User Entrepreneurship: Defining and Identifying an Explicit Type of Innovation[1]

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Abstract

Innovation is widely recognized as a key driver of economic growth, but innovation is now mainly measured by patent statistics and seen as reflecting earlier investments in formal innovation systems that produce new products an new technologies. A consequence of this approach to describing the innovation process is that there is little role for entrepreneurs and in particular little chance of innovation taking place in rural regions. Yet prior to the 20th century most innovation came from individual entrepreneurs and many innovations originated in rural regions. In particular one form of innovation - user-innovation, where individuals or single firms when confronted with a significant problem that has no acceptable existing solution create their own innovation, is particularly relevant to rural regions. While most rural innovations serve local or niche markets there are examples of major rural innovations that have had disruptive national or global impacts. Preliminary results from the new USDA Rural Establishment Innovation Survey confirm that user innovation is an important aspect of many rural entrepreneurs and an important aspect of firm competiveness.

1.0 Introduction

In rural regions the main source of innovation comes from the individual efforts of local entrepreneurs. Formal innovation systems are almost completely excluded from rural regions because this approach requires large numbers of highly trained scientists, large capital investments and a *milieu* where there is the potential for formal and informal interaction. Consequently, rural regions are rarely the source of patented innovations. This deficiency has been widely interpreted to mean that rural areas are not innovative and that firms in rural regions are unlikely to participate in driving the modern economy (Sternberg, 2000; Tanvig, 2003; Todtling and Trippi, 2005).

It is certainly true that the standard measure of innovation – patents filed per 1,000 population, indicates a lack of rural innovation, and it is equally true that formal innovation systems that produce induced technological change are unlikely to be found in rural regions. However, there are clear examples of disruptive innovations that originated in rural areas that have had global consequences. The most obvious is, of course, Wal-Mart which has radically altered the retail

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environment in multiple countries, but which still has its corporate headquarters in Bentonville Arkansas, the community in which it was founded.

The vast majority of rural innovations come from entrepreneurs who see an opportunity, or face a challenge in their existing work, and act to resolve that problem themselves because they cannot find an adequate external solution. Their actions result in a new product or process, but the innovation is developed not through formal research to address a general problem or a perceived market opportunity. Instead, the innovation comes from the specific situation of the entrepreneur and is an effort to improve either the output of an existing firm or address some personal problem. As an example, in the 1950s Armand Bombardier had difficulty getting his children to school during winters in rural Quebec when roads were impassible. One winter one of his children died because the family was were unable to transport him to a hospital due to impassable roads. As a result he was motivated to develop a tracked snow vehicle to ensure this would not happen again. Continuous subsequent refinements led to the personal snowmobile industry as a new form of winter transportation.

Armand Bombardier, like Sam Walton, are outliers, in that they both created disruptive innovations. More common is an entrepreneur who makes a modest change in a product or process that results in an increase in sales or a reduction in unit costs. The result is not a major expansion of the firm but perhaps greater long term firm viability and a small growth increment. The benefits are confined mostly to the firm and to a lesser degree to the community in which it operates. Nevertheless, these effects can be important in a cumulative sense in rural areas. If ten small firms in a community each add two three employees because their sales have expanded, this can result in a significant increment to community employment and earned income, as well as increasing firm and community viability.

However, because the majority of rural innovation is small scale and is never formally identified – no patent is registered, the extent of user entrepreneurship and innovation is not well understood. For the first time the new USDA sponsored Rural establishment Innovation Survey (REIS) offers some results that show entrepreneurial innovation continues to exist, even though outlays on innovation by entrepreneurs are dwarfed by expenditures on formal innovation systems. And, the survey shows that user-innovation, in particular, continues to be an important aspect of small rural firms activities.

2.0 Innovation and Economic Growth

The definition of innovation is imprecise, but it commonly entails the idea of the creation of a new idea that has direct connections to a firm or other organization being able to produce a better product or service. Teece suggests "... an innovation consists of technical knowledge about how to do things better than the existing state of art. " Roberts proposes that "innovation = invention + exploitation", again suggesting the idea of the creation of something new that has direct economic implications. Baregheh, Rowley and Sambook review sixty different definitions of innovation and arrive at the following definition:

> *Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace. p. 1334*

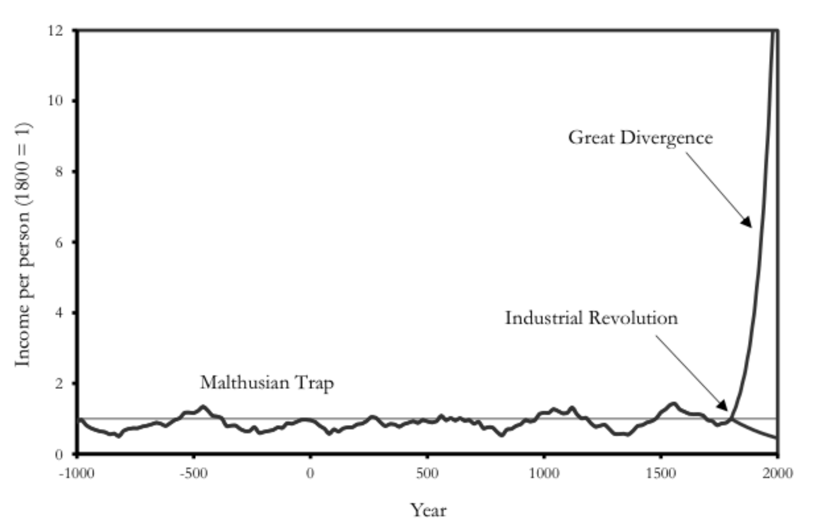
In these definitions there is a clear sense of creation, but also the idea of instrumental value. That which is created is not valued for its own sake, as is art, but is valued because it can be used to improve a desired outcome. This suggests that an innovation is an intermediate good, having a derived demand, not a final one. It also implies that a motive for innovation activity is to improve economic conditions, either by making some firms and individuals better off, or by making society better off.

Innovation is commonly seen as one of the major drivers of economic growth (Aghion and Howitt, 2009; HM Treasury, 2000). The effects of innovation are felt at multiple levels of geography: at the global level, through technology transfer and new market exchanges; the national level, in the form of shifts in shifts in comparative advantage; the regional level, in terms of changes in specialization and competiveness; and at the firm level in terms of profitability and viability. For economists the belief that innovation, in the form of technological change, can be induced has allowed the development of endogenous growth models that resolve the problem of earlier previous growth theories reaching a steady state where growth. This makes understanding and ideally, controlling the innovation process a crucial task.

3.0 Innovation Through the Lens of Modern Economic History

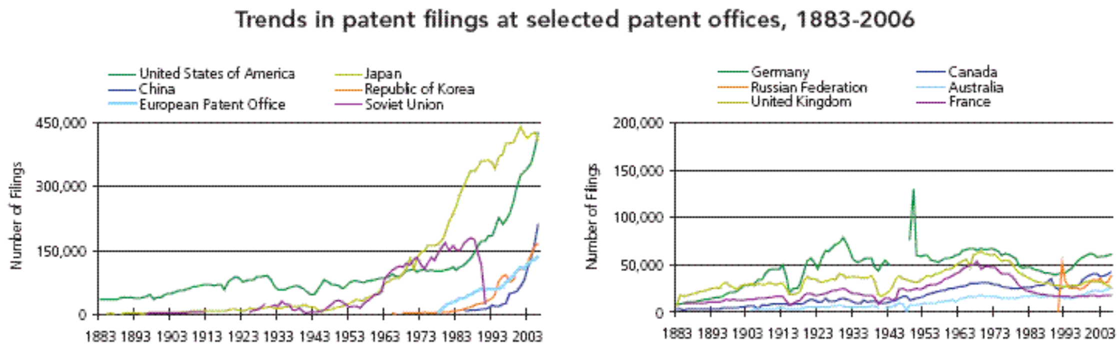
The historical reference point for the connection between innovation and economic growth is commonly seen as the industrial revolution which started in England in the late 1700s (Clark, ; Piketty,2014). At this point in time global economic growth accelerated rapidly from an extended period of stagnation (Figure 1). While individual entrepreneurs were the source of virtually all the innovations for the next hundred years there was a steady trend of the adoption of the scientific method to producing innovations where formal experiments became adopted as a way to move from initial idea to a product or process that could be marketed. In this process WIPO data from 2008 shows that the use of patents as a way to protect the effort of the inventor became more common, especially in the last decade of the 20th century (Figure 2).

Figure 1: A Schematic History of World Economic Growth



source: Clark, 2014

Figure 2: Trends in Patent Filings by Country



source: World Intellectual Property Organization, 2008

Economists have seized upon the Industrial Revolution as the start of the modern era of economic growth because the two events are contemporaneous, but one can also argue that the modern era began some three hundred years earlier with the Renaissance (Box1). While the Renaissance is typically described as an era where nature and culture were valued more than economic improvement, the Renaissance provided the environment in which the Industrial Revolution could develop (Brotton, 2006; Forest 2014; Mokyr, 2008). It encouraged individual expression, began the formal study of science, introduced the printing press, saw the expansion of exploration and trade beyond Europe, created the current banking system, and most importantly promoted creativity in all forms. While the Industrial Revolution provided the means for growth to accelerate it was the Renaissance that established an environment in which innovation could flourish. DaVinci, Gutenberg and Galileo are the most famous inventors of the era but are not alone.

Modern interpretations of economic history suggest that rural innovation was a major contributor to the period of modern economic growth that began with the industrial revolution in Britain (Mokyr and Voth, 2010; Allen, 2009). The first defining characteristic of the Industrial Revolution is that it was self-sustaining in that growth continued through time, unlike early episodes of progress. The second is that innovation became more systematic with later innovations building on previous work and with an increased use of scientific methods, particularly formal experiments. A third characteristic was that it involved a transformation from a predominantly rural society to an increasingly urban one.

Clearly the transition from a predominantly agrarian society to one where agriculture plays a minor role requires two things. The first is the rise of manufacturing as a major new source of output and employment, and the second is the ability of agriculture to release large amounts of labor while continuing to produce sufficient output to feed the new urban population. Economic history has largely focused on the first process and tried to understand why manufacturing flourished in Britain in the early 1800s and continued to flourish.

When the second point is considered by economic historians there is a recognition that output per capita in agriculture increased. Unlike the manufacturing sector, where major innovations can be identified that transformed the textile, iron and other industries, there is no comparable

BOX 1: The Renaissance

The Renaissance is largely seen as a period when the arts and humanities flowered, and there was a rediscovery in Europe, but primarily Italy, of the ideas and values of the Greeks and Romans. It is seen as a period where: individualism is encouraged, the dictates of the church and the medieval state are challenged, and there is a flowering of new forms of art. In short, it is a period of creativity that marks the end of the Middle Ages. While the time period of the Renaissance is not firmly established, there is a general sense that it begins somewhere in the mid-1500s about the time of the fall of Constantinople and ends somewhere in the mid 1600s.

Although most of the historical focus on the Renaissance is on the arts and culture there were significant economic aspects to the era. About 1450 Gutenberg developed the first effective printing press and this allowed widespread and accurate dissemination of books. It effectively removed power over the transmission of ideas from the Catholic Church and facilitated the development of science and commerce. In the early part of the Renaissance the major city states of Italy, Venice, Genoa, Napoli and Florence maintained major trading and banking enterprises that provided their population with exposure to ideas as well as goods from other parts of the world. Later in the era a major wave of global exploration and colonization occurred triggered by a search for a sea route to the Far East.

The period was a time of innovation, not just in the arts, but also in terms of ideas about: how society should be organized, the rights of the individual, the power of the nobility and the role of the Church. It was also the period when the middle class, and merchants in particular, became an important force in society. Although the Renaissance was a period of great social and cultural change it was not a period of great economic growth. Populations grew but per capita incomes remained fairly stable.

For economists the Renaissance has not typically been a factor in explaining the modern era of economic growth that begins in the early 1700s in Britain. The British Industrial Revolution remains largely unconnected to the Italian Renaissance in most discussions of economic growth. But in reality the ideas of the Renaissance can be seen as creating the *milieu* in which the applied science of the inventors of industrial technology later developed. As the Renaissance spread into Northern Europe from Italy it spread new ideas through books and trade. Crucially it set in motion the Protestant Reformation which further enabled individual enterprise. Similarly the advances in banking and business developed in Italy became part of the economic institutions of other countries.

Yet without a significant improvement in agricultural output in Britain the release of labor from farming could not have continued for long[3]. Allen suggests that the answer comes from a slow but steady process of farmer based innovation that steadily increased yields by introducing new varieties, new crop rotation systems and improving soil fertility (Allen 2009, pp. 67-74). He rejects the idea that modernization came from the enclosure system and rich estate owners

[3] At the time countries were largely self-sufficient in terms of food, with limited amounts of international food trade. Britain at the time had a relatively productive agriculture compared to other nearby nations making it more unlikely that much food could be imported from countries that were having difficulty feeding their own population.

conducting scientific research on their farms, since yields improved on all types of farms, and there is little evidence of widespread effort by rich estate owners to undertake this research (pp. 63-65). Instead Allen argues that the incentive to innovate came from an increase in the price of food, triggered by higher wages in manufacturing and the reduced supply of farm labor (p. 74). However while he is able to show a statistical relationship between increased demand and increased agricultural productivity, there are no variables in his model that reflect either levels of agricultural inputs or changes in agricultural technology (p. 130). Thus, while increased demand created a profit-based incentive for farmers to innovate, Allen ultimately provides no coherent explanation for either an actual innovation process or for why the effort was successful.

Absent evidence of a formal innovation system approach in British agriculture, the most likely answer is user-innovation. Allen alludes to the efforts of farmers individual and collectively in the various regions of Britain to improve yields, but he does not suggest why or how this happened beyond the increase in food prices. And in previous times high prices had prevailed, but without increases in agricultural productivity. What seems to have been different this time was two important things. Farmers always had a high degree of tacit knowledge of their farms, but prior to the 1800s lacked two significant things. The first was the great increase in rudimentary numeracy and literacy that allowed British farmers to develop and share production records over time and space. The second was a weakening of the power of the nobility and the Church due to the Reformation, which legitimized the search for economic opportunity and improved the chances of individuals retaining any profits they generated.

The individual inventors/entrepreneurs who provided the new technologies and products in the first years of the Industrial Revolution were able to build on several hundred years of intellectual progress and on a set of social and legal institutions that provided them with an environment that both created problems in manufacturing as trade expanded the scope for production and provided rewards for creating ways to resolve the problems. It was not until Friedrich List in the mid 1800s suggested that the state should play a formal role in promoting economic development that the idea of an innovation system emerged (Lundvall, 2005 p. 3).

Later in the 19th century formal innovation systems were developed to foster rural innovation, well before they were applied in urban areas. The best example is the American Land Grant University system which was created with the express purpose of expanding the agricultural and mechanical arts. In agriculture a combination of agricultural research undertaken at university experiment stations and directly by USDA expanded the basic science base and developed new agricultural varieties and processes. These were linked to farmers through an "extension system" that both repackaged ideas from research and provided a means for farmers' questions and problems to feed back into research activity. The US agricultural innovation system has been highly successful in modernizing agriculture and increasing agricultural productivity.

However, it was not until the 1980s that the idea of a science based national innovation system was fully developed (Lundvall, 2005; Sharif, 2006). This was followed by the idea of regional innovations systems in the 1990s. As Godin and others note the OECD has been instrumental in promoting the idea of national and regional innovations systems (OECD various citations).

4.0 Models of Innovation

In this section two competing models of innovation are discussed. The first is a synthesis of the way innovation is seen to occur in the majority of the economics literature that examines the role of innovation on national and regional growth. The second model, first introduced by William Baumol, provides a richer context for innovation and allows it to occur in a variety of ways. This second model is further extended by introducing user innovation.

4.1 The Usual Story

While innovation has played a role in discussions of economic growth going back as far as Adam Smith and the other classical economists it has become the central element in modern growth theory, particularly for endogenous growth models (Grossman and Helpman, 1994). Innovation is the means by which economists resolve the problem of an economy reaching a steady state where per capita output is constant. Although in principle constant per capita output is not necessarily undesirable, neither is it obviously undesirable to have growth continue. In particular, endogenous growth models suppose that some portion of today's output can be invested in Research and development (R&D) activities and these outlays generate enough new, economically valuable ideas (innovations) to provide a positive rate of growth that in turn allow subsequent rounds of investment in R&D (Aghion and Howitt, 2009).

The current approach to understanding innovation largely rests upon "the linear model" where, basic research leads to applied research and development (R&D), then to innovation, and then to diffusion of the new advance across firms and regions. In particular, by investing in the R&D process regions can induce technological change, which leads them to faster rates of economic growth and improved economic well-being (Godin, 2006). These "learning regions" are seen as the source of most economic progress and the drivers of national economic growth (Cooke and others). Typically regions invest in creating large scale research centers that can be corporate, government or university supported to target opportunities specific sectors and products. By focusing large numbers of scientists and engineers on a systematic program of experiments the chances of finding a breakthrough solution are improved. Once the breakthrough is achieved it a can be patented and brought to market. Obviously this effort takes place in large metropolitan regions, because they are the natural hosts for these specialized entities.

Two consequences of the predominance of the linear model are that: first, innovation is seen as being an urban phenomenon and not something that happens in rural regions, and second, that innovation depends not on individual creativity and inspiration, but on the systematic application of resources to a problem to produce a solution. An additional consequence of the linear model, and its link to economic growth, is that there has become an overwhelming focus on patents generated and expenditures on formal R&D as the respective measures of innovation outcomes and effort.

Critiques of the linear model as being too simplistic and deterministic are numerous (Bruland and Mowery, 2004; Godin, 2006; Kline and Rosenberg, 1986; Todtling and Trippi, 2005; Von Hippel, 2006)[4]. These critiques present a more nuanced understanding of how innovation occurs that includes various feedback loops from users to researchers and greatly qualify the

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[4] We thank Ed Malecki for reminding us of the extensive body of literature that challenges the assumptions of the simple linear model.

deterministic relationship between the quantity of inputs and a desired output. Yet, despite these significant qualifications, the fundamental nature of the linear model remains, in that there is the potential for induced technological change from adopting an innovation systems approach. For example, Fagerburg's (2006) guide to the innovation literature contains no discussion of approaches to innovation that fall outside typical innovation systems approaches. And crucially,, the macroeconomic growth literature (for example, Aghion and Howitt), the regional innovation literature (for example OECD), and a considerable part of the economic history literature on the industrial revolution (for example, Allen) continue to employ a fairly simple version of the linear model.

While there is a recognition that patents are a flawed measure of innovation, since many patents never result in the introduction of a new product or process, and that many innovations are either not patented or not patentable, the fact that patent statistics are both quantifiable and widely available as well as having some connection with innovation has resulted in most approaches to the study of innovation restricting themselves to formal innovation systems based on the linear model. This approach to innovation differs markedly from historical experience prior to the last century when innovation was largely the product of individual creation (Cohen, 2009; . Indeed the term creation is now rarely associated with the term innovation because it has a connotation of serendipity that is incompatible with the current production function approach, which while it does not claim certainty in producing intended outputs does imply significant probabilities of success.

A clear implication of these models is that the innovation process has to be systematic if growth is to continue. That is, innovation has to have some sort of production function where inputs are brought together to predictably produce desired outputs. While innovations may occur serendipitously this is not sufficient for a well-behaved endogenous growth model. Not surprisingly, endogenous growth models rest on the idea of induced innovation brought about through systematic investments in R&D (Hasan and Tucci, 2010). Moreover, there is a common belief that R&D investments have economies of scale, since only some fraction of the investments have a positive return making innovation more likely to be carried out by large corporations and national governments and be embedded in a national framework that fosters the production of scientists and engineers and coordinates investments (Acs, Audretsch and Feldman, 1994; Freeman, 1995).

Parallel to the focus on large firms and government laboratories as the main drivers of innovation has been the adoption of patent counts as the main measure of innovation success. Hasan and Tucci recognize that while patents are a flawed measure of innovation, because as Griliches first noted, not all patents are acted upon and not all innovations are patented, they do have considerable merit "... because (1) patents do indeed represent inventive output, and such output is intended to be commercialized; (2) detailed statistics have been collected and kept over the years; and (3) patents are in general costly to obtain and defend, implying some kind of financial benefit in return." (p. 1274).

Importantly, because patents are the only coherent and consistent measure of the effort to innovate they have become the default measure of innovation effort. And, because specific types of innovation are more conducive to patenting, for example new products in contrast to improvements in organizational structure or logistics, there is a tendency to focus on specific types of innovation. In addition as large formal R&D organizations have become to be seen as the source of innovation the importance of patents has been reinforced since these organizations must recoup their losses on failed efforts by ensuring they capture the social returns from their successes.

Supposing that there is a strong link between innovation and economic growth, then it is clearly in the interest of governments at any level, national, state or local, to find ways to induce innovation (OECD, 1997, 2010, 2011). Investments in improving human capital combined with innovation offer both increased productivity and improved standards of living for citizens. And, if innovation can be induced, then government expenditures to support innovation offer potentially significant rates of return. This provides the third leg of the formal innovation system tripod. The first leg is that growth ultimately depends on innovation, the second that innovation can be systematized and has economies of scale, and the third that governments have incentives to fund these quests. An unintended consequence of this approach is that innovation becomes an urban phenomenon, for only major metropolitan regions are capable of hosting large corporate, university and government research labs.

4.2 An Alternative Story

While the *Usual Story* is certainly true, it may not be the whole truth and there can be alternative innovation mechanisms that play a role in economic growth, especially at the regional level. Baumol (2010) provides a starting point for this theory. He identifies two distinct but complementary models of innovation. The first is the linear model driven by formal innovation systems. But the second is an informal process of individual innovator entrepreneurs who in the tradition of the early stages of the modern era of economic growth identify an opportunity that requires an innovation to address it. The innovation comes about not from an extended process of systematic scientific experiments, although experiments may be required to convert the original idea to a market ready form, but from inspiration. Often the motivation for the innovation is a specific problem that the individual has to deal with and the absence of an effective solution to it from existing technology and procedures.

Three examples clarify this process. After the Second World War Malcolm McLean had established a shipping company but was not satisfied with the existing "break-bulk" process of loading and unloading ships, which led to long delays, and significant breakage and loss that amounted to up to 75% of shipping costs in the 1950s (Tomlinson, p. 1). In 1956 Mclean used a converted oil tanker to ship the first load of containers from Newark to Houston initiating the container shipping process. He said the idea first came to him in 1937 while watching a ship be loaded with bales of cotton he had delivered on his truck (Economist May 31, 2001). James Dyson invented a new kind of vacuum cleaner that did not use fans and did not require a bag because in 1979 he was unsatisfied with a new vacuum he had just purchased (Helm, p.2). The basic idea came quickly, but it took him five years to develop an adequate prototype, and it was not until 1995 that the market took off. For decades Col. Harland Sanders had a small restaurant and gasoline station in Corbin Kentucky. While he was modestly successful with his fried chicken recipe he did not innovate until the early 1950s when a new interstate highway bypassed Corbin. As business declined he sold the restaurant at age 65, and in 1952 began to franchise his fried chicken recipe. His innovation was the fast food franchise and he accomplished this by personally visiting restaurants and cooking chicken for the owners to try, and if they liked it he provided the spices and cooking procedure for a fee of 5 cents a chicken sold.

In each of these cases an individual was confronted with a situation that they saw as being problematic and sought a solution. The solution did not come from an extended process of research, but from inspiration that was then followed by the nascent entrepreneur working through a process of refinement to create a new product or process. The time lag between inspiration and success can be an extended period, but in all three cases one individual succeeded in significantly transforming a major industry. Notably, all three of these individuals had a rural background, and in the case of Dyson and Sanders their innovation took place in a rural area. Mclean's moment of inspiration and subsequent wealth came from a trucking business he established in the rural south, even though he ultimately implemented his idea in the greater New York region.

The idea of the creative class also parallels Baumol's entrepreneur based innovation model. Florida argues that places that are favorable to the arts and culture are attractive to individuals who are creative (Florida, 2002). In a sense Florida recreates the ethos of the Renaissance. And, just as the Renaissance combined cultural creativity with business innovation, so too can a community that has creative artists also have creative entrepreneurs. While Florida does not make a formal link between the presence of the creative class and economic growth, there is an implicit connection through the idea that the presence of creative people leads to economic prosperity. If this is the case, the most likely mechanism is creative entrepreneurs who "see" novel ways to resolve either their own problems or the problems of others.

In the linear model innovation happens largely because of the systemic investigation of all the possible options that exist for investigating ways to develop a new idea. This is essentially a process of induced technological change since research is directed toward resolving a specific problem. Importantly, because of the large investment that is made in this formal research system approach and the limited probability of actually finding a commercially viable solution only problems that have both considerable profit potential and reasonably high expectations of a solution are investigated. The result of this, Baumol says, is that these large research systems tend to focus on patentable activities, to ensure intellectual property can be protected, and tend to make incremental advances. Only incremental advances are likely he claims because the nature of a formal experimental approach involves making small changes from what is currently known.

On the other hand, Baumol sees entrepreneurial innovation occurring because an individual, or small team, sees, or intuits, a profitable opportunity to create a new product or process. While experimentation may be involved in entrepreneurial research it is driven by an underlying vision of how the solution will occur. As a result, Baumol argues entrepreneurial innovation leads to both a much lower rate of success and a much high proportion of revolutionary, disruptive, or break-through innovations. These results reflect the fact that entrepreneurs start off by making a significant leap from what is currently known, so they are inherently looking for non-marginal change. Figure 3, from Baumol, shows a now somewhat dated set of major patented innovations identified by the US Small Business Administration in 1995 that came from entrepreneurial innovation. Several of these have rural origins. And, as Wennekers and Thurik (1999) demonstrate there is a clear link between a high rate of entrepreneurship and economic growth.

Baumol sees the two paths as complementary. He notes that while individuals may come up with break-through ideas, they are typically refined and extended over time by formal

Figure 3: Disruptive Technology Innovations by Small Firms

Some important innovations by U.S. small firms in the twentieth century

Air conditioning	Heat sensor	Portable computer
Air passenger service	Helicopter	Prestressed concrete
Airplane	High resolution CAT scanner	Prefabricated housing
Articulated tractor chassis	High resolution digital X-ray	Pressure sensitive tape
Cellophane artificial skin	High resolution X-ray microscope	Programmable computer
Assembly line	Human growth hormone	Quick-frozen food
Audio tape recorder	Hydraulic brake	Reading machine
Bakelite	Integrated circuit	Rotary oil drilling bit
Biomagnetic imaging	Kidney stone laser	Safety razor
Biosynthetic insulin	Large computer	Six-axis robot arm
Catalytic petroleum cracking	Link trainer	Soft contact lens
Computerized blood pressure controller	Microprocessor	Solid fuel rocket engine
Continuous casting	Nuclear magnetic resonance scanner	Stereoscopic map scanner
Cotton picker	Optical scanner	Strain gauge
Defibrillator	Oral contraceptives	Strobe lights
DNA fingerprinting	Outboard engine	Supercomputer
Double-knit fabric	Overnight national delivery	Two-armed mobile robot
Electronic spreadsheet	Pacemaker	Vacuum tube
Freewing aircraft	Personal computer	Variable output transformer
FM radio	Photo typesetting	Vascular lesion laser
Front-end loader	Polaroid camera	Xerography
Geodesic dome		X-ray telescope
Gyrocompass		Zipper
Heart valve		

Source: U.S. Small Business Administration, 1995, p. 114.

innovation systems. The cumulative effect of the resulting incremental changes makes the gap between the initial idea and the modern version huge. Baumol's example is the Wright brothers airplane and a Boeing 787. Similarly, the Steiger brothers invented the articulated tractor in their farm machine shed, but Deere, AGCO and Case-International have greatly improved it over time through a series of incremental changes.

Allen adopts a similar dichotomy in his discussion of the origins of the British Industrial Revolution (Allen, 2009). He distinguishes between “macro-inventors” and other inventors and examines the way they carried out their innovative activity (Chapter 10). He identifies 10 individuals who created major innovations that changed the industries in which they worked. He also identifies 69 additional inventors who made supplementary innovations that improved existing technology. Allen finds that while some of the macro-inventors could be said to have been strongly influenced by scientific methods and contact with scientific research, about half were not or were at best only weakly connected (pp. 242-247). And, about half of the other innovators cannot be strongly associated with formal efforts to innovate (p. 248).

4.3 User Innovation: An Extension of Baumol

Importantly, Baumol assumes that in both cases the profit motive drives the search for innovation. This suggests that innovation occurs because a perceived market opportunity exists before either the controlling process in a formal innovations system or the entrepreneur begins the search for a solution. Yet we know that in many cases innovations that come from entrepreneurs come from an effort to resolve a personal problem, and only later does the idea to market the innovation occur. User innovation becomes an alternative way to understand both the causes of innovation and the process by which it occurs.

Importantly, in the case of user innovation an individual faces some problem either in their consumption activity or in their business. Typically, after searching for an externally provided solution that can resolve the problem and being unsatisfied with what is available they are "forced" to find their own alternative. In this case the effort to innovate is not driven by a perceived profit motive, but by a personal problem. While a successful innovation may later lead to the decision to commercialization, this is not the initial motivation. In addition, because it is a personal problem that drives the search for an innovation there is less likelihood of a formal science based search. Even for entrepreneur based innovation Baumol proposes a directed search for innovation that is based on a formal search.

On the other hand, user based innovation is much more likely to be based on tacit knowledge that leads to an epiphany where the innovator "sees" a solution. An extended process of refinement might follow to make the idea fully effective, but even here the refinement process is typically trial and error, rather than formal experimentation. For example James Dyson took five years to perfect his idea for his vacuum cleaner after he developed the initial prototype. In their studies of the baby products industry Shah and Tripsas (2007) show that the majority of the firms they analyze came up with their idea after searching for a better product for their child and being unsatisfied with the available options. This led them to create their own solution, followed by a process of refinement until it met their needs. Only after they were satisfied did they begin to consider commercialization, and even then this decision was typically triggered by people asking where they could buy the product. Thus commercialization is often driven by actual demand, rather than by the expectation or belief of an entrepreneur, which explains the title of the article "the accidental entrepreneur".

Figure 4 below provides a simple schematic of the extended version of Baumol's model. The left most column shows the two major forms of innovation - formal systems and individual entrepreneurs. The columns proceeding from left to right first identify the trigger or motivating force for seeking an innovation and then the approach or method followed to identify this innovation. The next column results describes the types of innovation that each form of innovation produces, while the IP protection column describes how the innovator might try to protect the value of the innovation from imitators. The final column commercialization describes the entity undertaking bringing the innovation to market.

The italicized text indicates the modifications to Baumol's theory, showing that either curiosity or an unresolved problem can also trigger an individual to innovate, as well as the search for profit. The two arrows show that when an individual comes up with a significant innovation it can be commercialized either by the individual or by a large corporation after the entrepreneur sells the innovation. Thus for individuals there are three possible triggers and three potential approaches to achieving an innovation, with any combination of trigger and approach being possible.

Figure 4: Pathways to Innovation

Forms of Innovation: adapted from Baumol (2010)

Innovating Entity	Trigger	Approach	Results	IP protection	Commercialization
	Curiosity	***Inspiration/Serendipity***	Mostly niche or local markets	Some patents, often no formal protection	Entrepreneur
Individual	***User Problem***	***Trail & Error/ Adaptation***	Some disruptive or revolutionary		
	Profit Opportunity	Small scale experiments			
Formal Innovation System (corporate, government, large scale university)	Significant Profit Opportunity, Large Public or Social Problem	Rigorous, formal science-based, experimental process	Mostly incremental, but with large markets Some disruptive or revolutionary	Mainly patented, some trade secrets	Large Corporations

5.0 Rural Innovation

Both the new economic geography (NEG) and theories of endogenous growth have explicitly or implicitly led to an assumption that innovation is an urban phenomenon. In the NEG stylized models draw a distinction between two regions and two industries. The first industry exhibits increasing returns to scale driven by innovation is typically termed manufacturing, while the second exhibits constant returns to scale and is typically termed agriculture. Even if the two regions start with equal shares of employment and output in the two industries, over time one region will dominate by attracting manufacturing and the other, lagging, region will specialize in agriculture.

Similarly the logic of endogenous growth models assumes a linear innovation model based on large, science based R&D facilities located in major urban areas; because this is where we find large universities, major government research centers and corporate research centers. The linear model is attractive for growth models because it suggests a production function relationship between research effort and subsequent innovation that allows growth to become self-sustaining. When innovation is measured in terms of patents per capita, the dominance of the linear innovation model is assured.

But in reality innovation does take place in rural areas (Dabson, 2011; Freshwater 2012) and has always taken place in rural areas. What does not happen in rural areas is the formal science based innovation that results in patents. In rural regions innovation comes about from a different process, is typically not aimed at large markets or large problems, is seldom patented and consequently is not captured by current efforts to measure innovation. Howell's study of how geography affects innovation concludes that in some cases firms do not patent because they believe that competitors will not be able to successfully copy and implement their innovation due to lack of absorptive capacity (2002, p. 880). In addition, Howell finds that there is also a relatively strong spatial decay in the diffusion of innovation (p.880), which in rural areas could protect an innovation from copying if it is not patented, as filing the patent effectively reveals the innovation to distant potential competitors.

Rural innovation clearly falls into Baumol's entrepreneur based approach. And, consistent with Baumol's model, while most rural innovation produces incremental gains that address niche market concerns, there are major revolutionary or disruptive innovations that come from rural areas. Yet even in the presence of strong formal science based innovation systems operated by universities national governments and corporations the role of entrepreneur based innovation remains important in farming. Major technological advances continue to come from farm workshops, such as, the articulated four wheel drive tractor invented in 1958 by the Steiger brothers of Minnesota and the air seeder invented in 1956 by Albert Fuss in South Australia. While large farm equipment manufacturers like AGCO and Deere now dominate these markets and continue to make incremental innovations, farmers also continue to innovate, as shown in Figure 5, which shows a custom built 212 foot air seeder in Australia that was assembled from standard components.

Rural innovation is not restricted to agriculture. The modern self-propelled forest harvester was invented by a Finnish engineer, Sakari Pinomaki, in 1974 as an alternative to a number of previously developed first generation harvesters that relied on weld-on modifications to farm and construction equipment. His integrated machine offered great improvements in functionality and efficiency and was subsequently copied by other firms. Further, rural innovation can exist outside manufacturing. Sam Walton developed a logistics system in rural Arkansas that allowed Wal-Mart to dominate retail markets and become the largest retail firm in the world. Lego is one of the world's largest toy companies and still has its head office in the village of Billund, Denmark where it originated. Colonel Sanders at age 65 started selling his method for cooking chicken to restaurants after his own restaurant in Corbin, Kentucky failed when a new interstate diverted traffic around the town. In the process he invented the fast food franchise.

Figure 5: Modern User Innovation in Australian Agriculture

User entrepreneurship is particularly applicable in rural regions, although not restricted to them. First formal science based innovations systems largely fail to deal with most rural needs because the market is too mall. Even the giant agricultural bio-tech firms like Monsanto and Syngenta that dominate the pesticide and seed industries only focus on a few major crops like corn, soybeans and cotton. Minor crops are largely ignored leaving innovation for these commodities to a shrinking government public research system and farmer innovation. Second, in an increasingly urban dominated economy firms produce products that are mainly tailored for urban needs and which may not work well in a rural situation. This means that existing products offer only partial solutions to rural needs. Third, in rural regions tacit knowledge remains important. The nature of a problem may be specific to a particular place making the understanding of that place integral to any solution. This too favors the user-entrepreneur. Finally, because the problem is somewhat specific either to an individual or place the market for a solution may be too small to interest a conventional profit-oriented innovator-entrepreneur, once again making user-entrepreneurs the most likely candidates to develop solutions.

6.0 Preliminary REIS Survey Results on Entrepreneur Innovation

Early results from a still incomplete survey are of somewhat limited value so only a few data points will be presented. Table 1 provides a comparison between employment in rural and urban regions for all responding establishments and for manufacturing. The first block in the table focuses on employment in innovative and non-innovative places of work. From this part of the table it appears that metro establishments are somewhat more likely to engage in innovative activity (39%) than nonmetro establishments (35%). Similarly for manufactures it appears that 46% of employment is associated with innovative firms in metro areas, while 42% of nonmetro manufacturing employment is in innovative firms. The metro-nonmetro differences could reflect greater opportunities for a profit-seeking firm in a metro region from an innovation because the local market is both large and more complex creating space for a new innovation.

The second cell of the table decomposes innovative firms into those that follow a search for profit – Baumol's innovative entrepreneurs and into user entrepreneurs who first innovate in response to a problem they face, and subsequently commercialize the innovation. Here the results show that user entrepreneurship is more common in metro regions with about 20% of employment in metro innovative firms coming from engaging in user entrepreneurship compared to about 15% in nonmetro regions. For manufacturing the two percentages are 18 % for metro employment and 16% for nonmetro. The figures suggest that user innovation is fairly common in both types of region and more common in rural manufacturing than for all firms, but less common for urban manufacturing.

The third cell of the table further subdivides user innovation into two categories. The first category consists of individual who experienced a personal problem that led to their innovation. The second category consists of individuals who innovated in response to a problem encountered at their place of work. In this later category the innovation came about because part of their work responsibility was to find a solution to the problem. Results in this category suggest that personal use problems leading to innovation are more common in nonmetro than metro regions for all firms and manufacturing firms. About 39% of all nonmetro employment in firms that experienced user innovation is from personal use compared to 32 of for metro. For rural manufacturing almost 505 of employment in firms experiencing user innovation comes form personal use, compared to 31% in metro. This results suggest that user innovation follows a different path in metro and nonmetro regions with individuals in nonmetro regions being more likely to innovate in response to a direct personal problem, whereas in metro regions user innovation is more likely to occurs as part of someone' s job responsibility.

Table 1: Preliminary Results from the REIS on Innovation by Metro and Nonmetro Firms, Measured by Employmetn Share

Innovative vs. non-innovative			
All Establishments	not innovative	innovative	innovative share
nonmetro	3,338,846	1,785,856	35%
metro	24,947,769	15,889,527	39%
Manufacturing			
nonmetro	1,292,823	947,202	42%
metro	3,945,153	3,384,526	46%
conventional vs. user innovation			
All Establishments	conventional	user	user share
nonmetro	1,492,677	257,517	15%
metro	11,964,321	3,069,729	20%
Manufacturing			
nonmetro	782,714	145,374	16%
metro	2,683,559	583,461	16%
personal use vs. employer driven			
All Establishments	personal	employer	personal share
nonmetro	99,859	157,658	39%
metro	989,498	2,080,230	32%
Manufacturing			
nonmetro	72,563	72,810	50%
metro	178,902	404,558	31%

These results are very preliminary and subject to revision, but they do suggest that user innovation remains important to small firms and that it is reasonably common across urban and rural regions.

7.0 Discussion and Conclusion

Innovation has become the accepted driver of economic progress and it is widely believed that innovative regions will have both higher rates foo economic growth and better standards of living than lagging regions. While innovation is typically seen as resulting from a production process, the linear model, where inputs of scientists, engineers and capital are invested to produce specific types of innovation that results in induced technological change the reality is more complicated. Formal science based innovation accounts for most of the investment in Innovations and certainly generates most of the patents. However, most patents have no commercial value and, as Baumol notes, most formal innovation systems produce only incremental change. As a result conventional measures of the returns from large scale R&D can overstate the actual benefits it provides.

In particular, Baumol shows that small scale, entrepreneur based innovation produces a disproportionate share of break-through patented innovations, given the resources available to innovative entrepreneurs. He argues that innovative entrepreneurs follow a markedly different approach to innovation that relies more on creative invention, rather than systematic experimentation. While Baumol does not address the idea of user-entrepreneurs they fit easily into his distinction between large scale and small scale approaches to innovation. User-entrepreneurs differ from Baumol's entrepreneurs in that the profit motive is a secondary effect and not the main motive for seeking an innovation. User-entrepreneurs innovate mainly because they have a problem that has no current market solution, so they have to create one.

The economic growth literature typically takes the Industrial Revolution in Britain starting in the early 1800s as the starting place for an ongoing series of technological improvements that has led to the modern industrial economy (Piketty, 2014). This process is seen as one of substituting improved varieties of capital for labor, upskilling human capital and urbanization. It largely ignores the fact that much of the early innovations in British manufacturing took place in rural England and only subsequently moved to urban areas (Mokyr and Voth, 2010), just as there is little recognition that US farmers had a much faster adoption of electricity and telephones in their early stages of development.

Most importantly, theories of endogenous economic growth have largely ignored the role of user-innovation in agriculture in the early stages of the Industrial Revolution and the role of formal science based innovation systems in agricultural modernization starting in the late 1800s. Without these investments that massively increased agricultural productivity it would have been impossible to accomplish the current level of urbanization in OECD countries. This alone shows that rural innovation is an integral element of national economic growth.

But rural innovation extends well beyond agriculture. It is easy to identify breakthrough or disruptive rural innovations in virtually all OECD countries that have national if not global impacts. But these are typically the only rural innovations we know of . Because most rural innovations are largely designed to address the specific problems of an individual or a small firm, they tend not to result in large impacts in the marketplace. However these innovations typically result in the creation of a new firm to serve a niche market or improvements in the competitiveness of an existing firm. This can have an impact in the rural community where the firm is located and in aggregate and over time the cumulative effect of these innovations contributes to rural economic development.

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