**Literature Review**

There is no official or universally accepted definition for technology transfer. Although the terms technology transfer and knowledge transfer have been used interchangeably at times, several studies demonstrated that they are distinct but closely related and interconnected phenomena essential to innovation (Gopalakrishnan & Santoro, 2004; Ismail, Hamzah & Bebenroth, 2018). While the distinction between technology transfer and knowledge transfer can be somewhat abstruse, at a basic level it seems to boil down to the difference between conveying assets whether tangible or intangible (technology transfer) and conveying data, information, and conclusions derived therefrom (knowledge transfer).

While most studies of technology transfer didn’t explicitly define the term, they generally seemed to operationalize technology transfer as a financially-based exchange (Fraser, 2010; Gonzalez-Perni, Kuechle & Pena-Legzkue, 2013; Hallam, Wurth & Mancha, 2014; Markman, Gianiodis & Phan, 2009). Licensing, new venture formation, research collaboration, and faculty consulting were largely used as indicators of technology transfer. However, the operationalization of the construct generally seemed to conflate the concept of technology transfer with the mechanisms for achieving it.

The difficulties encountered with defining and operationalizing the construct of technology transfer seemed to be exacerbated by challenges defining what constitutes a technology. There is no universally accepted definition of technology. Several attempts have been made to grapple with this challenge (Arageorgis & Baltas, 1989; Feibleman, 1961; Herschbach, 1995; Schatzberg, 2018). While the term technology originally referred to the field of study focused on the useful arts, this meaning has generally faded in modern usage. Technology has generally come to be used as a synonym for applied science (Schatzberg). Technology can also be thought of as a distinct category of human endeavor along a spectrum that includes pure science, applied science, and engineering (Feibleman). Technology and knowledge are closely related, interconnected, and distinct. But technology undoubtedly has knowledge embedded within it (Herschbach).

Many studies of technology transfer didn’t bother to define the concept of technology. Academic research on technology transfer has generally conceived of technology as a patent right to a government recognized invention that was derived from R&D activity (Anderson, Diam & Lavoie, 2007; Markman, Gianiodis & Phan, 2005; York & Ahn, 2011). However, patentable subject matter is defined by law, which varies from country to country. Thus, patents are not universal phenomena. What is patentable in one jurisdiction may not be patentable in another. Moreover, not all technology is patentable and what is patentable may not necessarily constitute a technology. Some studies broadened the idea of technology to include knowledge (Chakrabarti & Dror, 1994; Gonzalez-Pernia, Kuechle & Pena-Legazkue, 2013). Such studies affirmed the interconnectedness of technology and knowledge. Such an approach tacitly acknowledges that technology is not the only benefit derived from research and development.

Defining success in the context of technology transfer has been problematic for scholarly studies of the subject. Many research studies seemed to select indicators and measures more for convenience rather than to maximize construct validity. Executed patent licenses, established new business entities, and executed sponsored research agreements have all been used as indicators of technology transfer (Gonzalez-Perni, Kuechle & Pena-Legzkue, 2013; Hallam, Wurth & Mancha, 2014; Markman, Gianiodis & Phan, 2009). As previously discussed, these are all financially-based definitions of success. Theoretically, technology transfer can occur in the absence of a financial transaction. These approaches also carry the risk of mis-categorizing or double counting activities depending on how the measures are used. For example, a patent license is often associated with the formation of a university spinout company (i.e., new business venture to commercialize technology developed at a university). In such situations, using both licenses and university spinout company formation as measures would essentially double count a single instance of technology transfer. Another example is sponsored research, which may not be related to technology previously developed at the university through its research activity. As such, it may be misleading to categorize all sponsored research as instances of successful technology transfer. Some studies used allowed patents as a measure of R&D and technology transfer success (Anderson, Diam & Lavoie, 2006; Kim, Anderson & Diam, 2008; Powers, 2003). While, patents are an important output of R&D activity they are not the final objective. Just because a patent is allowed doesn’t mean that it produces a societal benefit.

Several studies have demonstrated the feasibility of using patent data in the context of technology transfer and knowledge transfer (Choi, Jang, Jun, & Park, 2015; Hu & Jaffe, 2003; Ji, Lim & Park, 2016; Park, Lim & Ji, 2018; Sharma & Tripathi, 2017; Yoshikane, 2013). Hu & Jaffe specifically used patent citations as an indicator of knowledge transfer. Yoshikane explicitly studied the citation frequency of patents to investigate knowledge transfer and found that the number of classifications tied to a patent was positively associated with citation frequency. This seems to suggest that the more general a patent the more likely that the knowledge contained in the patent will be transferred as measured by the number of citations the patent receives.

Various studies have used regression analysis in their investigations of technology transfer. According to Licht (1995), the two primary uses of multiple regression analysis in studies are to either predict phenomenon for decision-making purposes or understand and explain the nature of phenomenon to develop or test theories. Studies of technology transfer have used various regression analysis methods to understand and explain the process. These studies demonstrated that regression analysis is a useful method for gaining insight into the factors associated with technology transfer success. Williams (2007) used multiple linear regression to understand the role of replication and adaption in the knowledge transfer process. Yoshikane (2013) used multiple linear, logistic, and binomial regression analyses to study patent citation data. Kirkman (2013) used multinomial logistic regression to understand how universities use technology transfer to disseminate research discoveries to biotechnology firms. Kirkman found that the innovativeness, proactiveness, and risk taking propensity of biotechnology firms influenced their selection of technology transfer modes. Kirkman specifically limited the modes of technology transfer in the study to licensing, sponsored research, and consulting agreements, which are all financially-based exchanges. Appio, Martini & Fantoni (2017) used a series of logistic regression models to explore the role of scientific and technological diversity in developing impactful bioinformatics inventions as measured by forward citation distribution. They found that different degrees of knowledge diversity were associated with different degrees of impact but combinations of scientific and technological knowledge diversity did not always lead to impactful inventions as defined in the study.

Many technology transfer studies seemed to focus on exogenous factors, such as organizational characteristics and financial resources (Markman, Gianiodis, & Phan, 2009; Powers, 2003). Endogenous factors associated with the nature of the technology itself are also likely to have a significant influence on technology transfer success.

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