade more incremental product innovation industries, such as a radical reformulation of many systems in an automobile. However, we can take a page from other countries, such as Korea and Taiwan, that have used public-private dialogues at the national and regional levels to identify what are the essential technology building blocks toward significant innovations in particular industries. Such charting exercises generate and share information by using indicative planning scenarios (what would it take to reach certain goals within resource constraints). They are "costly" in the sense that it takes a wide spectrum of stakeholders with expertise contributing to the building of the planning scenarios. Two recent examples of such roadmaps, one for energy and one for water resources, have been generated by the California Council on Science and Technology.[43] But the key is to turn an expert group's exercise into a broader community discussion to validate and amend the maps.

Building confidence about needs and some of the technological prerequisites is one important way of dealing with the issue of inducing funding without government writing a check. The likelihood of risk capital coming to bear on items that are clearly defined parts of a roadmap increases. In China, part of the abundance of funding for photovoltaic systems is the result of a government bank. But an even larger part is the commercial banking

41 For ideas along similar lines, see, James J. Duderstadt, chair. 2009. Energy Discovery Innovation Institutes: A Step Toward America's Energy Sustainability, Blueprint for American Prosperity. Washington, DC Brookings Institution; James J. Duderstadt, Mark Muro, and Sarah Rahman. 2010. Hubs of Transformation: Leveraging the Great Lakes Research Complex for Energy Innovation. Washington, DC Brookings Institution

42 The experience in San Diego proves that even just developing an inventory list of all the firms in the industry and what they do, is extremely worthwhile, but rarely done. The only such list in San Diego that is reasonably comprehensive for a sector is one for defense suppliers. This only exists because DOD funded an information gathering exercise called the "Connectory." On the value of costly participation for establishing trust, see: David Lake and Mathew McCubbins, "The Logic of Delegation to International Organizations," in Hawkins, Nielsen and Tierney, Delegation and Agency in International Organizations, Cambridge University Press, 2006.

43 California Council on Science and Technology, Innovate2Innovation, 2011.

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system's conviction that government roadmaps for reducing emissions cannot be met without photovoltaic systems.[44] To be sure, roadmaps can be flawed and investors can come to doubt them (witness the exit from some forms of green energy investments). But they also lead to a better sense of what capabilities need to be in place if an innovation (a successful movement from idea to commercialization) is to become more likely. And given the need for a supporting ecosystem of capabilities for innovation to be converted into American production, such roadmaps may be particularly valuable for the future.

Our fourth implementing action is to align the incentives of public officials using a new set of metrics to judge success in building networks. As strongly argued by Whitford, for these initiatives to work we must find different ways to motivate and evaluate public officials. Whatever the distrust of government in America, there are legions of government officials who are doing valued work at the regional level on economic development. They have a substantial level of bipartisan support. But we need to rethink many of the conventional measures of their success. Metrics such as simple calculation of the number of firms created, or the number of new jobs within defined period of time, or even simplistic cost-benefit analysis would give exactly the wrong incentives to policy makers, and the wrong evaluation of the effectiveness of these new policies by politicians and the public. We need to define metrics that actually measure the things that we care about, such as: growth of networks, the effective diffusion of innovation within them, the percentage of new production technologies that are implanted in the U.S., the growth rate of process and incremental innovation (which as Helper and Kuan shows are not even properly counted currently), and maybe the growth of new high-end specialized producers in the U.S.[45]

V. Moving Toward Solutions – Part Two: Updating the Conventional Model

The Conventional Model for priming novel product innovation is still working reasonably well in the U.S. But it requires constant attention, especially as science and engineering capabilities around the world close the gap with the U.S. The CONNECT Innovation Institute practitioners had a number of suggestions based on their experience on how to update the Model.

Like other practitioner groups they urged careful attention to national research investments in broad technology competencies that would fuel novel innovations in the future.[46] These investments would be the logical counterpart to the "technology roadmaps" discussed in the last section. They particularly noted that some key areas of innovation, such as novel financial product and transaction systems, might be more likely to emerge from large users of the service, not startup firms, but would still rely on these basic research investments by the nation. They also emphasized that regulatory streamlining, particularly (but not exclusively) for biotech, was crucial.[47] But their recommendations for the Conventional Model particularly focused on issues concerning financing, both public and private.

1. The U.S. Government funding for research and development is inadequate in size and has become too bureaucratized and conservative to allow clusters to achieve their full potential.

- The research funding for universities, especially early stage research, is critical to generating

44 We owe this point to Professor Junjie Zhang.

45 These are possible to do with at least as much precision as metrics looking at standard economic data because of major methodological advances that, for example, allow us to chart the pattern and density of networks and their flows (such as innovations).

46 CCST, Innovate 2 Innovation, 2011.

47 Roth, Duane. A Third Seat at the Table, The Hastings Center Report, 41/1, 2011.

important new innovation opportunities. But, at this point, the U.S. is not matching the pace of expanding research commitments of other countries. Moreover, the federal R&D programs have grown increasingly risk adverse in regard to new ideas which are very promising but essentially unproven. As an example of how to alter this path, the NIH and NSF should be willing to fund a year's worth of work on such "promising untested" ideas. Also, it might be suitable to try to steer some of the NSF and NIH funds into a DARPA-like funding mechanisms instead of relying solely on peer-review.

- Changes in DOD procurement rules no longer serve innovation well. Thirty years ago DOD used to fund fresh ideas from small firms and provide some money, as one of our practitioners put it, to just "poke around" to see what would emerge. This is virtually impossible today. While the Small Business Innovation Research (SBIR) grants from eleven federal agencies with large research budgets still work reasonably well, they constitute a very tiny part of the federal research and procurement engine.

2. The funding mechanism for startup and fast growth tech companies is no longer robust. Our practitioners focused on two problems.

- The ability to fund commercial innovation at early stages is a growing problem. In promising industries such as biotech pharma early stage risk is no longer covered by VCs. (Phase 2 trial results are often required before VCs will invest in biotech drugs.) This means that incentives for early stage investors are critical and we should fine-tune these incentives to keep this money engaged. One implication is careful examination of how tax and financial rules influence the behavior of angel investors. Another is the need to look at new types of financial instruments. For example, people could dedicate up to $2K of their 401K money into a hedge fund investing in cancer cures. Such a proposal would fund venturesome commercialization ideas while, the researchers estimate, providing perhaps a 10% return plus the satisfaction of supporting a good cause.
- Besides the initial money to start up, the struggle to keep the best people during the early stages of growth was crucial to success. While stock options have been subject to numerous critiques, our practitioners believe that they are among the most valuable tools for allowing newer firms to reward top talent. Changes in the rules for options are making it harder to use options (e.g., companies now have to expense options) and they are now somewhat less attractive to awardees because the monies from exercising the options are treated as ordinary income.

3. Concentrate on improving financing for the scale up of startup firms. When startup firms begin to scale up for large undertakings, especially production, they need to look for new sources of financing. They face problems with regard to commercial lending and funding from large (multinational).

- Given weaknesses in the banking sector (which often lacks expertise to assess risks) one possibility would be to open eligibility to existing government loan programs, such as SBA funding. However, the firms often fail to qualify for funding because their chief asset is IPR, and IPR does not qualify as an asset for SBA lending criteria. In light of the evidence of the value of IPR (see Google's purchase of Northern Telecom and Motorola Mobile for IPR) it is worth devising a realistic way to assess value to IPR assets of small firms for the purposes of government loan programs.
- For some companies the problems would be greatly alleviated if more funding from large corporate partners was more easily accessible. Our practitioners were particularly interested in proposals that would allow American multinationals to repatriate their offshore profits at favorable rates if the monies were invested in early stage companies (a provision lacking in a

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prior program for profit repatriation). They also noted that various financial regulations, such as FASB 167, are discouraging funding of biotech startups by large pharmaceutical companies.

The U.S. has all the necessary factors to continue to lead the world in innovation, while enjoying its job growth benefits. However, it is imperative to have a leadership which aims to achieve it within the next few years. It is our hope that our policy makers and business leaders can utilize some of the findings and recommendation of this project to do so.

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The CONNECT Innovation Institute was founded in July 2010 as a think tank to focus exclusively on innovation policy and competitiveness in the global economy. The CONNECT Innovation Institute publishes timely thought papers from San Diego leaders for use in addressing federal policy issues, and it raises funds for larger scale policy projects involving leading scholars of innovation.

CONNECT is a non-profit that has assisted in the formation and development of more than 3,000 companies in the San Diego region and is widely regarded as one of the world's most successful organizations linking inventors and entrepreneurs with the resources they need for commercialization of innovative products in high tech and life sciences. The program has been modeled in more than 50 regions around the world. CONNECT has been recognized by *Time*, *Inc.* and *Entrepreneur* magazines and in 2011 won the national State Science and Technology Institute's 2011 Excellence in Tech Based Economic Development Award for Building Entrepreneurial Capacity. In 2010, CONNECT was the recipient of the Innovation in Economic Development Award from the U.S. Department of Commerce for creation of Regional Innovation Clusters. CONNECT manages the San Diego, Imperial Valley, Inland SoCal Innovation Hub (iHub) designated by the state of California Governor's Office of Business & Economic Development in 2010. Key to our success has been the unique "culture of collaboration" between research organizations, capital sources, professional service providers and the established industries.

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