

# A Taxonomy of the University Entrepreneurship's Technology Transfer Office Literature

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## A Pinwheel Model of the TTO

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### Abstract:

The purpose of this theoretical work is to shed new light on how managers and scholars can view the individuals within the Technology Transfer Office(TTO). It is found that the absorptive capacity, ability to create a market for ideas, knowledge and intensity of network ties of the individuals within the TTO can synergize with each other through trust and are essential to technology transfer. The practical implication of this is that managers and researchers should analysis the members of the TTO team in these terms. Although previous research has looked at network ties in relationship to technology transfer the extant literature only looks at the knowledge creators. The TTO is important for analysis as it offers an intermediary between the knowledge creator and university partners and thus the TTO helps create a market for ideas. Most interestingly this paper introduces the counter intuitive theory of blowback, which is the concept that not only can strength of network ties and trust show diminishing returns but eventually even show negative returns.

### Introduction

This introduction will first outline the basic support for the theories that are at the base of the paper's outline. The theories will then be combined so as to later be used to derive propositions. Finally a counter intuitive line of reasoning is put forth and supported. Mindful scholarship is used to synthesize and extend the extant theories.

An entrepreneurial university is understood to be one that acts as a creator of technological development and local economic growth (Klofsten and Jones-Evans 2000). The ability to transfer knowledge from the university into the private sector is a burgeoning field of study (Rothaermal et. al. 2009). In an ideal market(Stolper 1943) resources are exchanged

without cost and full information on the value of those resources is known. A market for ideas (Grimaldi 2009) is a concept that indicates how closely the market for transferring patentable knowledge behaves as an ideal market does. A technology transfer office, often called a TTO (Powers and McDougall 2005) or OTT or technology licensing office TLO, is the department through which an entrepreneurial university attempts to transfer patentable knowledge it creates to the private sector. Gans and Stern (2003) present the problems associated with the presence or lack of presence of a market for ideas, something that is moderated by the staff within a technology transfer office (TTO). This paper studies the theory related to the entrepreneurial university's TTO as it relates to the TTOs staff.

Network ties can be understood as a relationship (Westphal Boivie and Ming Chng 2006) that an entity may have with a network of other entities, this is the focus of social capital (Feeney and Bozeman 2008). Owen-Smith and Powell (2003) found that those in the TTO rely on network ties to the private sector and their own expertise in order to create impactful portfolios of patented information and ascertain the importance of potential technology. Chapple et al. (2005) supports this claim by finding empirically that there may be a benefit to having increased skills among those in the TTO. The skills that are needed to transfer knowledge, particularly market orientation skills, are different across various sectors within the private sector (Druilhe and Garnsey, 2004) and thus may require a variation in knowledge.

Absorptive capacity (Cohen and Levinthal's 1989, 1990) is understood to be an organization's particular ability to value, assimilate and utilize new knowledge. The concept of networks (Powel et al. 1996) of learning explains that learning collaborations are not discreet interactions nor a way of simply compensating for a lack of internal skills but rather are used as a way to optimize synergistic partnering. Powell et al. (1996) offers an important theoretical basis

for this work in their observation of networks of learning. Networks of learning are seen as the basis from which innovation occurs when the environment is complex and expanding. This is supported by the understanding that networks of learning are underpinned by Cohen and Levinthal's (1989, 1990) absorptive capacity argument. Lane and Lubatkin (1998) later indicated that the absorptive capacity relationship is moderated by the organization's knowledge basis.

Another basic theory from which this paper argues is the knowledge based view of the firm. Penrose (1955) first observed that human tacit knowledge is valuable to the firm. Wernerfelt (1984) later added that resources are the basis by which the firm should be perceived. Barney (1991) then found that resources offer a sustained competitive advantage if they are rare, hard to copy and valuable. Flowing from this same stream of research is Kogut and Zander (1992) found that knowledge is broken down into know how and information and that this knowledge is tacitly embedded in the firm. From these arguments we could conclude that an organization is defined, competitively, by the knowledge it possesses. This is particularly important due to Kogut and Zander's(1996) support for the observation that people, and thus organizations, are rationally bound by knowledge.

The final theoretical framework that this paper uses is a modern understanding of trust. Each of the aspects of trust lead to one another(McKnight, Choudhury and Kacmar 2002). Willingness to take on the risk of an unknown outcome from dealing with another is the definition used across disciplines of trust (Rousseau 1998). One's willingness to overlook a violation of trust on the part of another actor is the intensity of the relationship (McKnight, Cummings and Chervany 1998). The perception of ability, benevolence and integrity is how trust is determined and intensified (Gefen 2008).

These points of view coalesce in the most modern run of literature related to technology transfer. Lyles and Salk (1996) found that ventures in which partnership is split evenly have a lower level of knowledge transfer than do partnerships in which there is a dominant member. This may be due to an impetus within an unequal partnership to allocate proper resources, which reduces the barriers related to knowledge transferability (Simonin 1999). Wong and Ellis (2002) observed that although weak network ties are good for identifying partners, strong network ties help in the speed and strength of the transfer of knowledge. Impetus, dominance and strength of ties are all ways of observing the concept the intensity of network ties.

Most interestingly this paper will introduce the counter intuitive concept of blowback. Blowback has been used to show how a strong reputation can make one a target for social problems claims (Best Lowney 2009). The blowback argument is that although strong network ties and trust are driving technology transfer, overly strong ties or over-trust between or within the organization can slow the pace of technology transfer. Previous literature has portrayed overly strong network ties between organizations as a matter of physical distance (Molina-Morales, Martinez-Fernandez 2009), this research extends this idea to the interpersonal level. Further this paper looks at technology transfer while other the previous research has looked at innovation, which is a measure of technological diffusion. This paper also argues from the perspective that it is not social interactions but psychological distance as measured by intensity of network ties and trust that is the key driver of this phenomenon. The previous literature has also based its arguments on premiums extracted from a centralized relationship, as supported by transaction cost economics (Williamson 1981), this research looks at the problem from the point of view of institutional theory combined with ambidexterity (Stock, Greis, and Fischer 2001).

## Problem Statement

The issue of technology transfer is very important. Executive order 13329 (Federal 2004) established a federal government focus on small business technology transfer. Following suit the National Science Foundation(2009) has given out grants in for the transfer of technology in the fields of biotech, information and communication technologies, nanotechnology, advanced materials, and manufacturing. The NSF awards have gone to over 750 recipients, many who have received at or above \$500,000 each. Billions of dollars more are being allocated to technology transfer by NASA (2009), the National Institute for Health(2009) and the Department of Defense.

The concept of the market for ideas has been looked at as needing an intermediary(Grimaldi 2008) in order to avoid problems with knowledge transfer that become apparent through classical game theory analysis. The technology transfer office, if it has the trust of both the knowledge creator and buyer, can serve as the intermediary. The problem of determining how the essential network ties are formed within the TTO context has been left unexplored. Further the extant literature does not tell us how the particular skills of members within the TTO may integrate with each-other.

Absorptive capacity has long been understood to consist of (Cohen and Levinthal's 1989) both being able to value outside information and absorb and apply that information. This ambidexterity of absorptive capacity should be kept in check to make sure that no one side of the two aspects overwhelms the absorptive capacity of the TTO. This two handed approach consists of structural and contextual aspects (Chang, Yang and Chen 2009), despite this knowledge little work has gone into the value of the social context of the members of the TTO. Presently the research on TTOs fails to integrate the value of the network ties of the individuals who make up the TTO.

The question of what creates a market for ideas and the related perfection of those markets has been left unexamined within the context of university technology transfer (Lichtenthaler 2008). Understanding these aspects of technology transfer would help the TTO with its mission of local economic development and would help companies better exploit the new knowledge coming out of universities. The ability to create an academic, holistic, appraisal of the individuals in the TTO would well serve existing university entrepreneurship practice and scholarship.

Trust formation within the context of technology transfer has been addressed as having limited but important use (Gilsing et al. 2008). This literature, though, does not address trust formation within a group trying to transfer technology so much as trust formation between a learning and teaching collaboration. Understanding how the systems that are influenced by trust would help the TTO manager better transfer technology. The ability to look at team formation as moderated by the trusting stance of the individual offers an important theoretical addition to the technology transfer literature and an often overlooked aspect of team formation to the practitioner.

#### Proposition(P)s

Trust is an essential attribute that allows individuals to interact with each other positively, is useful in almost all human interaction and without it the ability to build teams is hurt (Kramer, Cook p10). In a relationship trust offers an important mediator (Valenzuela, Vásquez-Párraga 2006). Given this and the understanding of the inverted U shaped relationship stated earlier we can use trust theory to come to our first proposition:

P1: Trust is an essential moderator in all aspects of relationship involved in the TTO team but has diminishing, leading to negative, returns.

By synthesizing Wernerfelt (1984) and Kogut and Zander(1996) we have found that an organization is defined by the knowledge it possesses. Lane and Lubatkin (1998) then add that technology transfer is moderated by an organization's knowledge basis. This along with the theory of the knowledge based view of the firm (Levinthal's 1989, 1990) helps us see that:

P2A: The TTO's ability to transfer knowledge is directly related to essential knowledge brought to it by its members

P2B: The essential knowledge necessary for a TTO to transfer technology sometimes differs based on the field.

P2C: Some of the essential knowledge necessary for a TTO to transfer technology in one field overlaps with that which is necessary in another field.

P2': For a TTO to transfer some technology the skills from one field can be overlapped with the skills from another in order to transfer to a third field.

These propositions work to create a pinwheel model of the TTO, the center around which the wheel spins is the market need met by the TTO. Each person adds to a leaf of the pinwheel, see model 1. For example one person may bring yellow (computer science knowledge) and another might bring blue (bio-medical knowledge) to the office. Independently they are capable of helping transfer technology within either field but together they can transfer out green(bioinformatics (Botstein and Smarr 1999)).

Adding to this we have the concept of wind direction and intensity, a way of looking at trust and strength of network ties. Network ties are related to the quality and speed of technology transfer (Wong and Ellis 2002). Network ties are further an impetus to allocate proper resources to technology transfer and thus improve the process(Simonin 1999). The pattern here is clear so propositions 4 and 5 are listed without the obligatory but theoretically necessary and

well supported sub-propositions as they are the same AB and C propositions that are found in propositions 2 and 3. Combining these entrepreneurial network theory concepts with those supporting the first four propositions we may conclude that:

P3A: The TTOs ability to transfer knowledge is directly related to the intensity of network ties brought to it by its members.

P3B: The intensity of network ties necessary for a TTO to transfer technology in one field overlaps with that which is necessary in another field.

P3C: Some of the intensity of network ties necessary for a TTO to transfer technology in one field overlaps with that which is necessary in another field.

P3': for a TTO to transfer some technology the intensity of network ties in one field can be joined with the intensity of network ties in another field in order to better transfer technology in a mutually related field.

P4: For the TTO to transfer some technology the absorptive capacity in one field can be joined with the absorptive capacity in another field in order to better transfer technology in a mutually related field.

P5: For the TTO to transfer some technology the market for ideas in one field can be joined with the market for ideas in another field in order to better transfer technology in a mutually related field.

These propositions work to create a definition of wind direction and intensity for the pinwheel model of the TTO. One person may bring a breeze of yellow (limited network ties to microchip designers) and another might bring a different breeze of yellow (limited network ties to microchip fabricators) to the office. Independently they are capable of helping transfer

technology to a limited extent, but together they may be able to increase the intensity of the transfer overall (stronger connectivity to a dual designer and fabricator while transferring **Silicon VLSI (Plummer, Deal and Griffin 2008)**). Now taking what we have derived and synthesizing it we can come to the prime proposition:

P6: What the individuals in the TTO bring to it in terms of knowledge, absorptive capacity, intensity of network ties, and the ability to create markets for ideas is directly related to their ability to transfer technology.

The final addition in this paper is a counter-intuitive one. When we look at the color and wind model we may notice that too much wind or too many colors start to look more and more grey (overly strong ties and too many colors leading to mal-adaptive relationships). Taking the theories backing the previous propositions and combining them with the literature present regarding the curvilinear relationship often found in the social-cognitive context we find that:

P7: That which team members bring to the TTO can be used with each other as moderated by trust and directed by intensity of network ties, both of which have diminishing returns leading to negative returns.

This all means that each person brings both a set of pinwheel colors and wind color and intensity with them to the TTO. One person may bring a breeze of yellow (limited network ties to Microsoft and a good deal of knowledge regarding computer science) another might bring a blowing blue (professional network ties to a bio-med researcher and bio-medical knowledge) to the office. Independently they are capable of some level of transfer but together they can help strongly transfer out turquoise (a biomedical facilitation program based on a beta-version Microsoft platform (Stegle et.al. 2009) licensed out to spin off a for-profit biomedical research institute). The first three aspects of wind are how strong the trust within the organization is and

thus how directly the wind hits the TTO, the second three are how strongly individuals interact with relevant social networks and thus what direction the TTO spins, both in their own way have an effect on speed.

== Insert image 1 about here ==

Others have answered similar questions about technology transfer (Chang, Yang and Chen 2009). Those questions, though, looked at the researcher as the unit of interest, in this case the paper looks at the university technology transfer office as the unit of interest. This is done because in the creation of a market for ideas (Grimaldi 2008) the TTO is uniquely poised as an intermediary. The previous research on the TTO also fails to look at the possibility of an inverted U curve in technology transfer.

A considerable amount of research has recently been done on spinoff companies, of those a fair number look at a more macro scale than simple incubation. O'Shea et al. (2008) Djokovic and Souitaris (2008) and Mustar (2006) offer a view of university spinoff entrepreneurial ventures that is best summed up in their literature reviews of the research done thus far on university spinoffs. The key point to be taken from a holistic review of these three literature reviews is that although the human resource has been looked at (Druilhe, Garnsey 2004, Fontes 2001, Franklin, Write, Locket 2001) the extant literature either focuses on technological diffusion within a startup, which though an important part of the technological life cycle, is not the transfer portion that the TTO deals with or is generally focused on spinoff ventures and not technology transfer in general. This research often includes such variables as absorptive capacity and strength of network ties but tends to give less focal importance to trust and almost none to the creation of a market for ideas.

It has been argued that the use of a business process model, regarding entrepreneurial networks and business support systems, is essential to the incubation of new firms (McAdam et.al. 2006). The model is one of two pyramids. In McAdam et.al.'s(2006) model one pyramid starts inverted with a lot of potentially marketable ideas eventually funneling down to one market viable idea. The second pyramid starts with very little marketing and logistic support ending with a great deal of support after the idea has been found to be marketable. The Longitudinally developed models that describe incubation have sometimes also found the diminishing returns of network connectivity (McAdam, McAdam 2008). These models have found that spinout companies grow in structure and complexity in an incubator until reaching a maximum usefulness at about four years. Next, the knowledge based view of the firm has been used to analyses incubators (Becker, Gassmann 2006). Many of the key variables used in this model are also used in the Becker Gassman(2006) model of incubators, though with slightly different names, they use constructs very similar to knowledge, absorptive capacity and intensity of network ties. The Becker Gassman(2006) model does, however, fail to centralize both trust and the creation of the market for ideas, most probably because the focus is on incubator firms instead of technology transfer in general.

### Validation

The constructs that form the basis of this model are absorptive capacity, the market for ideas, knowledge, trust and intensity of network ties. Absorptive capacity, as put forth by Cohen and Levinthal (1989, 1990) and essential to propositions 4,6 and 7, is defined by the ability to value, assimilate and utilize new knowledge. The market for ideas(Gans and Stern 2003) is an essential construct in the formation of propositions 5, 6 and 7. Connectivity to the private sector (Powell 2003) and market orientation skills (Druilhe and Garnsey, 2004) are what define the essential

attributes of the market for ideas. Knowledge (Barney 1991), as understood to be a strategic resource, is important to propositions 2, 6 and 7. Knowhow and information (Kogut and Zander 1992) are the two key variables that define the construct of knowledge. Trust (McKnight, Choudhury and Kacmar 2002) plays an important role in propositions 1 and 7. Trust is defined as the perception of ability, benevolence and integrity (Gefen 2008). Intensity of network ties (Simonin 1999) is an important construct for propositions 3 6 and 7. Impetus, dominance and strength of ties (Wong and Ellis 2002) all help define the domain of the construct.

Within absorptive capacity (Cohen and Levinthal 1990) ability to value new knowledge can be operationalized as availability of experts locally (O'Shea et.al. 2004). Further ability to assimilate new knowledge can be looked at in terms of the affective outcome of a short priming test (Marshall 1996). Finally for absorptive capacity's ability to utilize new knowledge can be operationalized as how well projects have the same type, size, risk level and key success factors as the partners to be interacted with (Lane, Lubatkin 1998). Absorptive capacity could, theoretically, be observed if individuals in the TTO were surveyed by a researcher or practitioner who asked about perceived availability of local experts, their reaction to a word-priming and vocabulary test and questions to determine the individuals risk aversion.

When it comes to creating a market for ideas(Gans and Stern 2003) connectivity to the private sector has previously been seen in terms of how often someone is contacted by or has transactions initiated by others (Gans and Stern 2003). Market orientation skills can be seen as being the perception of central locality of related marketing(Powel 2003) and R&D personnel (Lichtenthaler, Ernst 2007). Theoretically, then, questions about personal prestige within the related technological sector could link to connectivity to the private sector and questions about

personal knowledge of R&D and marketing workers could be used to determine market orientation skills.

In the assessment of knowledge (Kogut and Zander 1992) knowhow can be seen as a matter of employee skills and experiences (Hall 1992). Information can be looked at in terms of the individuals interconnectedness and ongoing education (Lou, Kogut and Powell 2009). This means that hypothetically a survey asking about experience and training can be used to determine knowhow and questions about ongoing learning and peer interactions in the technology being transferred can be used to determine the information a person possesses.

The concept of trust (Gefen 2008), as it relates to a perception of ability, can be looked at in terms of aptitude (Kasperson, Golding, Tuler, 1992) expertise (Blakeney 1986) and professional drive (Heivmovics 1984). Integrity can be seen in terms of honesty (Sato 1988), consistency (Mishra 1996) and steadfastness (Giffin 1967). Finally benevolence can be operationalized as kind intentions (Cummings and Bromiley 1996) personal sensitivity (Holmes 1991) and being considerate (Ring and Van de Ven 1994). These operationalized variables can be measured by using a projective test about those in the relevant industry and asking the test taker to choose between a neutral word and the operationalized variable. The measure for trust should allow the variable to go 'to high' so that a curvilinear relationship is possible. The percent of trust best-answers should be used as a multiplier to indicate the value of any given individual in a team.

Intensity of network ties (Simonin 1999) can have impetus measured in terms of reciprocal relationships (Westphal Clement 2008). Impetus could be measured on a test with questions about tendencies towards reciprocity. Dominance can be measured as strong clear first priorities (Shamsie 2003). . Dominance could be measured with questions regarding the

individual taking the test's willingness to prioritize those within the particular technology being transferred. Strength of ties can be looked at in terms of the physical (Molina-Morales, Martinez-Fernandez 2009) and psychological (Lane, Lubatkin 1998) closeness. Strength of ties could also be measured with a testing instrument, this time using questions regarding self-identification with those within the specified technology.

In order to determine TTO productivity selected variables used by Friedman and Silberman (2003) could be used. Ability to transfer knowledge can be looked at in terms of the variables: licenses executed, licenses generating income, start-ups initiated, and license income. Following the same research, type of university, be it land grant, medical, or private, Faculty quality index, number of departments, federal research grants, and industry research grants can each be used as control variables.

### Conclusions, Implications and Future Research

It might be concluded that the particular skills necessary for a TTO to transfer a particular technology need not reside within a single individual. The best practice for a TTO manager would be to create a team with abilities that are well suited to the kinds of technology that are most often created within his or her university. The value of the abilities of the department should be further increased by codifying and sharing knowledge about who knows what so that synergies can happen. The future researcher should know that taking the individual's abilities as the unit of analysis within the technology transfer office is well founded in theory.

It is further clear that the intensity of network ties is useful for a TTO to transfer a particular technology and the full necessary extent of those ties need not reside within a single individual. The manager of the TTO would be well guided in understanding the interpersonal relationships that exist within the team he or she has built. The overlap between individual's

networks and the synergistic effects that are possible should be taken into account when adding members to the TTO team. Future researchers could explore the kinds and amounts of ability and network ties necessary to transfer a particular kind of technology.

Finally a case can be made that a the TTO is essentially a creator of the market for ideas but that a market's level of perfection varies with the related and synergistic skills brought to the TTO by those within it. The power of the TTO as an intermediary between the researcher and the private sector should be understood by those both who are within the TTO and who deal with the TTO. The researcher interested in understanding how and why academic entrepreneurship occurs would do well to study the formation of ties between individual researchers and the TTO. Both practitioner and researcher would do well to keep in mind the diminishing returns of trust and over abundance of network ties that eventually lead to blowback.

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Image1:

The pinwheel model of the TTO

