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Technology Transfer Versus Transformation

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Research defines technology transfer from the viewpoint of business processes and personnel skills (Rogers, Takegami & Yin, 2001). The focus is on action to adapt and embrace an existing technology to gain efficiency (Gilsing et al., 2011). We examine this phenomenon as innovation based on the ability to transfer existing needs, desires, behaviors, and expectations to new technology. We find technology is adopted when transfer opportunities become manifest and each transfer builds upon its predecessor to create transformation in the long term. This relationship between transfer and transformation gradually builds technology adoption across chasms of the S-curve technology innovation curve.

TECHNOLOGY TRANSFER VERSUS TRANSFORMATION

As a young engineer, Guglielmo Marconi eventually succeeded in making a bell ring by wireless remote control. With this successful result, Marconi would become the inventor of wireless technology. Despite this achievement and all the effort he expended on making the bell ring wirelessly, it is alleged his father shook his head and remarked that there were easier ways to make a bell ring. The year was 1894 (Lorenz, 1996).

Marconi's invention did not disrupt the telegraph industry at the time, but a century later wireless technology is ubiquitous. In hindsight, the invention was ahead of its time and failed to be transformative or disruptive at inception. The cumulative effect of complementary technologies and infrastructures to leverage the value of wireless technology were not yet in place. The compatibility of the innovation with the values, experiences, and desires of adopters were also missing. Thus, Marconi's invention did not flourish at the time (Lorenz, 1996).

The readiness of technology adopters to embrace the change brought about by a technology is a key element in the adoption and subsequent ubiquity of a technology. Rogers (2003) notes that the collective decisions made by the members of a group, known as collective innovation decisions, affect the choice to adopt or reject an innovation. Also, the collective decision is further influenced by the perceived compatibility of the innovation; that is, the perceived consistency with existing values, past experiences, and needs of the potential adopters. Specifically, the perceived compatibility is positively related to the rate of adoption of the technology (Rogers, 2003). This perceived compatibility is influenced by the technology adopters' readiness to embrace the new technology. Adopters readiness is influenced by their ability to 1) identify needs and desires and 2) to adapt or transfer those needs and desires to the new technology to drive adoption.

This paper examines the juxtaposition between technology transfer and technology transformation. Many articles research technology transfer from the viewpoint of business processes and personnel skills (Rogers, Takegami & Yin, 2001) to adapt and embrace an *existing technology* in order to gain efficiency, or from the viewpoint of organizational or environmental barriers affecting the targeted transfer of *existing technology* across environments (Gilsing et al., 2011), this paper examines technology transfer from the viewpoint of adopting an innovation based on the perceived ability to transfer *existing needs, desires, behaviors, and expectations* to *new* technology. The key difference in this perspective is that when transferring an existing technology from one environment to another (e.g. academia to industry or developed countries to under-developed countries) there is a pre-existing notion of benefit from the transferor to the transferee (Khabiri, Rast, & Senin, 2012). However, in transferring existing needs and expectations to a new technology, there may not be a pre-existing paradigm to reference. The pre-existing notion of benefit or pre-existing transferor experience may not be available. Instead, the drive stems from the ability and desire from the potential new adopter to transfer their existing needs to leverage new technology and envision the benefits from the new technology. Thus, technology transfer is defined as the adopter's ability to identify existing and future needs, desires, behaviors, and expectations to new technology and transfer those needs, desires, behaviors, and expectations to the new technology to drive adoption. Because these needs are unique to a specific group and not to all groups simultaneously, the transfer is a gradual process. Transformation refers to disruption of the gradual, cumulative transfer of existing needs by a larger order-of-magnitude change brought about by innovation (Tushman & Anderson, 1986). The transformation can be competence-enhancing or competence-destroying and it creates a forceful disruption.

Historical Technological Innovations

The illustrations examined in the paper are an effort to study and interpret the relationship between technology transfer and transformation. The examples examine the gradual, ongoing transfer of existing needs to emerging technologies and their accretive effect that enable larger change and disruptive transformations. The goal is to explain how the cumulative effects of technology transfer support technology transformation and how the transformation is only possible through the collective effects of gradual transfers. Via this relationship, transformation need not be disruptive. Without the accretive effect of transfer creating social readiness to embrace the ongoing changes, the transformations would resemble Marconi's 1894 invention.

In modern times, it may appear that the ubiquity of technology and technological change is standard. The influence and impact of social media, medical technological advances, scientific discoveries, etc., is persuasive, but is this an unprecedented era? Are there relevant lessons from historical business technology changes to better understand these modern challenges? Contrary to modern rhetoric, a historical review of technology assimilation demonstrates a harmonious balance between transfer and transformation of business and social processes to leverage the opportunities created by technological change. This study contends the relationship between transfer and transformation in technology adoption is more of a harmonious, rather than an antagonistic, relationship.

Transfer of business process or social communications protocols to new technologies with the intent to gain efficiency and productivity (Rogers, Takegami & Yin, 2001) creates opportunities for assimilation. Without this transfer, the opportunity for new technology to be applied is lost. This paper will review two generally historic technological changes and explain how these changes have been assimilated under the lens of transfer and transformation. The benefit revealed by this study is that a historical review of business advances affected by technology gives us an objective review of how the interaction between transfer and transformation actually occurs. Part of the underlying premise of the interaction between transfer and transformation is seen when reviewed from afar, the business changes and impacts from technology innovation appear as a rapid transformation. However, closer inspection of these technology innovations reveal instead a gradual transfer of business processes, with each gradual transfer building upon its predecessor. The accumulation of gradual transfers creates an opportunity for the final transfers to be viewed as transformational when compared to the original transfer. Specifically, the two technological changes reviewed are (1) the steam engine and central workplace and (2) the telegram and its ramifications. These examples are evaluated due to their historical impact, relevance to the material at hand, context and detail available to ascertain the tensions and outcomes, impact to their current economy, and the dimensions available to study the effects on technology adoption.

These lessons from history provide another lens to evaluate the interplay of influences affecting technology adoption, for example, the interaction between transfer and transformation. Utilizing history as a guide for research is an excellent first step prior to qualitative or quantitative research. In this case, utilizing history allows the authors to analyze human behavior in an effort to guide the direction and effort for new research discovery. By learning from the past, academics and practitioners can avoid reinventing what has already been experienced (Baker, 2006) and more expeditiously create advances. The balance between transfer and transformation can provide a perspective to leverage lessons from the past to more effectively manage adoption of technologies.

Society, Innovation, and Diffusion

Scholars have developed approaches to define the nature and patterns of innovation. In the context of technology management, the term innovation encompasses a process of enhancing existing technology or a process of turning opportunities into practical use (Wonglimpiyarat, 2016). Innovation is complex in nature and has various facets, hence, it is important to explore innovation through the lens of the elements of the relationship between transfer and transformation.

Systemic innovation is a type of innovation which leans on complementary systems to realize the value of the innovation. In systemic innovation cases, diffusion of the innovation creates benefits which are external to the innovator and accrue to a wide range of users of other technologies. Systemic innovation is at the heart of interconnected innovations whereby an innovative coalition is necessary to achieve broad adoption (Wonglimpiyarat, 2016). An example of this is the current application ecosystem in mobile devices. The diffusion of the mobile operating system innovation has created an ecosystem platform for applications, the benefit of which is not directly captured by the innovator of the mobile operating system. Yet, the ecosystem – or coalition – helps create value for the users of the mobile devices.

Tushman and Anderson (1986) describe patterns of technological change as a cumulative process up until they are interrupted by discontinuous innovation. This causes technological shifts which they describe as either competence-enhancing or competence-destroying. Competence-enhancing discontinuities are order-of-magnitude improvements based on cumulative experience in earlier iterations of the technology. Competence-destroying discontinuities require the mastery of new technology skills (Wonglimpiyarat, 2016).

Freeman and Perez (1988) argue the process of economic development is radical and causes technoeconomic paradigms. They define a technoeconoimc paradigm as a cluster of interrelated technical, organizational, and managerial innovations that affect the economy as a whole. Similarly, Schumpeter (1939, 1967) advocates that creative destruction emphasizes discontinuity of current economic models. The process of creative destruction brings about the economic growth with the emergence of new products and processes which are not accretive from previous ones; rather, they eliminate them.

Hasegawa, Kozano, and Goto (2015) note that a methodology for technology innovation must analyze both technical aspects of the innovation as well as customer needs. Their notions are supported by research findings indicating that the diffusion of ideas among individuals within social groups depends on features of an innovation, the channels of communication, time factors, and the characteristics of the social group adopting the innovation. Studies indicate that the characteristics of an innovation clearly influence diffusion, adoption, and rejection (Rudd, 2004). These characteristics include the dimensions of an item, the meaning it has for people, and whether people can easily talk about it, see it, and use it.

Rogers (2003) also advocates that social groups are very influential in the diffusion of innovation. Social groups have a behavioral structure which influences individual behavior within the group. In addition, the social and communication structure of the group facilitates or impedes the diffusion of innovations within the group. The social group dimension is a key tenet affecting how technology transfer operates. As the groups identify their needs and meet them with technology, it affects the gradual process of technology adoption or transfer.

Betz (1993) identified several connections between technology innovation performance and the diffusion process of new technology. The *speed of diffusion* depends on whether radical innovation or radical change takes place. During the instances of radical innovation, Betz (1993) notes the speed of diffusion is affected by the interaction of the new radical innovation and the pace of increasing improvements. During the instances of radical change, the speed of diffusion is affected by the interaction the new technology and continual increasing improvements that, through accumulation, support a radical change through time. It is here that the intersection of transfer and transformation occurs for technology adoption. The cumulative effects of increasing improvements manifest themselves through an accretive effect, with the final cumulative transfer effects supporting a larger transformation.

S-curve, Innovation, and Adoption

Comin and Hobijn's (2010) study reveals that, on the average, technologies have been adopted 45 years after their invention. They define technology as "a group of production methods that is used to produce an intermediate good or service." As part of their study, they note that the magnitude of adoption costs affects the length of time between the invention and the eventual adoption of a production method. While not explicitly mentioned, the implicit significance of adoption costs directly intimates the ability to transfer the applicability of the technology change to business or social processes. In other words, high costs create a lack of transferability of technology which in turn impedes its adoption and which in turn affects the mainstream transformation.

Comin and Hobijn review data for 166 countries and 15 specific technologies spanning from 1820 through 2003. They organize the technologies into six general categories. One of the categories is transportation technologies, including the steam engine and railways; another category is telecommunications, including telegraphs and telephones. Their study reveals approximately 50 years from technology invention to adoption for "steam and motor ships", 60 years for "railways-passengers", 44 years for "telegraph", and 64 for "telephones". Their study also indicates that adoption lags are decreasing through time, with later inventions carrying a shorter adoption lag. Apart from the adoption of the MRI, which carries a 12-year adoption lag, the later inventions still hold a 20 year or larger adoption lag.

The evidence reveals a lag between technology invention and adoption of the technology. Comin and Hobjin's data does not suggest nor support a view of drastic, radical, or one-time transformation of business processes for the adoption of technology. Rather, their research shows how mainstream technology adoption occurs many years after the technology invention.

The S-curve widely enables the analysis of the evolution of the performance of technologies across various industrial sectors. Iterations of the S-curve, such as Pearl's Law, support the analysis by which an innovation is diffused throughout a determined social system (Nieto, Lopéz, & Cruz, 1998). Wonglimpiyarat (2016) contends the innovation process also supports an S-curve pattern. While the S-curve has been applied to various technology adoptions and the phases within the S-curve take on specific names depending on the technology adoption; the general concepts are straightforward. There is initially a slow and gradual start to the introduction and adoption of the technology. This phase typically represents the first third of the technology's life. Through time there is an increasing adoption of the technology, followed by a rapid assimilation; this is the second phase and it typically represents the shorter span of the curve in terms of time. The third and last phase involves the institutionalization of the technology whereby it becomes ubiquitous and saturates the adoption penetration. In general, the S-curve adoption process supports the notions of slow and gradual technology transfer, supporting the path to transformation in the later phases of the S-curve.

The impact of the S-curve directly supports, albeit from a different perspective, the lag of technology adoption presented by Comin and Hobijn. In presenting the rapid adoption in the second phase, it is the position of this paper that the adoption is in large part due to the transfer of business or social processes to the technology innovation and that this transfer occurs gradually, eventually leading to a transformation. The transformation as such is a change in degree, not in kind. It appears in kind when viewed from a historical distance.

Smil (2013) considers this premise from a different perspective in his recent study of technology changes over the last 80 years. His study includes various dimensions affecting technology adoption across large scales, including changing populations, energy use and nutrition, and political and social dimensions. One of the aspects that he also considers is gradual changes versus fundamental breakthroughs in technology. This is a shorter section of his study and the concepts are presented at a macro historical level, without delving deeply into historical evolutions of the gradual changes. He denotes that gradual development has been cumulatively more important than fundamental breakthroughs. The perspective supports this paper in that the gradual changes have been foundational for the adoption of technology in business; however, Smil presents fundamental breakthroughs in an opposing light to technology transfer adoption. This paper attempts to present a more influential relationship between gradual adoption and transformational or fundamental breakthroughs whereby they are not necessarily mutually exclusive, but rather a matter of degree, with gradual transfers leading to transformation.

Steam Engine and the Central Workplace

The steam engine is seen as a technology innovation that propelled economic growth and business advancement. The nature of the steam engine congregated the workforce into a central location which brought forth its own series of challenges (Wren & Bedeian, 2009). Although not a technology adoption per se, the workforce congregation or central workplace is a business and social result from a technology adoption and because of this it is explored in this paper and reviewed interdependently with the steam engine.

Central Workplace

The central workplace presents a robust example of transfer to meet technology adoption. The transfer in this instance was a multi-dimensional reassignment from farm work life and expectations to the central workplace supporting the location of the steam engine. The steam engine created an opportunity for centralization of workforce and leveraging of this opportunity, but it was initially met with a direct relocation of work customs, conditions, and expectations from the rural workforce.

The hours of work were transferred from farm life to the central workplace. The 'dawn 'til dusk' transfer created 12 to 14-hour workdays in the new central workplace (Wren & Bedeian, 2009). The expectations of workplace conditions were also transferred. Accustomed to toil and hard working conditions, these expectations were also the opening expectations at the new central location.

The existing workforce labor pool was also an element that was transferred to satisfy the needs of the central workplace supporting operations of the steam engine. The established work pool in the rural reality included child labor to support family and group crop growth needs (Wren & Bedeian, 2009). Thus, children were also part of the labor pool in the central workplace. The existing workforce pool had an established work ethic, not accustomed to set working days. This was also a group with an embedded learning method, inculcated by generations of a learning protocol suited for rural life, learning by doing and not necessarily training (Wren & Bedeian, 2009). This in turn yielded a skill set. These accumulated challenges were met gradually with administrative and management techniques, with trial and error, and subsequent individual improvements.

The reality of the central workplace was a direct transfer of reality in rural society to meet the opportunity created by the steam engine. As Wren and Bedeian (2009) state, the issues faced by the central workplace were a matter of congregation and visibility of an existing reality, not of a new reality.

As the issues were met and addressed, the central workplace reality appeared very different – in fact transformed – with reduced and established work hours, safety conditions, child labor protection, and an established management practice. This, however, was not a transformational change, but rather a cumulative set of changes through gradual transfer.

Modern technology, as defined by Chen and Shimomura (1998) has a constant labor productivity and its output is affected by the human capital itself. This suggests that the need for workplace improvements was not only for the behest of the laborer himself, but also implicitly for the improvement in productivity in using the new technology. The workplace improvements led to factory benefits by creating conditions whereby the laborer could better leverage the new technology and be more productive. The laborer, in turn, obtained a better working environment.

Steam Engine

The qualification of force of a steam engine, measured in horse power, is a clear representation of transferring the function and business relevance of the technology. The initial price for a steam engine was based on how many horses could do the same amount of work (Wren & Bedeian, 2009). More than a new technology, the steam engine represented a transfer of technology and innovation mechanical prowess for human and other natural sources of power. Yet, the steam engine centralized the workforce to be able to harness the machine power, creating dependence between the individual and the technology, necessitating business applicability to progress.

Despite the transfer of the source of power, the initial adoption of the steam engine did not result in overwhelming business gains; additional transfers still needed to take place. Sicilia (1986) challenged the traditional historical accepted role of steam in the American economic growth. His study showed that instead of consistently increasing productivity, lowering costs, and permitting large scale operations, the adoption of steam impacted each of these changes in different degrees. When viewed from the perspective of value added per capita, the gains in steam are mixed, with many non-steam using enterprises having a larger value add. This is in large part due to the steam driven enterprises requiring more scale to accommodate the large capital investment required for steam, creating an impediment to fully exploiting the technology adoption. Christensen, Craig and Hart (2001) refer to the performance trajectory of technology, which speaks to the ability of consumers to utilize the technology innovations, such ability being influenced by several factors, including factors of profitability. This supports Sicilia's study.

As the steam engine invention became mainstream, transfer opportunities would emerge. The steam engine technology presented a transfer opportunity to the locomotive. The steam engine technology and the railroad need would create an environment of continued transfer and eventual transformation.

Railroad

The railroad industry was a result of two transfers, rails used in the mining industry as far back as the 15th century and the attachment of a steam engine on wheels (Bernal, 2008). An adaptation to the output of the exhaust steam allowed for transfer from a steam engine designed to operate machinery to one able to carry out transportation needs. More importantly, this transfer created a primary form of transportation for a century (Bernal, 2008). The railroad's industry path was not an instantaneous one, as it was fraught with challenges and obstacles that had to be overcome through time. The initial transfer of natural resources, such as horsepower and labor, to steam machinery for labor scalability later combined with a transfer of the machinery and railways to create a transportation industry. It took years of gradual progress and capital investment, but when observed in hindsight decades later, the output appears transformational.

Hall and Khan (2003) hold that diffusion, rather than innovation, is what ultimately determines the rate of change in productivity and economic growth. They define diffusion as the cumulative result of incremental benefits of adopting new technology against the understood costs of the change. Among the factors that influence diffusion are demand and supply determinants. They identify the demand and supply determinants. The demand determinants include elements such as the availability of skilled labor.

The supply determinants include improvements in technology after its introduction, invention of new uses for the technology, and development of complementary inputs. Herein Hall and Khan are describing transfer under a slightly different light; however, the invention of new uses for technology outlined by Hall and Khan speak directly to the gradual transfer of steam technology to the locomotive space. The same holds true for the transfer of the rails themselves, whereby a slightly different use of that technology was utilized.

The transfer synergy between the central workplace and steam engine helped move the steam engine through the phases of the innovation S-curve. The adoption and assimilation of the steam engine were increased with the transfer to the locomotive, moving the steam engine farther up the innovation S-curve into institutionalization. Comin and Hobijn (2010) note the average of 50 years from technology invention until adoption: the transfers of the workplace and the locomotive help to illuminate the relationship between cumulative transfer effects and overall transformation, helping explain the institutionalization of the steam engine on the S-curve model.

Telegram

The telegram is a technology innovation that is considered to have revolutionized and transformed economic growth and industry. This is true when considering not just the technology innovation and invention, but also the total normalized impact of the technology, analyzed from afar, several decades and more than a century after its time. However, the adoption and immersion of the telegram was far from smooth, far from certain, and near to proximity of failure. It was the transfer of applicability and business needs that created the opportunities for the initial adoption and this adoption built on itself to create the lasting impact we recognize today. The telegram technology invention and its aggregate and cumulative impact tell another story of gradual transfer of business processes and social needs that leaned on every gradual transfer to cumulatively deliver a transformational impact, supporting the notions of this paper.

The telegram became pervasive for its time and the impact was multi-dimensional, changing businesses across industries and society across social and economic levels. Akin to modern rhetoric, the telegram technology innovation, once it became mainstream, was seen as a "subjugation of nature and conversion of her powers to the will and use of man" (Morus, 1996). This notion is also covered in more detail by Leiss (1970). Leiss' direction studied the conquest of nature as a means to achieve utopia, specifically in its relation to harmonious social order. Technology innovation is the instrument to achieve this end.

Despite the power over nature rhetoric, the path from laboratory to mainstream stay was not an easy one. There was no market for the product and because of that, no capital funding. The challenge of a market evidences direct support for the transfer of technology argument. A market is an outlet whereby the business processes, productivity or impact can be transferred to benefit from the technology. Without these initial and subsequent cumulative transfers leading to transformation, there was no movement of the technology. This lack of momentum leads to the demise of an eventual transformation.

The initial display of the technology was conducted over the course of several years in museums and exhibitions and the initial reaction was of something ingenious, but not necessarily marketable (Morus, 1996). The venues were not specifically for the telegraph, but rather for innovation, lectures, and exhibitions at large that spanned several countries and continents. As such, the progress was slow and tedious; it seemed that a breakthrough via this channel had an element of randomness.

Cook, the co-founder and co-patent holder of the telegram with Wheatstone, was focused on finding a market and patronage for the technology innovation. He focused on industries where the telegram could provide a cheaper and more efficient form of communication. This was a key step in creating a direct link to transfer business process, needs, and potential productivity to the telegram. Another avenue of transferability Cook was seeking was secrecy of communication, thus targeting governmental and military entities (Morus, 1996). This overall process of finding an applicable business need to transfer was ongoing and part of a multi-dimensional strategy at technology assimilation and impact while Cook and Wheatstone pursued their patent. This strategy was one of survival for the invention, but in retrospect it was a strategy that sustained the technology innovation. Creating multiple industry transfer impacts for the technology to become mainstay was necessary. The performance trajectory of Christensen, Craig, and Hart (2001) was at play with Cook and Wheathouse in a race seeking that ephemeral intersection that creates the ability for the consumers to leverage the technology innovations.

Steam Engine and Railroad Collision to the Rescue

The transfer of the steam engine to the locomotive industry was the first influx of energy and opportunity for the railroad industry. The design and thinking around the laying of rails was a direct transfer of road building mentality and as such, presented a staggering infrastructure capital cost to the industry.

The concept of dual directional lanes was an apt solution to potential collisions of locomotives. This meant doubling up on railroads which created a feasibility challenge due to high entry costs. The alternative was to have a single lane with a single car, but this in turn affected scalability, effectively cutting it in half. The true challenge was how to have more than one locomotive in a single rail, or minimize rail manufacturing as much as possible. More than a logistical challenge, it was a communication challenge.

The next injection of opportunity for this industry developed with a need for the telegram. The business need for logistics of more than one train per rail, at the heart of the business challenge, suited one of the transferability elements made possible by the telegram. Cook and Wheathouse could transfer this business need to apply to the technology's capabilities. They presented the need for sophisticated logistics as being pre-empted by a business communication need at the core, with the telegraph being the answer to this business need. It was a direct transfer of a true business need to one of the efficiencies readily granted by the telegraph.

The harmony created by the transfer of business needs to these innovative technologies kicked-off a symbiotic relationship. Using the telegram, the railroad industry could resolve the logistics need and significantly reduce the build-out costs. Using inexpensive, reliable communication of the telegram, the railroad industry could leverage mainly single lines of rail for locomotive transportation. The railroad's communications needs transferred to the telegram and was such a strong fit that a single line with the electric telegraph was seen as superior in passenger security and efficiency than double lines without the telegram (Morus, 1996).

The S-curve dynamics held true for the telegram at this stage of its adoption curve. The seeds sown by Cook and Wheathouse's strategy of pursuing multiple industries began to pay dividends. After success with the railroad industry, the dimension of secure communications provided by the telegram found a business need transfer with the U.S. government's military forces.

By this time the telegram had become mainstream and ubiquitous with the general population. In business, the opportunity for deeper levels within the organization to communicate directly with other organizations increased, reducing the cost and time involved in face to face communication. The telegram also expanded access across industries as every business began having access to this communication technology. Citizens became was aware of its nature and availability and individual use began to increase as well. The transfer of vernacular language to written telegram form became commonplace and a violation of proper etiquette and behavior. The "meaning of communication changed as its components became commodities to be carefully packaged and valued" in a telegram (Morus, 1996). The telegram had become, as Christensen, Craig, and Hart (2001) would describe, a disruptive technology, both at a business and social level. Disruption, in this context, especially at the business level, creates choice and competition because traditionally entrenched firms are challenged. From a different perspective, the telegram, with its ubiquitous nature, was the opening act and kicked off Lektorsky's (2013) "electronic democracy" concern. The telegram's availability and contemporary nature allowed anyone to say anything and start to create a threat to culture causing traditional culture to require standards, models, and hierarchy not enforced by the telegram.

The infrastructure needed to sustain the telegram later was subsequently leveraged by the telephone. Social and business behavior were integrated with it. The capital investment required to lay copper lines across and between continents had already expanded globally. The addition of voice to communications was a transfer of natural communication and progression for the introduction of the telephone. The path had already been laid. The synergies between the telephone and the telegram were different in kind from the synergies between the steam engine and rail's needs, but from a transfer point of view, they were different degrees of transfer that essentially built on each other to cumulatively create a transformation.

CONCLUSION

In closing, pointing out the gradual transfer and packaging of communication needs through the groundwork created by the telegram becomes self-evident. The opportunities created by gradual transfers were not present when Marconi initially invented wireless: the business and social infrastructure were not ready. His father's reaction was a true testament of the nonexistence of opportunity for gradual transfer.

A historical review of transfer versus transformation allows for thinking differently about technology adoption. Some current rhetoric calls for re-transformation of business, as present with Rogers, Takegami, and Yin's (2001) definition of technology transfer, to capture opportunities created by technology adoption. The concepts presented in this paper portray a different approach to this strategy. We argue for a perspective that alternatively interprets the value of transfer opportunities and advocates an understanding of identifying current and future transfer opportunities to lay the foundation for transformation.

Transfer and transformation move technology adoption along the innovation S-curve. Each transfer solidifies technology adoption, eventually moving across different phases. As transfers continue to increase, assimilation increases as well, eventually propelling the innovation into the institutionalization creating transformations.

REFERENCES

Anderson, P., & Tushman, M. (1990). Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change. *Administrative Science Quarterly,35*(4), 604-633.

Bernal, J. (2008). Science, Industry and Society in the Nineteenth Century. *Centaurus*, *50*(1/2), 73-100. doi:10.1111/j.1600-0498.2008.00102.x

Betz, F. (1993). *Strategic technology management* (McGraw-Hill engineering and technology management series). New York: McGraw-Hill.

Chen, B., & Shimomura, K. (1998). Self-fulfilling expectations and economic growth: A model of technology adoption and Industrialization. *International Economic Review*, *39*(1), 151.

Christensen, C., Craig, T., & Hart, S. (2001). The Great Disruption. *Foreign Affairs*, *80*(2), 80-95.

Comin, D., & Hobijn, B. (2010). An Exploration of Technology Diffusion. *American Economic Review*, *100*(5), 2031-2059. doi:10.1257/aer.100.5.2031

Freeman, C. & Perez, C. (1988). Structural crises of adjustment, business cycles and investment behavior. *Technical Change and Economic Theory*, 38-66.

Gilsing, B., Bodas, F., & Van Der Steen. (2011). Differences in technology transfer between science-based and development-based industries: Transfer mechanisms and barriers. *Technovation, 31*(12), 638-647.

Hall, B. & Khan, B. (2003). Adoption of New Technology. *National Bureau of Economic Research. JEL No. O3, L1,* 1-19.

Hasegawa, Kozano, & Goto. (2015). S-Curves Analysis Focusing on WOM for Technological System Evolution. *Procedia Engineering, 131*, 1094-1104.

Jacobson, H. K. (1971). Technological Developments, Organizational Capabilities, and Values. *International Organization*, *25*(4), 776.

James, J. (2013). The Diffusion of IT in the Historical Context of Innovations from Developed Countries. *Social Indicators Research*, *111*(1), 175-184. doi:10.1007/s11205-011-9989-0

Khabiri, Rast, & Senin. (2012). Identifying Main Influential Elements in Technology Transfer Process: A Conceptual Model. *Procedia - Social and Behavioral Sciences, 40*, 417-423.

Kucharavy & De Guio. (2011). Application of S-shaped curves. *Procedia Engineering,9*, 559-572.
Leiss, W. (1970). Utopia and technology: reflections on the conquest of nature. *International Social Science Journal*, *22*(4), 576.
Lektorsky, V. A. (2013). Social Technologies and Man. *Russian Studies In Philosophy*, *52*(1), 70-81.
Lorenz, D. (1996). How the world became smaller. *History Today*,*46*(11), 45.
Modis, T. (2007). Strengths and weaknesses of S-curves. *Technological Forecasting & Social Change, 74*(6), 866-872.
Morus, I. (1996). The electric Ariel: Telegraphy and commercial culture in early Victorian England. *Victorian Studies*, *39*(3), 339.
Nieto, Lopéz, & Cruz. (1998). Performance analysis of technology using the S curve model: The case of digital signal processing (DSP) technologies. *Technovation, 18*(6), 439-457.
Phillips, F. (2007). On S-curves and tipping points. *Technological Forecasting & Social Change, 74*(6), 715-730.
Rogers, E. (2003). The Diffusion of Innovations. Fifth Edition. The Free Press, New York.
Rogers, Takegami, & Yin. (2001). Lessons learned about technology transfer. *Technovation, 21*(4), 253-261.
Rudd, R. E. (2004). Diffusion of Innovation. *Encyclopedia of Health & Behavior, Vol. 1,* Encyclopedia of Health & Behavior, vol. 1, Thousand Oaks, CA, Sage Publications, 2004.
Ruttan, V. W. (1996). What Happened to Technology Adoption-Diffusion Research? *Sociologia Ruralis*, *36*(1), 51-73.
Schilling, & Esmundo. (2009). Technology S-curves in renewable energy alternatives: Analysis and implications for industry and government. *Energy Policy, 37*(5), 1767-1781.
Schumpeter, J. (1939). *Business cycles: A theoretical, historical and statistical analysis of the capitalist process, 2 Vols.,* New York: McGraw-Hill.
Schumpeter, J. (1967). *The theory of economic development (*5th ed.). New York: Oxford University Press.
Sicilia, D. B. (1986). Steam power and the progress of industry in the late nineteenth century. *Theory & Society*, *15*(1/2), 287-299.
Skolnikoff, E. B. (1971). Science and Technology: The Implications for International Institutions. *International Organization*, *25*(4), 759.
Smil, V. (2013). The Last Eighty Years: Continuities and Change. *Population & Development Review*, *38*265-279. doi:10.1111/j.1728-4457.2013.00563.x
Tushman, M. L., & Anderson, P. (1986). Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly, 31*(3), 439-65.
Vannoy, S.A. & Palvia, P. (2010). The Social Influence Model of Technology Adoption. *Communications Of The ACM*, *53*(6), 149-153. doi:10.1145/1743546.1743585
Wonglimpiyarat, J. (2016). S-curve trajectories of electronic money innovations. *Journal of High Technology Management Research, 27*(1), 1-9.
Wren, D. A., & Bedeian, A. G. (2009). *The Evolution of Management Thought*. Hoboken, NJ: Wiley.