INTERNATIONAL JOURNAL OF INTERDISCIPLINARY RESEARCH

VOLUME 7, NUMBER 2, December 2018 ISSN 2165-3232

A PUBLICATION OF EASTERN WASHINGTON UNIVERSITY AND THE INTERNATIONAL ACADEMY OF BUSINESS DISCIPLINES

WWW.IJIR.NET

INTERNATIONAL JOURNAL OF INTERDISCIPLINARY RESEARCH

VOLUME 7, NUMBER 2 December 2018

Chief Editor
Ahmad Tootoonchi
College of Business and Public Administration
Eastern Washington University
668 N. Riverpoint Blvd. Suite A
Spokane, Washington 99202-1677
Tel: 509-828-1224
tootoonchi@ewu.edu

Associate Editor
Suzanne Milton
EWU Libraries
Eastern Washington University
816 F. Street. 100 LIB
Cheney, Washington 99004-2423
Tel: 509-359-7887
smilton@ewu.edu

Published By:
Eastern Washington University and the International Academy of Business Disciplines

ISSN 2165-3232 WWW.IJIR.NET

INTERNATIONAL JOURNAL OF INTERDISCIPLINARY RESEARCH

OFFICERS AND EDITORIAL BOARD

INTERNATIONAL
JOURNAL OF INTERDISCIPLINARY RESEARCH

VOLUME 7, NUMBER 2 December 2018

Selection process

The December 2018 issue of the *International Journal of Interdisciplinary Research (IJIR)* has been the result of a rigorous process in two stages:

- Stage 1: all papers that were submitted to the 2018 IABD conference went through blind reviews, and high quality papers were recommended for presentation at the conference.

- Stage 2: approximately ten percent of the articles which were presented at the conference and one invited manuscripts (originally reviewed by the Chief Editor) were selected for possible publication in *IJIR*, and the respective authors were contacted and asked to resubmit their papers for a second round of reviews. These manuscripts went through a rigorous blind-review process by the editorial board members. In the end, four articles were recommended for publication in the December 2018 issue of *IJIR*.

IJIR is listed in *Cabell's* Directory of peer-reviewed publications, and we, the Editorial team, are committed to maintaining high standards of quality in all manuscripts published in *International Journal of Interdisciplinary Research*.

Ahmad Tootoonchi, Chief Editor

Contents VOLUME 7, NUMBER 2, December 2018

INTERDISCIPLINARITY IN PORTUGUESE WATER RESEARCH: THE ASYMMETRY BETWEEN THE SOCIAL AND THE PHYSICAL SCIENCES.

Marta Pedro Varanda, ISEG & SOCIUS/CSG – University of Lisbon,
marta@iseg.ulisboa.pt

João Duarte, CFCUL, University of Lisbon
cao.joao@gmail.com

Tibor Yvan Stigter, IHE-Unesco, Delft
t.stigter@un-ihe.org

ABSTRACT

Difficulties in the management of water have made clear that "technical fixes", not taking into account social, political and cultural contexts, fail to address the root of problems and lead to unsustainability of the resource. This paper examines whether Portuguese water research is constructing interdisciplinary knowledge and how it integrates social science contributions. To explore the prevalence and nature of interdisciplinarity the co-authorships of a random selection of papers were assessed. The use of social network analysis reveals a divide between the social and the physical sciences as well as the asymmetric epistemological power between the fields.

INTRODUCTION: THE CHALLENGE OF INTERDISCIPLINARITY IN WATER RESEARCH

Anthropogenic and natural factors have led to unparalleled changes in the global water system, raising concerns for its unsustainability and a demand for better policies and management practices that are informed by solid scientific knowledge. With an aim to improve the social conditions of human kind, especially in developing countries, such matters started being discussed at least as far back as the 1977 United Nations Water Conference (Mar del Plata, Argentina). Fifteen years later the United Nations hosted an International Conference on Water and The Environment in Dublin, with the aim of addressing urgent problems related to water linked to environmental and socio-economical societal conditions. This conference proposed an Integrated Water Resources Management (IWRM) approach, for it recognised that exclusively top-down, supply-led, technically-based and sectoral approaches to water management were imposing unsustainable, high economic, social and ecological costs on human societies and the natural environment. The new approach requires the integration of different outlooks or frames of thinking about water and its management, as well as an important, not to be devalued, shift away from traditional knowledge construction circumscribed by the borders of disciplines.

Forty years later the planetary challenges linked to poor and unsustainable water management persist. They were translated into the Sustainable Development Goal 6: Ensure access to water and sanitation. As reported by the United Nations, 2.4 billion people still lack access to basic sanitation services, such as toilets or latrines; each day nearly 1,000 children still die due to preventable water and sanitation-related diarrhoeal diseases; more than 80 per cent of wastewater is discharged into rivers or seas without any pollution removal; and underground water sources in many places are threatened by the pollution produced in certain mining, farming and industrial activities, as stated by the United Nations (http://www.un.org/sustainabledevelopment/water-and-sanitation/). So many years after the Mar del Plata alert, one cannot but question the way science is addressing these challenges, particularly as most of the challenges denote problems which science has the scientific and technical knowledge to answer. The situation seems to be that current water research has largely ignored the underlying socio-economic forces (e.g. rapid urbanization, economic development, poverty, lack of education) and the conservation of species and ecosystem processes related to their sustainability (Braimoth & Craswell, 2008).

In other words, research does not seem to be addressing the ultimate end of water sustainability. Moreover, as people are increasingly placing a high value on maintaining the integrity of water resources and the flora, fauna and human societies that have developed around them, it has become harder to ignore sustainability issues (Gleick, 2000). Research agendas have responded by promoting interdisciplinary knowledge to a central role, for it was recognised as a precondition for sustainability (e.g. Porter & Rafols, 2009; Sterling 2004; van Rijnsoever & Hessels, 2011).

That "there is no question that research in water resources is an interdisciplinary endeavour" (p. 1865) was the conclusion reached by Freeze (1990) looking back at the interdisciplinary successes and failures of the Water Resources Research Journal on its 25th anniversary. Rajaram et al. (2015), reflecting on the first 50 years of the same journal, reached a similar conclusion. It is clear that the study of water includes a very wide number of disciplines such as hydrology, agronomy, civil engineering, mathematics, statistics, ecology, economy, hydrogeology, biology, chemistry, political science, history, business, sociology, and law, etc. Yet, it remains unclear for water studies what is actually meant by interdisciplinarity. Often this concept is used interchangeably with that of multidisciplinarity, and even if they both pertain to the idea of linking disciplines for the purpose of researching complex problems, their purpose and reach are fundamentally different. Interdisciplinarity refers to the notion of something greater than the sum of the parts, "a synthesis of knowledge, in which understandings change in response to the perspectives of others" (Petts et al., 2008, p. 596). According to Raffols (2014) knowledge constructed this way constitutes a means of reaching new answers to new problems. By contrast, multidisciplinarity refers to the addition of parts from multiple disciplines without conscious, organic integration among them (Hansson, 2012).

Multidisciplinary studies, rather than interdisciplinary studies, are still abundant in environmental studies, and this practice in itself may be at the root of the environmental problems. For Bina (2013) a significant part of the problem has arisen from the highly fragmented and reductionist manner of knowing and interpreting reality. This idea is eloquently stated by Pope Francis in the encyclical Laudato Sí, (2015): "the fragmentation of knowledge and the isolation of bits of information can actually become a form of ignorance, unless they are integrated into a broader vision of reality" (p. 104). He also says, "If we are truly concerned to develop an ecology capable

of remedying the damage we have done, no branch of the sciences and no form of wisdom can be left out, and that includes religion and the language particular to it" (p. 45). The implications of this knowledge fragmentation for sustainability are increasingly a matter of concern and have raised demands for change (sometimes even for radical change) in the way of doing science and constructing knowledge for the 21st century (UNESCO 2016).

However, despite frequent calls to foster interdisciplinary research, active collaboration, including knowledge exchange, remains rare to date (e.g. SCSS, 2012). The difficulties of collaboration among disciplines have been widely reported. Both the formal and informal structures of university and research centres have created negative incentives for interdisciplinary teaching and research. The whole institutional organisation of university and research centres is conceived in a way that motivates and compensates narrow disciplinary orientation. At the formal level the division into disciplinary based departments, practices such as promotions and recruitment following the logic of disciplines, and teaching with a strong discipline bias, just to name a few examples, all obstruct interdisciplinary knowledge construction.

Informally there are also built-in negative incentives, such as the stigma of interdisciplinary researchers being worse than disciplinary researchers, or the accusation of superficiality in interdisciplinarity research, on top of researchers' psychological discomfort of doing research in areas the researchers do not control epistemologically. Doing interdisciplinary research involves overcoming resistance from disciplinary logics and incumbencies that are anchored in their scientific practices (Cortner, 2000). Some of these disincentives and informal sanctions reflect the ethos of science today: science is a short term enterprise that values above all the quantity of published materials in the top journals of each discipline (Fischer et al., 2012). Because disciplinary integration is a long-term effort and implies great investment of time and energy, incentives are needed to motivate researchers to pay this price (Lyall et al., 2013).

All these obstacles are amplified if the collaboration crosses the social – natural/physical sciences divide. In its 2009 position paper, the Standing Committee for the Social Sciences of the European Science Foundation identified the collaboration between social sciences and life sciences as a key cross-cutting challenge for the 21st century (SCSS, 2012). Despite the increasingly prominent support for research engaging both the natural and social sciences (though rarely the humanities) in a truly collaborative endeavour, practice beyond statements of good intentions remains rare. One example of an obstacle is simply that researchers from both fields "do not know each other" (Varanda & Bento, 2012). In the case of interdisciplinary research on water, water conferences are usually at least twice as expensive as typical social science and humanities conferences, so social scientists working with much lower budgets cannot afford to spend their limited funds there. But even when they do get to know each other, misunderstandings are still common. Skills like empathy, positive relationships and humility are not valued and trained in the academic environment, but are preconditions for understanding one another's position and for the effective translation of multiple knowledges into a coherent whole (Podesta et al., 2013). For instance social scientists working in natural sciences-led research projects may become frustrated by their reduced involvement in the research problem, and by the invitation to intervene only in communication and dissemination tasks (Varanda & Bento, 2013). The resistance of some social scientists to be limited to communication and dissemination tasks may be perceived by natural scientists perceive as lack of interested in collaboration (Heberblein, 1988), hence a "chicken and egg" problem.

The history of science illustrates how difficult the process of integration of knowledge from these paradigms of thinking is. Since the 19th century science has been characterised by a process of disciplinarisation and professionalisation of knowledge (Gulbenkian Comission, 1996). A consequence of this process is that the social sciences and humanities have become marginalised. In the 19th century the context was that of the triumph of Science (Newtonian knowledge) over philosophy (speculative knowledge). At this time natural sciences (or simply "science") had already conquered internal cohesion and an autonomous institutional life, unlike the social sciences and the humanities, which at the time had not even agreed on a common designation. The social sciences and humanities were called: arts, humanities, philosophy... By contrast, the standing of "science" was already the result of the social, political and financial support, received in return for the production of practical outputs which could be translated into immediate utility (Gulbenkian Commission, 1996).

A more recent history of the science of water depicts a not so different picture. The hydraulic-engineering and the scientific paradigms, which are closely linked to the economic-financial paradigm, have dominated water research and have guided its management in advanced industrial states and global financial systems of the 20th and 21st centuries (Hassan, 2011). Furthermore, these have subjugated the spiritual religious and aesthetic – recreational paradigms of previous epochs and have led to a deficient understanding of water systems (Hassan, 2011). Notwithstanding, the social sciences have been perceived as taking on the role of brokers between the technical disciplines (e.g. hydrological fluid mechanics, geochemistry, geomorphology, etc.) with policy making. The idea that "…the social sciences provide sound principles as guides to the public decisions about the development of water" is well established (Rajaram et al., 2015, p. 7830). But again, practice is different.

A meta-analysis of water science projects shows that persistence of disciplinary perspectives impedes the much desired integration of water science with water policy (Braimoth & Craswell, 2008). Similarly, Freeze, again on the 25th anniversary of the Water Resources Research journal, recognises the lack of truly interdisciplinary policy articles: "one can count on one hand the papers that have been co-authored by physical and social scientists together" (1990, p. 1866). He adds that "the one interdisciplinary interaction that was most explicitly desired by the founders of the journal, and which has been actively promoted by every editorial board since, has in many ways been the least successful". It is not surprising that a reliance on physical solutions continues to dominate traditional planning approaches even in the face of increasing opposition (Gleick, 2000). For Heberlein (1988) "the public is ill served as we present pieces of the puzzle but seldom the whole picture" (p. 5). This can only be overcome when all those dealing with water - both academics and practitioners - develop common frameworks, concepts and methods for knowledge construction.

Freeze's (1990) last message was that there is great value in physical scientists and social societies sharing the same journal, but he is clear that "this is not a marriage, it is a limited partnership. We should not expect more from their relationship than it can deliver" (p.1867). Has the limited partnership moved on to a marriage 17 years later? Is water research still framed by the visions of disciplinary knowledge or is it integrated to address the water challenges of our time? Dwelling into these questions, we concentrated on water research in Portugal. Therefore, this paper aims to inform how recent water research in Portugal embeds interdisciplinarity in knowledge

construction, through the empirical analysis of the networks of co-authorships. We will focus on which disciplines cooperate in the study of water, how prevalent they are, what network patterns are to be found between them, and what they can reveal about the power relations among disciplinary fields, with a specific concern for the collaboration between the social sciences and the physical sciences.

METHODOLOGY: DATA COLLECTION AND ANALYSIS

The initial step of data collection was a web-based search (complemented by the authors and their colleagues' previous knowledge of the field) to identify all the research centres studying water in Portugal. A total of 29 research centres were found. In order to assure each research centre's specialisation in water and its level of expertise in the matter, complementary information was collected:

- description of the mission of the research centre or just the water subgroup + board members (and their disciplines);
- FCT (Portuguese Foundation of Science and Technology) field area;
- FCT evaluation.

Secondly, based on the websites of each research centre, 3 articles (year 2015 or the most recent available) were randomly chosen. These were chosen using a key word search of all the research related to water. Key words and or prefixes used were: *water, hydr, hidr, aqu, água, ocean, sea, mar, river, rio, estuar, lake, lago, rain, chuva, pluv, precip, wave, onda, bent, dam, barrage*. Tricky issues were dealt with on a case by case basis. For example, articles on some freshwater species were not regarded as water research as such in spite of having "water" in the title of the article. By contrast, research about humans or other species linked with water were accepted (e.g. a hydro-gymnastics study or a study of the effects of different water conditions on crabs). This second step resulted in 67 articles selected. Thirdly, for each article the PhD disciplines of the first 3 authors were identified. The disciplines of authors were coded based on:

- Web of Science (WoS) subject area; and
- OECD's 2007 revised field of science and technology.

The final step, related to data management, was to build a two mode (rectangular) matrix "article x discipline of author", which was transformed into 1 mode (square) matrix "discipline of author x discipline of author" (Borgatti et al., 2012). This last matrix is the database used to identify the prevalence and nature of interdisciplinarity. Using social network metrics the integration of disciplines of co-authors of randomly selected papers can be visualised and measured. Social network analysis (for a classic reference see Wasserman & Faust, 1994) is a useful tool to identify relations (or patterns of interdependencies or networks) through the measurement of the flows and

exchanges of resources of all kinds (material, informational, emotional, etc.). It can also be used to identify commitment vis-à-vis the exchange partners (Lazega, forthcoming). The assumption is that there are no social processes without a relational dimension, and scientific research in general and co-authorships in particular are social processes, like any other, and as a result are constrained by social relations (Moody, 2004). The relationship of co-authorship implies great commitment among the parts, especially with regard to interdisciplinary collaboration, as it implies an interaction beyond the comfort zone of each researcher, which entails greater risk (e.g. Ledford, 2015). Viewed from the perspective of the individual, interdisciplinarity can be counterproductive because it is much easier (less demanding) to work with others from the same discipline, who employ the same theoretical framework and methodologies and use the same terminology. As a consequence, an interdisciplinary career, driven by scientific curiosity and creativity, is often a more strenuous trajectory (Pfirman & Begg, 2012; Klein, 2010).

RESULTS

The results section will start by presenting a simple analysis of frequencies of the disciplines and disciplinarily fields of water researchers followed by the social network analysis mapping and metrics.

Sample Description per OECD disciplinary fields, disciplines and number of researchers

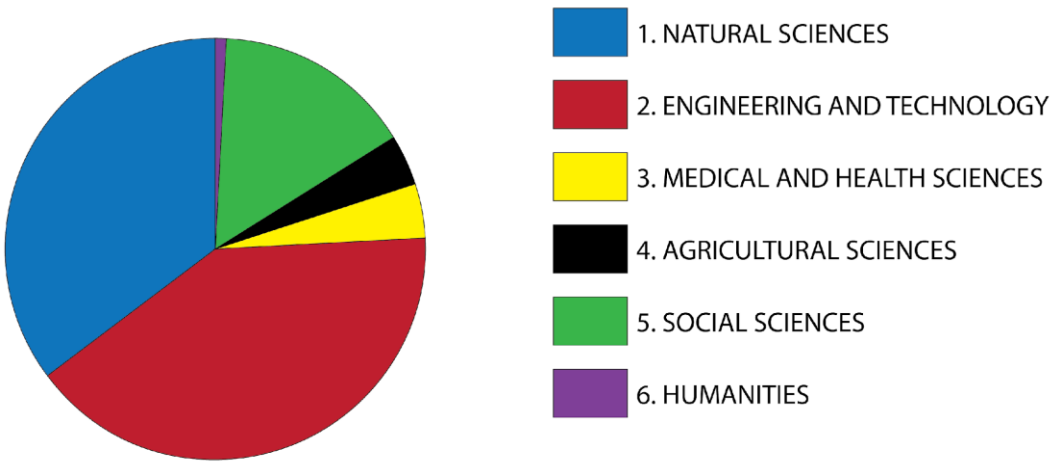

FIGURE 1. ILLUSTRATES THE WEIGHT OF EACH OECD DISCIPLINARY FIELD IN THE STUDY OF WATER IN PORTUGAL FOR 2015

TABLE 1. SAMPLE DESCRIPTION

OECD disciplinary fields	# of researchers	# of disciplines
1. Natural Sciences	67	20
2. Engineering & Technology	77	13
3. Medical & Health Sciences	8	5
4. Agricultural Sciences	7	4
5. Social Sciences	29	10
6. Humanities	2	2
Total	190	54

The visual mapping of the network of co-authorships

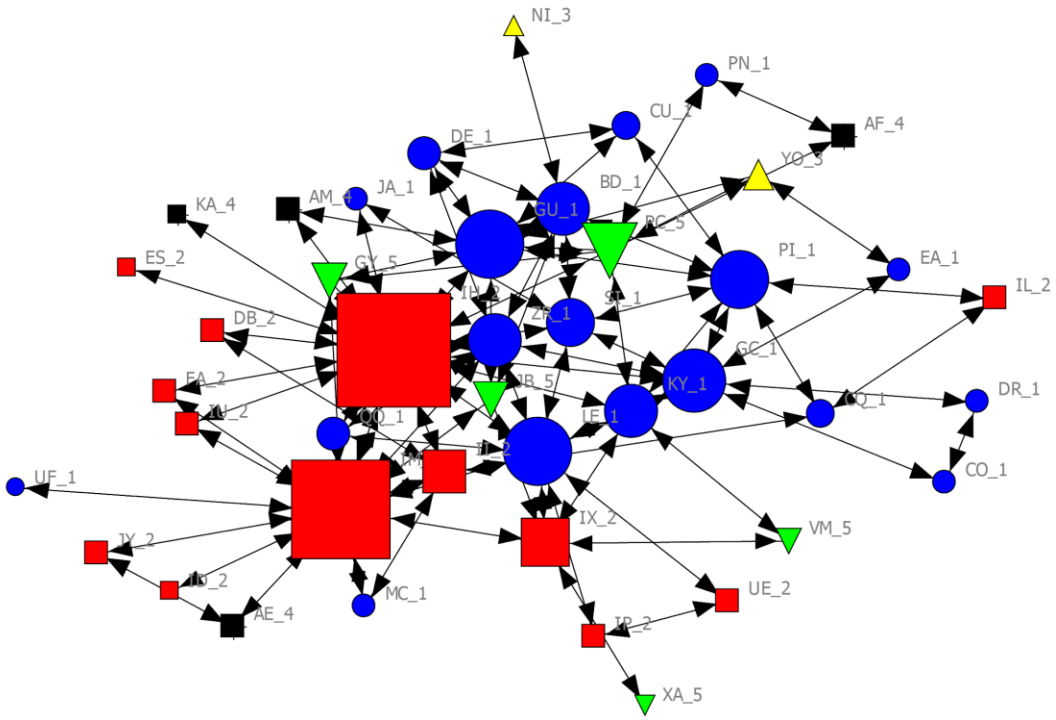

FIGURE 2. THE MAIN COMPONENT OF THE NETWORK OF DISCIPLINARY CO-AUTHORSHIPS

Colour/shape codes: Natural Sciences: Blue /circle; Engineering & Technology: red/square; Medical sciences: yellow/up triangle; Agricultural Sciences: black/square; Social Sciences: green/down triangle; Humanities: purple/box. The nodes represent disciplines and their size is linked to their centrality degree (i.e. the number of links per discipline)

The network graph expresses well the divide between the Engineering & Technology (red/square) and the Natural Sciences (Blue /circle) and the positioning of other scientific areas in the periphery. (Below we will present social network analysis metrics corroborating this visualisation of the network.) As previously noted, this divide has long characterised science. These two areas of knowledge with two different epistemologies have been separate since the 19th century under the concepts of nature vs. humans, matter vs. mind, physical world vs. social/spiritual world, and they refer to two ways of knowing, or in the expression of C.P. Snow "two cultures" (Gulbenkian Commission, 1996).

The prominence of the engineering & technology and natural sciences disciplinary field: top centrality results

The centrality measures in social network analysis give a measure of the importance of nodes in the network. In this case nodes are disciplines. The centrality measures used here are degree and betweenness (Freeman, 1979). The degree centrality calculates the number of adjacent relations of a node. In this case a discipline with a high centrality score is a discipline that is present in a high number of articles with other disciplines. On the other hand, when a discipline has low or zero centrality (an isolated node), it signifies that it is not present in articles with other disciplines. Having a high centrality degree reveals the prominence of a discipline in the field. As shown in Table 2, the disciplinary fields with the highest presence in co-authorships are Engineering & Technology and the Natural Sciences. The Social Sciences are represented in the top seven of the most active disciplines through the discipline of Management.

TABLE 2. DISCIPLINES AND INTERDISCIPLINARY FIELD – LIST OF THE TOP SEVEN IN-DEGREE CENTRALITY

Discipline and its OECD field	Degree Centrality
IH_2 **Environmental engineering**	**18**
IM_2 **Civil engineering**	**15**
Gu_1 **Ecology**	**10**
LE_1 **Geosciences**	**10**
GC_1 **Geochemistry & geophysics**	**9**
PI_1 **Aquatic biology**	**8**
PC-5 **Management**	**7**

Betweenness centrality (Freeman, 1979) is a measure of how often a given node falls along the shortest path between two other nodes. Betweenness reaches its highest value when the node lies along every shortest path between every pair of other nodes, measuring the bridging capacity of a node, in this case a discipline. A discipline with high betweenness centrality is a kind of broker that provides links among diverse disciplines. In this case Environmental Engineering is the discipline that bridges the most with other disciplines in water research. Again the disciplines with the highest centrality are those of the Natural Sciences and Engineering & Technology. Among the Social Sciences only Management and Economics are represented in this top list of degree betweenness.

TABLE 3. DISCIPLINES AND INTERDISCIPLINARY FIELD – LIST OF THE TOP 7 IN BETWEENNESS CENTRALITY

Discipline and its OECD field	Betweenness Centrality
21 IM_2 Civil engineering	**22.000**
IH_2 Environmental engineering	**18.000**
Gu_1 Ecology	**17.000**
GY_5 Economics	**10.000**
PC_5 Management	**6.000**
BD_1 Biodiv_conservation	**6.000**
IX_2 Geological Engineering	**3.000**

It has been argued that the centrality of nodes (here disciplines) is related to their power (Lazega, 1998; Brass & Burkhardt, 1992), meaning that those with higher centrality have greater control of the resources (knowledge, information) circulating in the network. In other words, nodes/disciplines with higher centrality are less dependent on others' resources, which is in itself a measure of power. The results show that the Natural Sciences and Engineering & Technology occupy the most central places in the network and have easier access to all the resources flowing through it. Thus, these disciplines are the ones most engaged in knowledge production, most active and most capable of making bridges among disciplines. Furthermore, as the number of authors is restricted here to the first there authors, it is possible that underlying such co-authorships other resources are expected to be exchanged such as information on access to funding, job or contracting opportunities. The authors belonging to disciplines in the periphery of the network, or those who are isolated, must make much a greater effort to access such resources.

The core vs peripheral disciplines in water research: the "elite vs the masses"

The core periphery metrics in social network analysis allows for the identification of the nodes (i.e. disciplines) within the core vs the periphery of a network. According to Borgatti & Everett (1999, p. 377), "the core periphery model consists of two classes of nodes, namely a cohesive subgraph (the core) in which actors are connected to each other in some maximal sense and a class of actors that are more loosely connected to the cohesive subgraph but lack any maximal cohesion with the core". Table 4 indicates the disciplines at the core of the network.

TABLE 4. THE CORE OF THE NETWORK OF CO-AUTHORSHIPS

OECD Disciplinary field	Disciplines
Natural sciences	**GC_1;KY_1;LE_1;SI_1;ZR_1;BD_1; GU_1;PI_1**
Engineering	**IM_2;IH_2;**
Social Sciences	**GY_5 ; PC_5**

The core includes seven disciplines from the Natural Sciences, two disciplines from Engineering & Technology, and two disciplines from the Social Sciences. The Social Science disciplines are Economics and Management. These disciplines can be looked upon as the "elite" of water studies. This subgroup of disciplines has a much greater cohesion. This is measured though the density, which is simply the number of ties in the network, expressed as a proportion of the number of potential ties (Borgatti et al., 2012). In this case the core has a density of 0.47, meaning that they co-author papers much more frequently than the disciplines of the periphery, which have a density of just 0.028 (*i.e.* the core is almost 17 x denser than the periphery). These values can be read as a measure of the power of each group in the water research field. Such cohesion implies some trade-offs in the process of knowledge building. If, on the one hand, the core has a solid epistemological approach that favours internal coordination (e.g. making it easier to create and manage large research teams that are more able to access funding and conduct large research projects), on the other hand it is potentially less open to innovation, less creative, less able to introduce new ideas in its milieu and to re-think its approaches. The core becomes a victim of path dependency; they continue to do the same as they have always done, as long as they keep on being rewarded for it.

The social sciences literature - especially that using the social network analysis approach - has shown how the cohesion (Coleman, 1990) (or closure (Burt, 2005) or bonding social capital (Putnam, 2001)) of a social system is related to high levels of trust, reciprocity and the capacity to coordinate efforts. The same literature has pointed to the relation between the network's sparseness, translated by concepts such as brokerage capacity (Burt, 2005) or bridging social capital (Putnam, 2001), with the innovation potential and creativity of that collective. These references can be found in Kadushin (2012, p. 63), together with a summary of the argument. The strong cohesion of the core raises doubts as to its capacity to come up with a completely new approach to water planning and management that successfully meets human demands in the next century (Gleick, 2000).

"Homo vs hetero" collaboration in water studies

The homophily tendency, i.e. the attractiveness between equals, has been repeatedly detected in its multiple dimensions (age, race, religion…) in social science studies (e.g. Mcpherson et. al., 2001). Naturally, the choice of discipline with which one chooses to collaborate will follow the same tendency. In interdisciplinary collaboration researchers rapidly fall into a discomfort zone as "our educated capacity in one discipline (or more realistically in one subdiscipline) tends to be associated with trained incapacity in other fields of relevant knowledge" (Freeman 2000, p. 484). Hence interdisciplinarity has to face human beings' "natural" impetus to relate to equals and strengthen the relations among them (e.g. Homans, 1950) in addition to the institutional barriers referred to previously (e.g. disciplinary career track, division into departments, etc.).

Through the measure of E-I index, it is possible to verify which disciplines choose to collaborate with each other more frequently. In our case, we seek to confirm whether in water studies there is also a tendency for homophily and which disciplines show a greater tendency to collaborate in the write-up of scientific articles. The E-I index measure, developed by Krackhardt & Stern (1988), is a very simple and useful measure to compare the numbers of ties within groups and between groups. The E-I (external - internal) index takes the number of ties of group members to outsiders, subtracts the number of ties to other group members (in this case disciplines belonging to a disciplinary field), and divides by the total number of ties. The resulting index ranges from -1 (all ties are internal to the group) to +1 (all ties are external to the group). (For more details see for instance Hanneman & Riddle, 2005.)

The following E-I index results were obtained:

- **Natural Sciences**: with an E-I index value of - 0.275, the natural sciences show the highest homophily, i.e. it is the group of disciplines that has the greatest tendency to co-author with those of the same group. Note that - 1 is the value of maximum homophily and 1 is the value of minimum homophily.

- **Engineering & Technology**: this field has an E-I index close to zero - 0.067, which indicates a similar number of co-authorships both inside and outside the disciplinary area.

- **Medical Sciences and Agricultural Sciences:** both have an E-I index of 1 (minimum homophily), meaning that all co-authorships are with colleagues from different disciplinary fields.

- **Social Sciences**: the value of 0.778 represents a very low homophily, which indicates a great tendency to collaborate with colleagues from other disciplinary fields.

One can reflect on these results with reference to epistemic power issues, an idea that has emerged before in the context of centrality and core-periphery metrics. Engineering & Technology and the Natural Sciences co-author with their disciplinary peers in greater proportion than other scientific areas. The Social, Medical and Agricultural Sciences, which both have low centrality values and

are at the periphery of the network, have the lowest homophily values. That is, they rarely or never co-author within their disciplinary fields. They do not have autonomy; on the contrary, they depend on other disciplines to participate in a significant manner in the world of water research. For instance, they may lack access to funding for water research, which is consistently and disproportionately higher in the Natural Sciences and Engineering & Technology). The Directorate General Research & Innovation of the European Union report, Integration SSH in Horizon 2020: Participants, Budget and Disciplines, edited by Hetel, Møller, & Stamm in 2015 reveals that only 5.9% of the whole funding goes to Social Sciences and Humanities partners.

All the social network metrics analysed indicate that the Social Sciences are in a position of dependence towards other disciplinary fields in water studies. Paraphrasing George Orwell in Animal Farm (1944), one can say "all are equal but some are more equal than others". It is as if they do not have a life of their own, such as when they are called upon to tick the box of communication and dissemination and societal impact but without the real commitment of incorporating social science theory and methods in the research. The so-called character of interdisciplinarity, such as mutuality and reciprocity, is based on the assumption that power differentials do not exist. According to Callard & Fitzgerald (2015), those in the social sciences and humanities who have experienced collaboration with the natural sciences feel the asymmetry of power. They go on to say, "You can have all the frank conversations in the world with collaborators about the conditions under which your exchanges are taking place; you can agree on clear distribution of resources and labour throughout the collaboration; you can put in agreed strategies to ensure, as far as possible, that this will work; you can reason as open, and transparent and clear, as dialogic as possible; but the reality is that financial and epistemic power is not distributed equally within the collaboration" (Callard & Fitzgerald, 2015, p. 103). In such a setting social scientists' reactions may range from feelings of frustration to feelings of being insulted (Ledford, 2015). These feelings of frustration are not only shared among social sciences and humanities. Interdisciplinary collaboration is often entangled in less than obvious and much thicker structures of power than those involved in it are able or willing to recognise, creating huge obstacles to both natural and social scientists who want to collaborate. Furthermore, one should not ignore that "scientists" who collaborate with social scientists lose value in the process (Callard, Fitzgerald, 2015).

CONCLUSIONS AND DISCUSSION

"When we speak of the "environment", what we really mean is a relationship existing between nature and the society which lives in it. (…) Recognising the reasons why a given area is polluted requires a study of the workings of society, its economy, its behaviour patterns, and the ways it grasps reality (…)." (Pope Francis, 2015, p. 147). Similarly, to understand the workings of water systems and to manage them implies knowledge about nature, people, technology, and political and organisational structure. However, despite the critical situation of the resources and the severity of its social and political impact (e.g. see the Liquidity Crisis, 2016), the paradigm currently leading water research, public policies and the management of water resources is techno-scientific and economic-financial, and it marginalises social, spiritual and aesthetic structures of

thinking. To frame issues in this way, which in fact, extends to all the environmental fields, inevitably leads to a narrowing of the possible range of solutions (e.g. Bina, 2013).

This paper aimed to determine how recent water research in Portugal fit the current paradigms by empirically analysing the networks of co-authorships of water researchers, and specifying the patterns of collaboration, with a special concern for the collaboration between the social sciences and the physical sciences. The findings corroborate the hegemony of the techno-scientific and economic paradigm. The scientific production in the field of water is based mostly on a collaboration within the physical sciences (mainly earth and environmental sciences and biological sciences and engineering) with some collaboration with social sciences (humanities excluded), represented by business and economics. That business and economics are the most active social sciences in water studies is revealing. Despite the short time span of the data analysed, and the circumscription to Portugal, it is consistent with the recent EU report, on the role of social sciences and humanities in the Horizon 2020 (Hetel et al., 2015).

All three network analysis measures, as well as the visualisation of the network map, clearly reveal the dominance of the Natural Sciences and Engineering & Technology fields on water research and the divide among these and the Social Sciences. The centrality measures give us such information on the most prominent disciplines in this field, and the a core–periphery measure clearly identifies a core composed of Natural Sciences and Engineering & Technology, while the Social Sciences are in the periphery, revealing a hierarchical division of work within water research. Moreover, there is a tendency for homophily in the Natural Sciences and very high heterophily in the Social Sciences, which, linked to their peripheral position, suggests a position of dependence. Today it is clear that whenever social problems have the slightest technical dimension, politicians call technical experts – the natural scientists – to help solve them (Lélé & Noorgaard, 2005). This can also be a form of "protection" for politicians, as the belief in the superiority of the natural scientists is so deeply rooted that it would be too risky to call for social scientists, who continue to be perceived as "second class" scientists, i.e. those that were not good enough to get into the "science stream". This should be a matter of concern for science funders and water policy makers because the epistemic division and power imbalances impede the creation of innovative knowledge. In a case study of geo-engineering, Szeerszynski & Galarraga show that the task of social science is to "expose assumptions, bring out the multiplicity and incommensurability of different views and ontologies and keep problem definitions open", thus producing "greater diversity and reflexivity in how different disciplines and approaches are brought together" (2013, pp. 2818-2822). Old thinking is still prevalent among water planners and managers. The direct consequence of this knowledge construction paradigm leads us to continue policies that do not preserve the sustainability of resources. It is because fundamental changes on how water is thought about and acted upon are required that the goal of sustainability is coming about slowly (Gleick, 2000).

A change of paradigm in research and teaching of water seems urgent. One that moves beyond positivist, empiricist and technocratic ways of knowing. Other ways of knowing related to the social, spiritual and aesthetic dimensions of water have been relegated to marginality, with the justification that it is difficult and complex to collect data (Mcdonnell, 2008). Yet at the same time, higher education institutions worldwide have invested millions in the production, dissemination and application of scientific and technical knowledge and information. According to Peters & Wals

(2014), a body of systematic ignorance is produced due to the priorities, methods and dynamics of our educational and political systems and by the workings of power. Investments in the social production of wisdom are far smaller and weaker (Maxwell, 2007).

If the inevitable links within the different domains of the social and the natural sciences, as well as links across these scientific worlds, are not taken into account in forming scientific inquiries, then our ability to gain knowledge and understanding of how we can sustain societal developments will be inherently limited. By failing to take into account the social, political, economic and cultural context, water studies fail to address the root of the problems and, in not doing so, endanger the sustainability of the resource. This has been repeatedly stated in the context of the rhetoric on development models for sustainability and the use of resources (Bina, 2013).

One of the follow-up aims of this research will be to understand why at the level of policy-making (planning and the ensuing implementation) social scientists' epistemologies are marginalised and what can be done to naturalise them. *Homophilisation* among social and physical sciences could do the trick. Whether the steps to get there are a matter of equalising funding, creating more interdisciplinary higher education programs, organisational participatory methodologies or other is a focus of future research for the authors.

REFERENCES

Bina, O. (2013). The green economy and sustainable development: An uneasy balance? *Environment and Planning C-Government and Policy*, *31*(6),1023–1047.

Bina, O., Varanda, M., Sessa, C., Guimarães, H. and Alexander, D. (2017). *Interdisciplinarity, the social sciences and the humanities and responsible research and innovation in EU research*, 2nd INTREPID Report, COST Action TD1408. Retrieved from http://www.intrepid-cost.eu/wp-content/uploads/2017/05/2ND_REPORT_EU-research-ID-SSH-RRI-Full-REPORT.pdf

Borgatti, S., Everett, M.G., & Johnson, J.C. (2013). *Analyzing social networks*, London, UK: Sage.

Borgatti, S.P., & Everett , M.G. (1999). Models of core/periphery structures. *Social Networks, 21*(4), 375-395.

Borgatti, S.P., Everett, M.G. & Freeman, L.C. (2002). *Ucinet for Windows: Software for social network analysis.* Harvard, MA: Analytic Technologies.

Braimoth, A. & Craswell, E.T. (2008). Quantitative assessment on interdisciplinarity in water science programs. *Water Resources Management*, *22*(4), 473-484.

Brass, D. J. & Burkhardt, M.E.(1992), Centrality and power in organisations. In Nohria, N. & Eccles, R. (eds.), *Networks and organizations* (pp.191-215). Boston: Harvard Business School Press.

Burt, R. (2005). *Brokerage and closure: an introduction to social capital*. Oxford: Oxford University Press.

Callard, F. & Fitzgerald, D. (2015). *Rethinking interdisciplinarity across the social sciences and neurosciences.* Basingstoke: Palgrave Macmillan.

Coleman, J. (1990). *Foundations of social theory*. Cambridge, Mass.: Harvard University Press.

Cortner, H.J. (2000). Making science relevant to environmental policy. *Environmental Science & Policy, 3*(1), 21-30.

Cummings, J. & Riesler, S.(2005). Collaborative research across disciplinary and organizational boundaries. *Social Studies of Science*, *35*(5), 704-722.

Fischer, J., et al. (2012). Academia's obsession with quantity. *Trends in Ecology & Evolution, 27*(9),473-474.

Freeman, D.M. (2000). Wicked water problems: sociology and local water organizations in addressing water resources policy. *Journal of the American Water Resources Association*. *36*(3), 483-491.

Freeze, R.A. (1990). Water resources research and interdisciplinary hydrology. *Water Resources Research, 26*(9), 1865-1867.

Francis, PP (2015, May 24). *Laudato Sí, Encyclical Letter Laudato Sí of the Holy Father Francis on care for our common home*. Second Encyclical Letter of Pope Francis. Holly See, Rome.

Freeman, L. (1979). Centrality in social networks conceptual clarification. *Social Networks, 1*(3), 215-239.

Freeman, L. (2004). *The development of social network analysis: A study in the sociology of science*. Vancouver: Empirical Press.

Frodeman, R., Klein, J.T. & Pacheco, R.C.S. (Eds). (2010). *The Oxford handbook of interdisciplinarity* (Oxford Handbooks). Oxford: Oxford University Press.

Gleick, P.H. (2000). The changing water paradigm: A look at twenty first century water resources development. *Water International*, *25*(1), 127-138.

Gulbenkian Commission (1996). *Para abrir a ciências sociais: relatório da Comissão Gulbenkian sobre a reestruturação das Ciências Socais*. Lisboa, Portugal: Publicações Europa –América.

Hanneman, Robert A. & Riddle, M. (2005). *Introduction to social network methods.* Riverside, CA: University of California, Riverside. Retrieved from http://faculty.ucr.edu/~hanneman/

Hassan, F. (2011). *Water history of our times*. IHP essays on water history (Vol. 2). Paris: Unesco Publishing.

Hansson, D.(2012, March), Unpacking Spinoza: Sustainability education outside the Cartesian Box, *Journal of Sustainability Education*. Retrieved from http://www.jsedimensions.org/wordpress/content/unpacking-spinoza-sustainability-education-outside-the-cartesian-box_2012_03/

Heberblein, T.A. (1988). Improving interdisciplinary research: Integrating the social and natural sciences. *Society and Natural Resources, 1*, 5-16.

Hetel, L., Møller, T.-E. & Stamm, J. (Eds.) (2015). *Integration of social sciences and humanities in Horizon 2020: Participants, budget and disciplines*. Monitoring Report, Directorate-General for Research and Innovation, Inclusive, Innovative and Reflective Societies. Luxembourg: Publications Office of the European Union.

Homans, G. (1951). *The human group.* London, UK: Routledge.

Kadushin, C. (2012). *Understanding social networks: Theories, concepts and findings*, Cambridge UK: Cambridge.

Klein, J. T. (Ed.). (2001). *Transdisciplinarity: Joint problem solving among science, technology, and society*. Basel: Birkhauser.

Klein, J.T. (2010). *Creating interdisciplinary campus cultures: A model for strength and sustainability*. San Francisco: Jossey Bass.
Krackhardt, D. & Stern, R. (1988). Informal networks and organizational crises: An experimental simulation. *Social Psychology Quarterly, 51*(2), 123-140.
Lazega, E. (1998). *Réseaux Sociaux et Structures Relationnelles*. Paris : PUF.
Lazega, E. (forthcoming). Networks & neo-structural sociology. In Ryan Light & James Moody (eds), *Handbook of social networks*. Oxford, UK: Oxford University Press.
Ledford, H. (2015). Team Science. *Nature, 525*(7569), 308-311.
Lélé, S., Noorgaard, R.B. (2005). Practicing interdisciplinarity. *Bioscience, 55*(11), 967-975.
Lyall, C., et al. (2013). The role of funding agencies in creating interdisciplinary knowledge. *Science and Public Policy, 40*, 62-71.
Maxwell, N. (2007). *From knowledge to wisdom: A revolution in the aims and methods of science* (2nd ed.). London: Pentire Press.
McDonnell, R.A. (2008). Challenges for integrated water resources management: How do we provide knowledge to support truly integrated thinking? *International Journal of Water Resources Development, 24*(1), 131-143
Mcpherson, M., Smith-Lovin, L. & Cook, J.M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology, 24*, 415-444.
Moody, J. (2004). The structure of a social science collaboration network: Disciplinary cohesion from 1963 to 1999. *American Sociological Review, 69*(2), 213-238.
OECD (2007). *Revised field of science and technology (FOS) classification in the Frascati manual*, STI/EAS/STP/NESTI(2006)19/FINAL. Retrieved from http://www.oecd.org/science/inno/38235147.pdf
Orwell, G. (1945). *Animal farm: A fairy story.* London, England: Secker and Warburg.
Peters, S. & Wals, A. (2014). Learning and knowing in pursuit of sustainability: Concepts and tools for transdisciplinary environmental research. In Marianne E. Krasny & Justin Dillon (Eds), *Trading Zones in Environmental Education Creating Transdisciplinary Dialogue.* Bern: Peter Lang
Petts, J., Owens, S, Bulkeley, H. (2008). Crossing boundaries. *Geoforum, 39*(2), 593-601
Pfirman S.L. & Begg M.D. (2012). Perspective: Troubled by interdisciplinarity? *Science Career Magazine*. Retrieved from http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2012_04_06/
Podestá, G.P., et al. (2013, February). Interdisciplinary production of knowledge with participation of stakeholders: A case study of a collaborative project on climate variability, human decisions and agricultural ecosystems in the Argentine Pampas, *Environmental Science Policy, 26*, 40-48.
Porter, A. L. & Rafols, I. (2009). Is science becoming more interdisciplinary? *Scientometrics, 81*(3),719-745.
Putnam, R. (2000). *Bowling alone: The collapse and revival of American community*. New York: Simon and Schuster.
Raffols, I., (2014). Knowledge integration and diffusion: Measures and mapping of diversity and coherence. In Ding, Y., Rousseau, R., & Dietmar, W. (Eds.), *Measuring scholarly impact: Methods and practice* (pp. 169-19). Stuttgart: Springer Nature.

Rajaram, H., Bahr, J.M, Bloschl, G., Cai, X., Mackay, D.S., Michalak, A.M., Montanari, A., Sanchez-Villa, X., Sander, G. (2015). A reflection on the first 50 years of Water Resources Research. *Water Resources Research, 51*(10), 7829-7837.

SCSS. (2012). *The good, the bad and the ugly.* (Strategic Workshop Report). Strasbourg: European Science Foundation.

Sterling, S. (2004). *Sustainable education re-envisioning learning and change*. Green Books for the Schumacher Society, Devon.

Szeerszynski, B. & Galarraga, M. (2013). Geoengineering knowledge: Interdisciplinarity and the shaping of climate engineering research. *Environment & Planning A. 45*(12), 2817-2824

The liquidity crisis. (2016, Nov 5th). The Economist. Retrieved from https://www.economist.com/news/briefing/21709530-water-becomes-ever-more-scant-world-needs-conserve-it-use-it-more-efficiently-and),The

UNESCO (2010) *World social science report*. Paris: UNESCO Publishing.

UNESCO (2016) *Education for people and planet: Creating sustainable futures for all*. UN Educational, Scientific and Cultural Organisation (UNESCO), Paris. Retrieved from http://unesdoc.unesco.org/images/0024/002457/245752e.pdf

Van Rijnsoever, F.J. & Hessels, L.K. (2011) Factors associated with disciplinary and interdisciplinary research collaboration. *Research Policy, 40*(3), 463-472.

Varanda, M., Bento, S. (2013) Scientists and stakeholders: Can two separate worlds be joined for sustainable water management? In *Proceedings of the TWAM2013 International Conference & Workshops*, Aveiro: CESAM – Department of Environment & Planning, University of Aveiro. http://hdl.handle.net/10451/8278

Wasserman, S., Faust, K. (1994). *Social network analysis: Methods and applications*. Cambridge: Cambridge University Press.

THE IMPORTANCE OF INTERDISCIPLINARITY: INSIGHTS IN THEORY APPLICATION AND DEVELOPMENT

Ross F. Lordo, University of South Carolina
rlordo@email.sc.edu

ABSTRACT

Throughout academia, there lacks an existence of commonly utilized interdisciplinary theories to aid in understanding the interconnectedness of our outside world. This paper provides a sample of the current state of interdisciplinarity in research and the need for interdisciplinary theory development. The health belief model (HBM) is provided as a theoretical framework that lacks interdisciplinary characteristics in comparison with the interdisciplinary nature of systems theory and game theory. Through the comparative analysis of the HBM, game theory and systems theory, guidelines to developing interdisciplinary theory are proposed for scholars to consider when crafting theory constructs and descriptors. These guidelines are applied to show that the HBM can be redefined to explain nonprofit volunteer behaviors, demonstrating the power and impact of interdisciplinarity.

INTRODUCTION

In a world of increasing complexity, the importance of diversity in thoughts, opinions, and ideas is central to a well-functioning society. Over the past decade, the concept of interdisciplinarity has regained credibility, signaling the reinvention of novel approaches to issues that cannot simply be undertaken within the confines of traditional isolated disciplines (Ross, 2009). Defined by Engerer (2017), interdisciplinarity serves as a relationship in which ideas and concepts from one discipline are introduced into the basic ideas and models of the other. The movement of these ideas between individuals or groups, termed knowledge flows, are not only key components for the cohesion and connectivity of academic research communities (Rawlings, McFarland, Dahlander, & Wang, 2015), but also helps spur innovation relating to new ideas, tasks, and procedures. There currently exists an absence of a commonly utilized interdisciplinary approach to promote such flows, where science has tried to explain observable phenomena by reducing them to elementary units investigated independently of one another (Bertalanffy, 1969). As early as the mid-twentieth century, physics, chemistry, biology, economics, sociology and other disciplines, have been called to go beyond developing theories that have a single application in their own empirical segment (Boulding, 1956), but such insulation is still proposed to exist (Rogers, Rizzo, & Scaife, 2003).

If science continues to evolve into infinite sub-groups, the total growth of knowledge will be slowed by the loss of collective communication (Boulding, 1956). With integrated technology being used to exchange news, data, reports, equipment, instruments and other resources, dispersed collaborations are easier now than ever before (Hesse, Sproull, Kiesler, & Walsh, 1993). As academia and research look towards more collaborative approaches, the theories developed in

singular arenas must follow in progression to lay the foundation for interdisciplinary theory to assist in the knowledge sharing network. The question must be, then, how can researchers develop interdisciplinary theories that spark collaboration and knowledge-sharing across academic barriers?

Introduction to Interdisciplinary Theory

To discuss the nature and importance of interdisciplinary theory, the role of theory itself must be understood. Theories have been described as generalizations that seek to explain the relationship certain phenomena have with others (Glazier & Grover, 2002). Further, a "theory" is known to be a multiple-level component of the research process, comprised of generalizations that move beyond descriptive keywords to a more explanatory level (Glazier & Grover, 2002). Glaser & Strauss (1967) add that distinct theories have certain qualities that make them valid and verifiable and are readily understandable to scientists, students, and laymen alike. In explaining phenomena, a theory should provide clear categories and hypotheses so that any conclusions are continually able to be verified in present and future research. A theory must be able to fit the situation being researched, meaning the categories are readily applicable and are relevant to the behavior under study (Glaser & Strauss, 1967), aiding into the debate about how generalized a theory can become to promote an interdisciplinary approach to answering questions. This paper argues that theory may contain various levels of explanatory description that can keep content applicable and valid for any situation it may describe.

Many theories have the potential to be applicable outside of a singular area, as studies have found that potential variations of the health belief model (HBM) on general behavior are consistent with applications of the theory to health-related actions (Lindsay & Strathman, 1997). Other theories have already embraced their interdisciplinary nature. When considering game theory, it was originally devised to simply study poker, chess, and other games, but was later adapted to explain markets, competition, and even animal behavior (Pool, 1995), offering evidence that the original construction of the theory does not have to stand as its only avenue of applicability. Additionally, systems theory proposes itself as a general science of wholeness that had previously not existed.

In general, boundaries to theories are determined more by method and conceptual framework than necessarily by subject matter (Klein, 1996). For interdisciplinary theory to exist, theory development must take on an evolved approach to increase the level of applicableness that such a theory contains. In attempting to develop guidelines to promote theory development that spans discipline-specific arenas, examples of both isolated and broadly used models are needed for comparison. In this analysis, the health belief model is examined as an example of a self-limiting theory that is published primarily in public health, whereas systems theory and game theory are recorded as having an increased diversification of citations. It is the hope that providing these theories as illustrations of differences in theory constructs and usage will lead to the discovery of the key components of an interdisciplinary theory.

METHODS

The following paper is structured to provide perspective and guidance to incorporating interdisciplinarity in theory development. Through this effort, the researcher utilizes the health belief model as a proposed framework that is limited in applicable scope due to its health-specific constructs. Contrastingly, systems theory and game theory were chosen for comparison for their proposed interdisciplinary nature.

To verify the hypothesis that the health belief model (HBM) is primarily isolated in its applicability to public health, a citation analysis was conducted to quantify the model's respective publishing in specific academic areas. In coming closest to the most authentic multidisciplinary database that provides the earliest origin of data, in comparison to *Scopus* and *Google Scholar* (Jacso, 2005), the *Web of Science* was the chosen database reference tool of choice for the paper. Searching the *Web of Science Core Collection*, the field was populated with "<THEORY NAME>" as the topic and limited to only peer-reviewed journal articles. Using the Web of Science's "analyze results" feature, article classification data was gathered in sorting by "research areas" to quantify the frequency of theory publication in specific disciplines. If an article was deemed to be interdisciplinary itself, each field comprising the study would be included in the calculation. A chi-squared analysis was performed between the resulting highest two research areas within which each respective theory was published to determine if at least one area was statistically significant and isolated in distribution. The two primary areas for each theory that underwent a chi-squared analysis are explicitly outlined and the remaining eight highest are listed for reference in the results.

From a quantitative perspective, analyzing the areas of publication of these theories and confirming the interdisciplinary nature of systems theory and game theory provided validation for further study. What are the elements of systems and game theory that make them more interdisciplinary, compared to the health belief model? To confront this question, a coding mechanism was utilized in the analysis of these theories to discover qualitative characteristics and traits that may be applicable to developing and defining theory constructs. To code the most influential literature for each respective theory within *Web of Science*, the ten most cited peer-reviewed articles that incorporated the theory name in the title were chosen. Such methodology was followed to permit a uniform coding process of selection for all three theories. It is significant to note that the ten articles did not always contain extensive descriptions of the theories' constructs but were believed to be effective in offering examples of the most-referenced studies that expose scholars to their respective ideas.

The researcher notes that when sorting for the ten most-cited articles for "systems theory" within *Web of Science,* certain results were omitted due to their irrelevance. Within the database, the capability does not exist to separate "systems theory" from "systems: theory" or "systems- theory." As a result, there were articles that populated that were considered false positives in not pertaining to general systems theory, such as *"*Interval type-2 fuzzy logic systems: theory and design." The top ten most-cited articles pertaining to general systems theory were coded for interdisciplinary trends and qualities, which are listed in Table 1.

TABLE 1: LITERTURED CODED FOR ANALYSIS

Health Belief Model	***Janz & Becker, 1984***
	Rosenstock et al., 1988
	Rosenstock, 1974a
	Rosenstock, 1974b
	Becker, Maiman, Kirscht, Haefner, & Drachman, 1977
	Harrison, Mullen, & Green, 1992
	Becker, 1974
	Austin, Ahmad, McNally, & Stewart, 2002
	Carpenter, 2010
	Maiman & Becker, 1974
Systems Theory	***Boulding, 1956***
	Schilling, 2000
	Bot, Lowie, & Verspoor, 2007
	G. Chen & Kanfer, 2006
	Walby, 2007
	Joshi, Speyer, & Kim, 1997
	Orr, 1998
	Kast & Rosenzweig, 1972
	Young, 1997
	Hendry & Seidl, 2003
Game Theory	***Rabin, 1993***
	Brown, Laundré, & Gurung, 1999
	Roth, 1984
	Saad et al., 2009
	Roth, 2002
	Hauert & Szabó, 2005
	Wang et al., 2010
	Srivastava et al., 2005
	Elster, 1982
	Ferrero, Shahidehpour, & Ramesh, 1997

To pinpoint specific characteristics that differentiate systems and game theory as more interdisciplinary than the HBM, the theories were coded to analyze specific characteristics that may distinguish them following guidelines in grounded theory research listed by Corbin and Strauss (1990). Further, to understand interdisciplinary characteristics holistically, systems theory and game theory were coded collectively. In identifying common words or phrases present within published literature, the researcher gives such phenomena conceptual labels detailing the specific language utilized. Similar concepts and phrases that describe comparable phenomena were then grouped to form categories, such as "generalized verbiage." Using the coding results, guidelines in developing interdisciplinary theory were proposed. These guidelines will require further study but are meant to offer a starting point in expanding previously isolated theories of the past. Due to a call for additional research on the HBM to test for never-before considered hypotheses (Lindsay & Strathman, 1997) and previous associations of volunteering as a public health intervention (Jenkinson et al., 2013), the proposed guidelines were applied to reframe the HBM as a potential explanation for the proposed problem.

RESULTS

The quantitative citation distribution data is listed first followed by the qualitative coding results to determine the proposed interdisciplinary characteristics of theory. These results where then applied to propose the guidelines for interdisciplinary theory development.

Citation Distribution

The quantitative results of each theory's citation distribution are outlined by the top ten research areas of publication specified in tables 2, 3 and 4.

TABLE 2: HEALTH BELIEF MODEL PUBLISHED RESEARCH FIELDS

Research Area	*Record Count*	*%*
Public Environmental Occupational Health	807	34.62%
Psychology *	387	16.60%
Nursing	256	10.98%
Oncology	181	7.77%
Health Care Sciences Services	170	7.29%
General Internal Medicine	166	7.12%
Education Educational Research	142	6.09%
Social Sciences Other Topics	90	3.86%
Biomedical Social Sciences	88	3.78%
Psychiatry	71	3.05%
Total	*2358*	

* $p < .05$

TABLE 3: GAME THEORY PUBLISHED RESEARCH FIELDS

Research Area	*Record Count*	*%*
Engineering	5888	29.86%
Computer Science	5771	29.26%
Business Economics	4277	21.69%
Telecommunications	2529	12.82%
Operations Research Management Science	2485	12.60%
Mathematics	1956	9.92%
Automation Control Systems	1027	5.21%
Environmental Sciences Ecology	911	4.62%
Physics	630	3.20%
Mathematical Methods in Social Sciences	586	2.97%
Total	*26060*	

TABLE 4: SYSTEMS THEORY PUBLISHED RESEARCH FIELDS

Research Area	*Record Count*	*%*
Computer Science	1596	16.72%
Engineering	1560	16.34%
Psychology	1206	12.63%
Physics	1145	11.99%
Business Economics	835	8.75%
Mechanics	803	8.41%
Mathematics	777	8.14%
Automation Control Systems	754	7.90%
Social Sciences Other Topics	479	5.02%
Education Educational Research	316	3.31%
Total	*9471*	

While the researcher acknowledges that there are potential flaws in methodology, the results above indicate the present issue of published isolation for the health belief model. The health belief model is significantly isolated in its usage in articles that are categorized as "public environmental occupational health" compared with others, namely the second-closest category of "psychology." This is hypothesized to be a result of the constructs relating to health-specific behaviors and preventative health actions, rather than behaviors as a collective notion. It is understood that the HBM was developed as a specific model to explain health behaviors (Rosenstock, 1974b), however the question of the need for such specificity arises. If a model is applicable across the confines of disciplines, this can display the importance of knowledge sharing in using data to confront phenomena spanning the academic spectrum.

From the distributions quantified above, it is apparent that both game and systems theory have an increased dispersal in publication areas. Each has a nonsignificant differentiation between their publishing in engineering and computer science. It is noted that these disciplines have similarities but are still representative of differentiated schools of knowledge. In addition to just the top two categories of computer science and engineering, the diversity of disciplines present in the top ten areas showcases the interdisciplinary nature and usage of these two theories. Analyzing what elements have led to such a nature are the topic of interest below.

Analysis of Qualitative Interdisciplinary Components of Theories

Following a holistic review of the literature relating to game theory and systems theory, in comparison to the health belief model, distinct phenomena were noticed that alludes to their constructs' applicability and relevance across disciplines. Specific concepts have been identified, followed by two proposed categories that compile these concepts into collective ideas. The resulting categories of interest are comprehensive, generalized construct language and the line of interdisciplinary contextualization, described in the section below (see Figure 1).

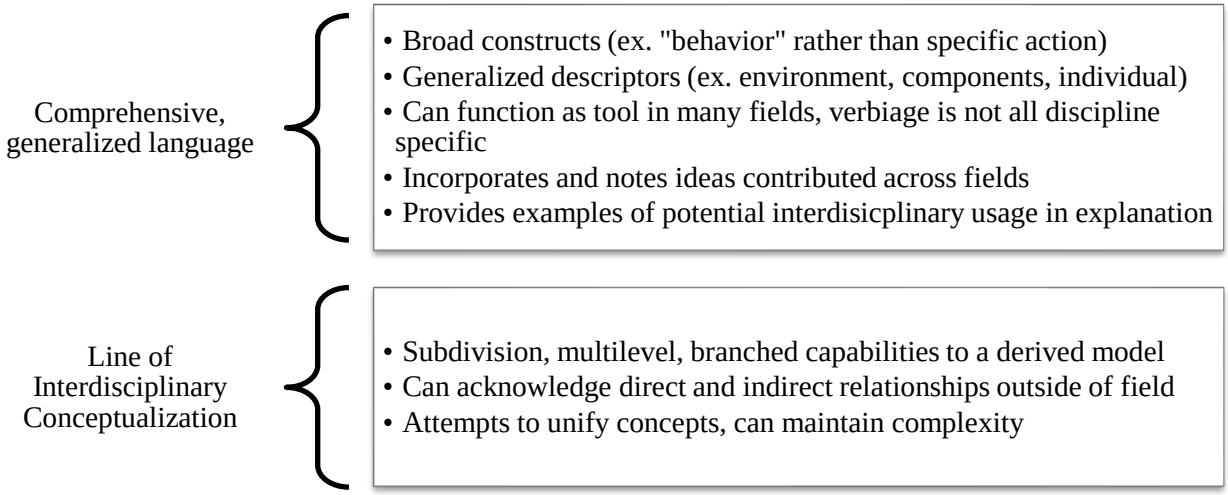

FIGURE 1: INTERDISCIPLINARY COMPONENTS OF THEORIES

Comprehensive, Generalized Language

Specific keywords and phrases were often incorporated into the text describing the theory constructs of systems theory and game theory, samples of which are noted in Table 5.

TABLE 5: EXAMPLES OF THEORY DESCRIPTORS

Broad-Construct Language *(systems and game theory)*	**Discipline-Specific Language** *(health belief model)*
Boulding, 1956	***Janz & Becker, 1984***
"Highly generalized constructions"	**"preventative health behaviors"**
"Framework of general theory"	**"health-related actions"**
"General relationships of the empirical world"	***Rosenstock et al., 1988***
Bot et al., 2007	**"health-related actions"**
"General principles"	**"patient"**
"Complete interconnectedness: all variables are interrelated"	**"perceived susceptibility to and severity of illness"**
Kast & Rosenzweig, 1972	***Rosenstock, 1974a***
"unification of science"	**"prevention of disease"**
Rabin, 1993	**"to avoid a disease"**
"applied generally"	**"possibility of a disease occurrence"**
"multiple applications"	***Harrison et al., 1992***
Hauert & Szabó, 2005	**"value-expectancy model to explain health actions"**
"interdisciplinary links"	***Becker, 1974***
"link between unrelated disciplines"	**"medical model"**
	"health and illness behavior"

A significant occurrence in the description of the game or systems theory constructs were words such as 'broad' (G. Chen & Kanfer, 2006; Rabin, 1993; Saad et al., 2009) and 'generalized' (Boulding, 1956; Brown et al., 1999; Rabin, 1993; Schilling, 2000; Walby, 2007). It is proposed that these descriptors lay a foundation for researchers of various disciplines to take notice of its potential usage in describing phenomena of interest. This usage of taking a theory with broad descriptors and applying it to a specific situation was observed by Joshi et al. (1997) as a systems theory approach was utilized to describe the physics concept of Poiseuille flow. With this article being quantified as one of the top ten articles cited in the *Web of Science* relating to systems theory, it is apparent that the research team's methods provided an example of interdisciplinary theory utilization. The same can be considered in Roth's (1984) analysis of the labor market for medical interns by applying game theory concepts, or even Srivastava et. al's (2005) study in using game theory to analyze wireless ad hoc networks.

As expected, an observation when analyzing the literature pertaining to the health belief model was the immense usage of the word 'health'. In each article, the HBM was described as originating to provide an understanding of preventative health behaviors. As such, the descriptors of the model reference its applicability in health specifically and the use of these constructs has followed suit, alluding to its constructs' lack of interdisciplinary characteristics. For reference, Becker (1974) terms the HBM as a 'medical' model of behavior, Austin et al. (2002) state its use to develop health interventions, and Janz & Becker (1984) consider the dimensions of the model to be used for health education programming. Harrison et al. (1992) performed a metaanalysis of the effectiveness of the HBM and required the study to pertain to health to be considered. The constructs of perceived susceptibility and perceived severity were primarily presented in public health terms (Austin et al., 2002; Becker, 1974; Carpenter, 2010; Harrison et al., 1992; Janz & Becker, 1984; Maiman & Becker, 1974; Rosenstock, 1974a), rather than a general psychosocial approach, using terms like health behavior, perceived severity of disease, and illness. Often, subjects were listed as patients rather than individuals (Becker, 1974; Rosenstock et al., 1988), and topics of interest were relating to smoking, alcohol and substance abuse, physical activity, and dietary habits (Rosenstock et al., 1988), subconsciously limiting its scope to health-related situations.

Line of Interdisciplinary Conceptualization

Most significantly, in explicitly stating their usage as a tool for widespread analysis in different fields (Hauert & Szabó, 2005; Srivastava et al., 2005; Wang et al., 2010), game and systems theory have subdivisional capabilities in describing specific situations. Further, the overarching generalized theory is manipulated in describing a certain phenomenon, but it still represents the application of the overall model, such as the Nash equilibrium model being a defined subset of game theory or growth model being a subset of systems theory. This ability is termed by various phrases, such as multilevel (G. Chen & Kanfer, 2006), having subdivisions (Boulding, 1956), branches (Wang et al., 2010), even subsystems (Kast & Rosenzweig, 1972; Orr, 1998). To offer an example, Schilling (2000) notes how general systems theory can be applied to interfirm product modularity and derives a model that demonstrates how this general theory can be applied to a certain system. The importance of this characteristic, however, is the connection the specific theory

makes in its utilization throughout different disciplines. It offers a unification of science (Kast & Rosenzweig, 1972) that is needed in promoting knowledge sharing throughout our academic world. From this observation, the researcher proposes a term called "line of interdisciplinary conceptualization" for generating interdisciplinary theory. Theories that are above this line can be considered interdisciplinary and those that are below describe a specific phenomenon of interest. In theory development, researchers should ensure that there is no higher classification in describing the constructs through proper verbiage and descriptors (Figure 2).

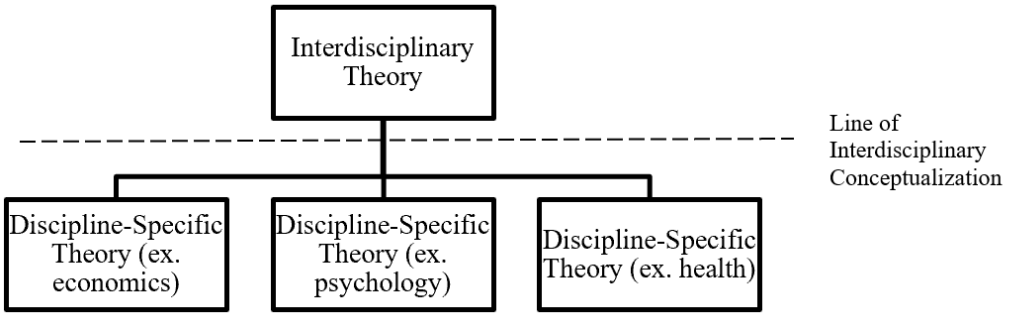

FIGURE 2: LINE OF INTERDISCIPLINARY CONCEPTUALIZATION

A common observation in this qualitative analysis was the promotion of system and game theory's ability to connect ideas into a holistic model. Brown et al. (1999), Hauert & Szabó (2005), Rabin (1993), Roth (2002), Saad et al. (2009), Srivastava et al. (2005) and Kast & Rosenzweig (1972) all allude to the importance of the interconnectedness of ideas that game theory and systems theory provide. The keywords used vary, as words such as connecting, interconnectedness, incorporation, cooperation and unifying were all present to distinguish the relationship between constructs and therefore, should be present above the line of interdisciplinary conceptualization. These concepts further the idea that an interdisciplinary theory is more than just broad and generalized, rather it emphasizes the potential for models to be explanatory of phenomena observed in different academic arenas.

In the literature, there was often criticism regarding the ability to measure the variables listed in the health belief model. Rosenstock (1974b) called into question the lack of standardized questions to measure health perceptions. Carpenter (2010) discredited many studies relating to the HBM for having unreliable measures of the variables in question and a lack of understanding of outside influences within the model. The additional discussion of motivation and self-efficacy in the HBM resulted in a revised model being generated in 1975 (Harrison et al., 1992). Resultantly, this shows that the model was too narrowly defined, and under the line of interdisciplinary conceptualization, leading other researchers to have to make additional constructs to apply it to the phenomena in question. By initially developing a theory above this conceptual line, researchers can be more efficient in theory creation.

DISCUSSION

Guidelines for Interdisciplinary Theory Development

Utilizing the characteristics discussed above, guidelines in theory development are proposed below. The theory should also be able to exist in both an extensive, or rigidly structured, and strategic, or generalized, form, similar to game theory described by Myerson (1991). There should be a clear distinction present that can allow for the model to have interdisciplinary nature above the line, as well as specific derivatives under the line of interdisciplinary conceptualization. Although the HBM has connections with the social cognitive theory and theory of reasoned action, there exists no clear relationship between the models themselves (Carpenter, 2010). There have been six different parallel models of decision making similar to the HBM (Maiman & Becker, 1974), proving the notion that knowledge is consistently isolated to explaining specific situations rather than attempting to understand the interconnected world. Interdisciplinary models must maintain a complexity in describing situations, but also understand the potential interconnectedness of phenomena. The following guidelines were generated by the researcher as a suggestion in developing such interdisciplinary theory.

1. Be cognizant to avoid field-specific verbiage when developing name and constructs, ensuring that they maintain generalizability and the appropriate broadness.
2. Ensure that the theory can be placed above the line of interdisciplinary conceptualization through its ability to directly lead to subdivisions, or branched derivatives, to explain the desired phenomena of choice, warranting there would not effectively exist a more-generalized model.
    If applicable:
    a. Offer specific theory branches that could describe certain discipline-specific environments
    b. Confirm that the theory can fit with varying descriptors if above the line

The Health Belief Model – A New Context

In applying these interdisciplinary guidelines and characteristics, the health belief model is proposed to have an ability to be broadened to elevate it above the line of interdisciplinary contextualization. It is of note that the researcher believes that name ‘health belief model’ would additionally need changing, but for explanatory purposes, it will remain in this discussion. The following diagrams propose changes in the terminology relating to the HBM’s constructs to promote its applicability in areas outside of public health and above the interdisciplinary line. The comparison is illustrated in Figure 3 which describes some of the HBM constructs from Becker et al. (1977).

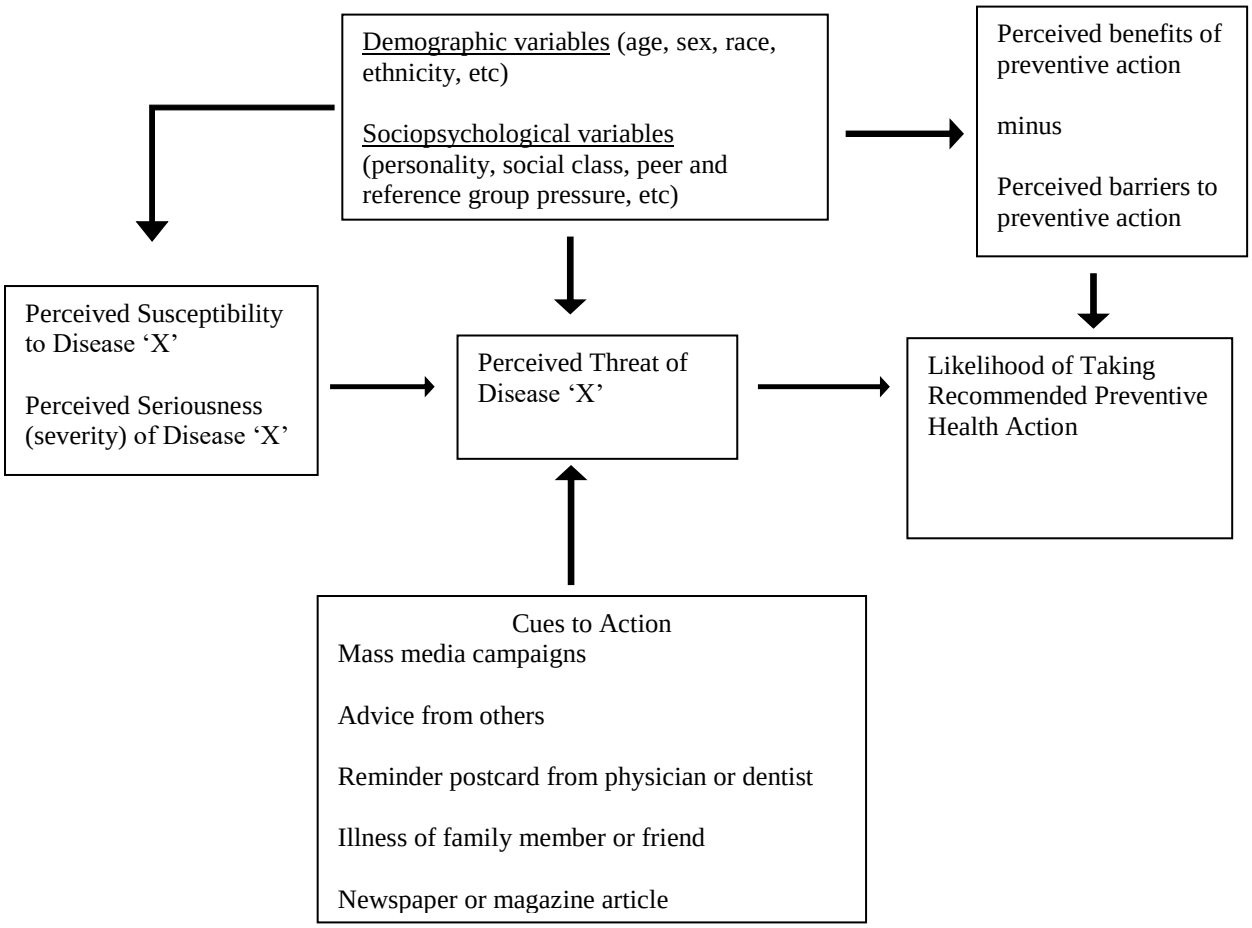

FIGURE 3: THE HBM AS DESCRIBED BY BECKER ET AL. (1977)

In exemplifying the second guideline in interdisciplinary theory development above, a redefined HBM will be proposed above the line of interdisciplinary contextualization, as well as derived theory below the line will be proposed. The HBM is proposed for this argument as being applicable in the information science field due to links between non-profit volunteering and health observed in the literature. Below, the line of interdisciplinary conceptualization is displayed utilizing each construct of the health belief model in its current form alongside proposed interdisciplinary and volunteer-specific forms (Figure 4).

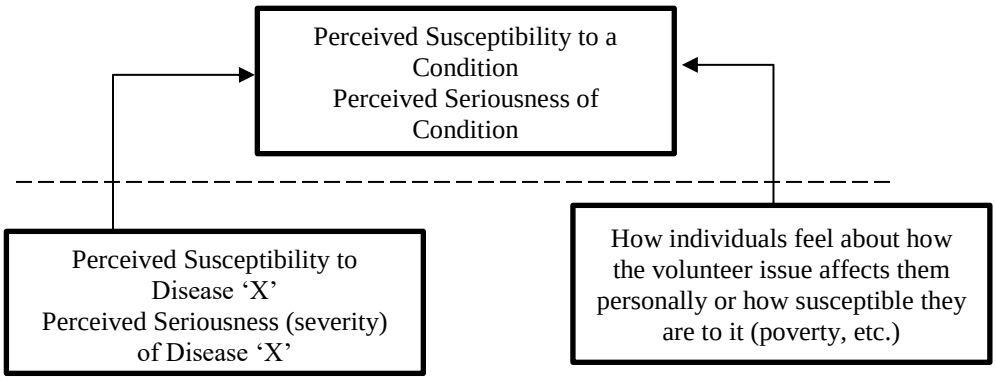

FIGURE 4: HBM CONSTRUCT – PERCEIVED SUSCEPTIBILITY/SERIOUSNESS

Altering the text from 'disease' to 'condition' in the generalized model offers researchers more flexibility into the phenomena of interest, as well as the ability to go below the line to mid-range theory. Condition may take on roles in the social sciences which contrast that of biological or environmental science. The word 'disease' is proposed to limit the HBM in only referencing health-relating behaviors. In volunteering, perceived susceptibility would be centered on how the specific volunteer issue affects them personally. Using the proposed guidelines of developing an interdisciplinary theory, the construct was broadened and generalized, but also exhibited capabilities of describing specific situations, like disease or volunteering if necessary (Figure 4).

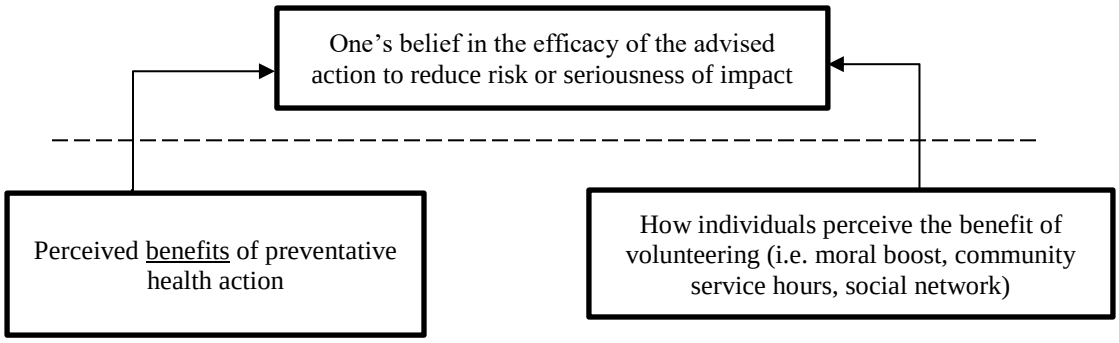

FIGURE 5: HBM CONSTRUCT – PERCEIVED BENEFITS

To broaden the language in accordance with the guidelines, the term 'preventative health' was eliminated to increase its interdisciplinarity. The process of performing an act to prevent disease can be related to 'impact', which is seen inserted. Further, 'patient' is commonly seen in article descriptors of the HBM, so explicitly using 'one's' was included. With volunteering, the perceived benefits would be how the individual perceives the benefit of volunteering, whether that is a moral boast, community service hours, or even the increase in social network (Figure 5).

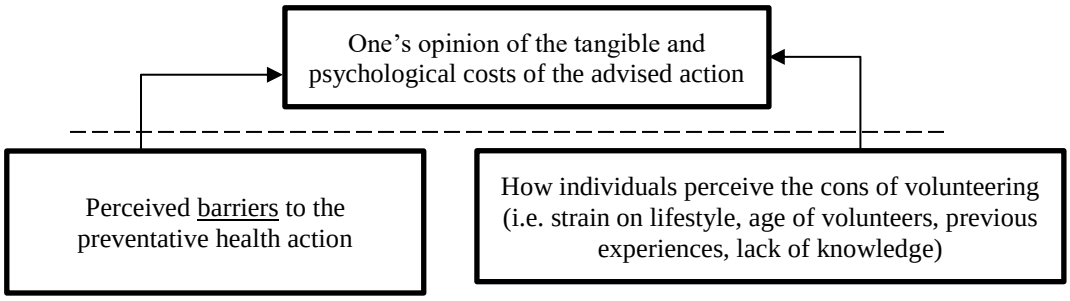

FIGURE 6: HBM CONSTRUCT – PERCEIVED BARRIERS

Like perceived benefits, eliminating 'preventive health' will produce a more interdisciplinary theory. Describing the construct using only 'action' is also meant to broaden the verbiage used. In volunteering, these perceived barriers can be the strain on one's lifestyle, lack of knowledge of the responsibilities, stigmas surrounding the age of volunteers, amongst other factors (Figure 6).

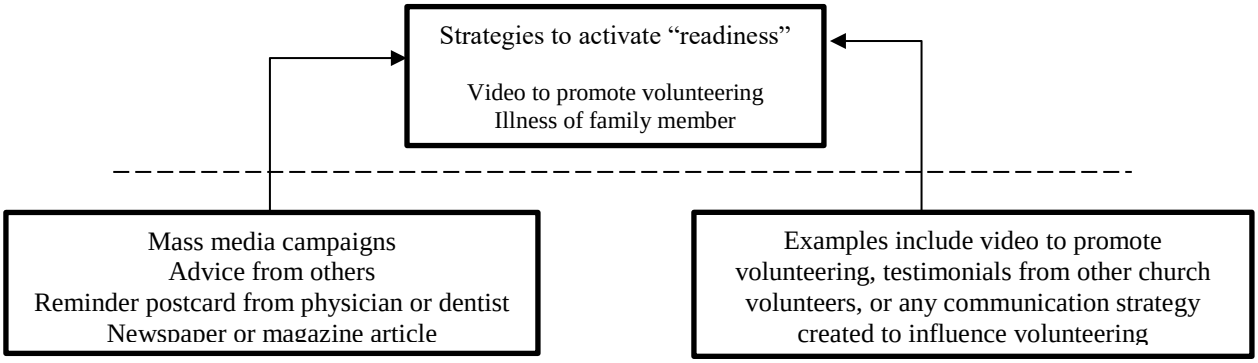

FIGURE 7: HBM CONSTRUCT – CUES TO ACTION

Cues to action has the most significant proposed transformation of all constructs. For the HBM to take on a uniquely interdisciplinary approach, the theory must be open for researchers to apply general concepts. In accordance with the interdisciplinary theory guidelines, offering examples of multiple applications of the generalized model is observed using health and volunteering (Figure 7).

CONCLUSION

From this study, the researcher has attempted to provide context to the ongoing trend of interdisciplinarity in academia and the need for theory to follow suit. Many models and theories, namely the health belief model in this discussion, are proposed to be limited in their usage due to the description of the constructs from their original development and publishing. Such a limitation on the sharing of models can lead to isolation of knowledge, decreased collaboration, and most significantly, less efficiency in understanding the world around us. Future research is needed for

further analysis as to the specific components of interdisciplinary theory. It is meant that this paper serves as a call-to-action for the scholarly community to recognize the possible systematic link between fields.

Although referenced in a multitude of research, interdisciplinary theory is not extensively defined as its own entity in great depth. The discussion of characteristics of the language and terminology used in a theory being categorized as interdisciplinary is minimal. The best processes in interdisciplinary theory development are largely lacking. Resultantly, there must be a new era of research that can contribute to answering some of these questions. With trends showcasing the increase in collaboration among research teams, the academic community must begin to examine the impact of interdisciplinarity theory in continuing this upward trend. It is not a simple call for new theories to be produced that explain phenomena from a grandiose scale, rather an analysis of previous theories and their lack of interdisciplinary characteristics can lay a foundation for future work and development. Through an interdisciplinary approach in understanding the interplay of distinct phenomena, scholars can begin to demonstrate the power and impact of knowledge sharing in solving some of society's greatest questions.

REFERENCES

Austin, L. T., Ahmad, F., McNally, M. J., & Stewart, D. E. (2002). Breast and cervical cancer screening in Hispanic women: A literature review using the health belief model. *Women's Health Issues*, *12*(3), 122–128.

Becker, M. H. (1974). The health belief model and sick role behavior. *Health Education Monographs*, *2*(4), 409–419.

Becker, M. H., Maiman, L. A., Kirscht, J. P., Haefner, D. P., & Drachman, R. H. (1977). The health belief model and prediction of dietary compliance: A field experiment. *Journal of Health and Social Behavior*, *18*(4), 348–366.

Bertalanffy, L. V. (1969). *General system theory: Foundations, development, applications*. New York: George Braziller Inc.

Bot, K. D., Lowie, W., & Verspoor, M. (2007). A dynamic systems theory approach to second language acquisition. *Bilingualism: Language and Cognition*, *10*(1), 7–21.

Boulding, K. E. (1956). General systems theory - The skeleton of science. *Management Science*, *2*(3), 197–208.

Brown, J. S., Laundré, J. W., & Gurung, M. (1999). The ecology of fear: Optimal foraging, game theory, and trophic interactions. *Journal of Mammalogy*, *80*(2), 385–399.

Carpenter, C. J. (2010). A meta-analysis of the effectiveness of health belief model variables in predicting behavior. *Health Communication*, *25*(8), 661–669.

Chen, G., & Kanfer, R. (2006). Toward a systems theory of motivated behavior in work teams. *Research in Organizational Behavior*, *27*, 223–267.

Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons and evaluative criteria. *Zeitschrift für Soziologie*, *19*(6), 418–427.

Elster, J. (1982). The case for methodological individualism. *Theory and Society*, *11*(4), 453–482.

Engerer, V. (2017). Exploring interdisciplinary relationships between linguistics and information retrieval from the 1960s to today. *Journal of the Association for Information Science and Technology*, *68*(3), 660–680.
Ferrero, R. W., Shahidehpour, S. M., & Ramesh, V. C. (1997). Transaction analysis in deregulated power systems using game theory. *IEEE Transactions on Power Systems*, *12*(3), 1340–1347.
Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Hawthorne, N.Y: Aldine de Gruyter.
Glazier, J. D., & Grover, R. (2002). A multidisciplinary framework for theory building. *Library Trends*, *50*(3), 317.
Harrison, J., Mullen, P., & Green, L. (1992). A metaanalysis of studies of the health belief model with adults. *Health Education Research*, *7*(1), 107–116.
Hauert, C., & Szabó, G. (2005). Game theory and physics. *American Journal of Physics*, *73*(5), 405–414.
Hendry, J., & Seidl, D. (2003). The structure and significance of strategic episodes: Social systems theory and the routine practices of strategic change. *Journal of Management Studies*, *40*(1), 175–196.
Hesse, B. W., Sproull, L. S., Kiesler, S. B., & Walsh, J. P. (1993). Returns to science: Computer networks in oceanography. *Communications of the ACM*, *36*(8), 90–101.
Janz, N. K., & Becker, M. H. (1984). The health belief model: A decade later. *Health Education & Behavior*, *11*(1), 1–47.
Jenkinson, C. E., Dickens, A. P., Jones, K., Thompson-Coon, J., Taylor, R. S., Rogers, M., … Richards, S. H. (2013). Is volunteering a public health intervention? A systematic review and meta-analysis of the health and survival of volunteers. *BMC Public Health*, *13*(1), 1–10.
Joshi, S. S., Speyer, J. L., & Kim, J. (1997). A systems theory approach to the feedback stabilization of infinitesimal and finite-amplitude disturbances in plane Poiseuille flow. *Journal of Fluid Mechanics*, *332*, 157–184.
Kast, F. E., & Rosenzweig, J. E. (1972). General systems theory: Applications for organization and management. *The Academy of Management Journal*, *15*(4), 447–465.
Klein, J. T. (1996). *Crossing boundaries: Knowledge, disciplinarities, and interdisciplinarities*. Charlottesville, Virginia: University Press of Virginia.
Lindsay, J. J., & Strathman, A. (1997). Predictors of recycling behavior: An application of a modified health belief model. *Journal of Applied Social Psychology*, *27*(20), 1799–1823.
Maiman, L. A., & Becker, M. H. (1974). The health belief model: Origins and correlates in psychological theory. *Health Education & Behavior*, *2*(4), 336–353.
Myerson, R. B. (1991). *Game theory: Analysis of conflict*. Cambridge, Mass: Harvard University Press.
Orr, K. (1998). Data quality and systems theory. *Communications of the ACM*, *41*, 66–71.
Pool, R. (1995). Putting game theory to the test. *Science*, *267*(5204), 1591–1593.
Rabin, M. (1993). Incorporating fairness into game theory and economics. *American Economic Review*, *83*(5), 1281.
Rawlings, C. M., McFarland, D. A., Dahlander, L., & Wang, D. (2015). Streams of thought: Knowledge flows and intellectual cohesion in a multidisciplinary era. *Social Forces*, *93*(4), 1687–1722.

Rogers, Y., Rizzo, A., & Scaife, M. (2003). *Interdisciplinarity: an emergent or engineered process?* Brighton: University of Sussex, School of Cognitive and Computing Sciences.
Rosenstock, I. M. (1974a). Historical origins of the health belief model. *Health Education & Behavior*, *2*(4), 328–335.
Rosenstock, I. M. (1974b). The health belief model and preventive health behavior. *Health Education & Behavior*, *2*(4), 354–386.
Rosenstock, I. M., Strecher, V. J., & Becker, M. H. (1988). Social learning theory and the health belief model. *Health Education & Behavior*, *15*(2), 175–183.
Ross, F. (2009). Degrees of disciplinarity in comparative politics: Interdisciplinarity, multidisciplinarity and borrowing. *European Political Science*, *8*(1), 26–36.
Roth, A. E. (1984). The evolution of the labor market for medical interns and residents: A case study in game theory. *Journal of Political Economy*, *92*(6), 991–1016.
Roth, A. E. (2002). The economist as engineer: Game theory, experimentation, and computation as tools for design economics. *Econometrica*, *70*(4), 1341–1378.
Saad, W., Han, Z., Debbah, M., Hjorungnes, A., & Basar, T. (2009). Coalitional game theory for communication networks. *IEEE Signal Processing Magazine*, *26*(5), 77–97.
Schilling, M. A. (2000). Toward a general modular systems theory and its application to interfirm product modularity. *The Academy of Management Review*, *25*(2), 312–334.
Srivastava, V., Neel, J., Mackenzie, A. B., Menon, R., Dasilva, L. A., Hicks, J. E., Gilles, R. P. (2005). Using game theory to analyze wireless ad hoc networks. *IEEE Communications Surveys Tutorials*, *7*(4), 46–56.
Walby, S. (2007). Complexity theory, systems theory, and multiple intersecting social inequalities *Philosophy of the Social Sciences*, *37*(4), 449–470.
Wang, B., Wu, Y., & Liu, K. J. R. (2010). Game theory for cognitive radio networks: An overview. *Computer Networks*, *54*(14), 2537–2561.
Young, I. M. (1997). Unruly categories: A critique of Nancy Fraser's dual systems theory. *New Left Review*, (222), 147–160.

THE INFLUENCE OF FILM CRITICS ON MOVIE OUTCOMES

Owen Eagan, Emerson College
owen_eagan@emerson.edu

ABSTRACT

This study complements previous research regarding the influence of word of mouth on the success of Hollywood movies. In the absence of a formula that studios can use to guarantee a predictable return on investment for movies, word of mouth has been shown to be the best determinant of a film's success. However, there are obviously other variables that play a role in this process. Therefore, as part of a series of studies intended to analyze the impact of these other variables, this study focuses on the influence of film critics on movie outcomes. Our findings show that film critics have a moderate influence on wide releases and a weak influence on limited releases based on reviews from Rotten Tomatoes. Also, negative reviews had more of an impact than positive reviews on both types of movies. This research further found that this moderate influence could have a significant impact on box office revenue.

INTRODUCTION

Despite the rise in big data, movie success is still unpredictable as films are influenced by a number of variables. In fact, industry analyst Harold Vogel states that on average six or seven out of 10 movies are unprofitable and one might break even (Vogel, 2011).

One variable that is the subject of much debate is the role of film critics. To that end, an array of studies has been conducted over the years to determine the extent to which film critics influence movie outcomes.

The majority of these studies have found that film critics have historically played a significant role in the success of movies (Terry, Butler & De'Armond, 2004). These studies have also found that critics can influence movies in various ways. Although, the way we consume media has changed dramatically since many of these studies were conducted. As a result, this study aims to provide an additional perspective to this field of study by evaluating the influence of Rotten Tomatoes on movie performance.

Rotten Tomatoes is the leading online aggregator of movie reviews by professional critics. The site uses one rating called the Tomatometer score which consists of the percentage of positive professional reviews. The best movies are then designated as Certified Fresh™ once they receive a Tomatometer score of 75% or higher and a minimum number of reviews. Although, a movie is designated as Fresh when at least 60% of its reviews are positive. Conversely, a movie is designated as Rotten should it fail to meet the 60% threshold (Rotten Tomatoes, 2018).

This paper will consist of a review of the existing literature on this subject, followed by a discussion of our methodology and findings. It will then provide an analysis of these findings in the context of previous research on this issue.

LITERATURE REVIEW

Research regarding the role of film critics has typically consisted of whether they serve as influencers or predictors. That is, influencers are defined as the degree to which critics will influence box office performance in the short term based on their reviews. The predictors are defined as their ability to predict movie success in the long term but not necessarily influence movie results in the short term.

Eliashberg and Shugan were the first to develop these concepts in 1997, and found that critics served as predictors but not influencers (Eliashberg & Shugan, 1997). However, other studies have found that critics can serve as both influencers and predictors. For instance, Basuroy, Chatterjee and Ravid found that both positive and negative reviews are significantly correlated with box office revenue within the first eight weeks (Basuroy, Chatterjee & Ravid, 2003). As a result, this finding confirms the dual role of critics.

Another study by Terry, Butler and De'Armond used Rotten Tomatoes ratings to determine their economic impact on movies. They found that a ten percent increase in a critical review translates into $7.8 million at the box office. Their findings suggest that critics serve as both influencers and predictors. Although, they state that they are likely more predictors than influencers. (Terry et al., 2004)

A study by Reinstein and Snyder (2005) examined the effects of the two popular film critics Siskel and Ebert, who were regarded as the most influential critics at the time. One of their goals was to better understand the influence of experts on consumer demand for experience goods. These are defined as goods for which the quality is uncertain prior to consumption.

They found weak evidence of the influence of critics on all of the movies they studied. However, they found that this influence varied across categories of movies and was strongest for dramas and narrowly-released movies. They stated that there was virtually no effect for movies with a wider release and those in the action and comedy genres (Reinstein & Snyder, 2005).

Moon, Bergey and Iacobucci (2010) later discovered, using Rotten Tomatoes, that film critics' early ratings could be an important quality signal. For instance, they found that critics' ratings could contribute significantly to movie revenue in the opening week. They also found that advertising spending on movies with high ratings could lead to sustained revenue.

In September of 2017, it was reported by *The New York Times* that studio executives were blaming Rotten Tomatoes for lackluster movie performances, especially after the worst summer in 20 years and a loss of billions of dollars at the box office (Barnes, 2017). However, Yves Bergquist, the Director of the Data & Analytics Project at USC's Entertainment Technology Center, subsequently

published a study which found that there was no correlation between Rotten Tomatoes scores and the box office returns of the 150 films in 2017 that earned more than $1 million (Bergquist, 2017).

Moreover, Bergquist analyzed both total gross and opening weekend performance. His results showed that there was a correlation coefficient of only .12 for box office returns. He found even less of a relationship with opening weekend performance with a correlation coefficient of .03 (Bergquist, 2017).

This study was completely reasonable given the samples it analyzed and its results were widely reported in high-profile publications. These outlets included *Variety, Entertainment Weekly, The Washington Post* and others.

Despite these findings, there is some evidence such as the Reinstein and Snyder study to suggest that critics reviews have different effects on mainstream and independent movies. Additionally, a study by a group of Dutch researchers found that reviews in newspapers had influence effects on art house movies and prediction effects on mainstream movies. Although, the effects in both cases were the result of the number and size of the reviews, and not the nature of the reviews (Gemser, Van Oostrum & Leenders, 2006).

While the Dutch study didn't find any correlation based on the nature of the reviews, it did find that these audiences were distinct. That said, we thought it would be worth exploring if there was a difference in the effect of Rotten Tomatoes scores on these two types of films.

That is, most of the studies had either analyzed all films released within a certain period or had used thresholds that wouldn't distinguish independent films from major motion pictures. In particular, the previous study by Terry, Butler and De'Armond used Rotten Tomatoes scores but their sample consisted of movies opening in at least 25 theaters or eventually reaching at least 100 theaters (Terry et al., 2004). The Moon, Bergey and Iacobucci study used movie releases by major studios as well (Moon et al., 2010).

We felt that using different samples – specifically, distinguishing between wide releases and limited releases – would provide different results. Therefore, our first hypothesis was that Rotten Tomatoes scores would likely demonstrate an influencer effect on wide releases but not on limited releases. We surmised that there wouldn't be evidence of an influence effect on limited releases given Bergquist's findings. We also thought it was likely that the audiences of limited releases were more discerning. Our second hypothesis was that the Rotten Tomatoes scores would show prediction effects similar to the influencer effects for these reasons as well.

The Negativity Bias

Previous research has found evidence of a negativity bias from critics' reviews. That is, negative reviews were found to hurt revenue more than positive reviews helped revenue. In particular, this bias was strongly supported in the first week but was found to diminish over time (Basuroy et al., 2003).

This is likely the result of our well-documented aversion to losses as first discovered by Daniel Kahneman and Amos Tversky. In 2002, Daniel Kahneman was awarded the Nobel Prize in economics for work he conducted with his colleague Amos Tversky on the development of an economic model called prospect theory. This theory countered traditional assumptions that people always make rational choices when it comes to economic decisions (Smith, 2002).

Specifically, the researchers found that people have a greater aversion for losses than they have an affinity for gains. As Kahneman writes in his best-selling book *Thinking, Fast and Slow*, many of the options we face in life are mixed with a risk of loss and an opportunity for gain (Kahneman, 2011).

As an example, Kahneman provides the following illustration of a mixed prospect. Suppose you are offered a gamble based on the toss of a coin. If the coin is tails, you lose $100. And, if the coin is heads, you win $150. You are then asked if you would find this gamble attractive and whether you would accept it.

Kahneman claims that most people would find this bet unappealing. This is because, in his words, "losses loom larger than gains." He also states that you can measure the extent of your loss aversion by simply asking yourself how much money it would take to balance an equal chance of losing $100.

Loss aversion manifests itself in a variety of ways. For instance, one of the most common investing mistakes consists of investors selling appreciating stocks prematurely and hanging on to depreciating stocks (Lehrer, 2009). As another illustration, a study of 2.5 million putts by professional golfers found that they were more successful putting for par than for birdie. This was thought to be the result of trying harder to avoid the loss of receiving a bogey, which is one stroke over par (Kahneman, 2011).

In addition, Antonio Damasio and George Lowenstein developed an investing game to illustrate this emotional reaction to losses. Participants were given the option of investing $1 or nothing based on a coin toss. A result of heads meant the participant would lose a $1 and a result of tails meant the participant would gain $2.50. The game continued for twenty rounds (Lehrer, 2009).

The rational choice would be to always invest as the value of each round is $1.25 (i.e., $2.50 x 50%) compared to $1 for not investing. In fact, there's only a 13 percent chance of losing money if one invests every time. However, the results showed that only about 60% of people invested every time and that they were especially averse immediately after losing a gamble (Lehrer, 2009).

It is thought that our brains evolved to be more sensitive to negative stimuli as a result of the need to keep us out of harm's way. Although, this negativity bias is evident in many aspects of our lives. This is especially true in social relationships. In fact, researchers have found that a specific ratio of positive to negative interactions is required for married couples to find their relationship satisfying. That ratio was found to be five to one (Estroff Marano, 2003).

Based on prospect theory and loss aversion, our third hypothesis was that there would be evidence of the negativity bias among wide releases. This was thought to be likely due to evidence in

previous research and the shortcut that Rotten Tomatoes provided to large audiences (Basuroy et al., 2003; Moon et al., 2010).

METHODOLOGY

Our methodology consisted of analyzing all wide releases and limited releases from 2015-2017. The source we used for our data was www.The-Numbers.com and the source we used for the film critics reviews was www.RottenTomatoes.com (The Numbers, 2018; Rotten Tomatoes, 2018).

To assess the influence of critics' reviews, we used a movie's domestic gross revenue for the first weekend. We used the first weekend figure because moviegoers have very little information about a movie before its release other than critics' reviews and the marketing material produced by the studios and filmmakers.

To gauge the predictive nature of reviews, we used a film's total domestic gross. We used the total domestic gross figures rather than the international gross figures as they corresponded to the opening weekend numbers we used to assess critics' influence.

As previously mentioned, the Rotten Tomatoes scores are based on the percentage of positive reviews a movie receives. According to Rotten Tomatoes, the reviews are aggregated among qualified critics. For instance, the requirements, which are posted on the company's website, state "Online critics must have published no less than 100 reviews across two calendar years at a single, Tomatometer-approved publication" (Barnes, 2017).

It's important to note that Rotten Tomatoes is owned by Fandango, which is owned by NBC Universal. However, despite being owned by a movie studio, Rotten Tomatoes asserts that it operates independently (Barnes, 2017).

We defined wide releases as those movies that were released in 600 theaters or more. Conversely, we defined limited releases as those that were released in less than 600 theaters. This is the standard used by the website Box Office Mojo, another popular box office reporting service (Box Office Mojo, 2018).

Our data set consisted of 393 wide releases from 2015-2017. We then conducted a correlation analysis between a movie's first weekend domestic gross and its Rotten Tomatoes score.

Correlations are evaluated on a scale of -.01 to .01, which is the equivalent of -100% to 100%. Negative numbers represent correlations with an inverse relationship. It is generally accepted that correlation coefficients of -0.5 to -1.0 and 0.5 to 1.0 indicate a strong association, -0.3 to -0.5 and 0.3 to 0.5 a moderate association, -0.1 to -0.3 and 0.1 to 0.3 a weak association and 0 no association.

But, this association is contingent on the correlation being statistically significant with a p value equal to or less than .05. This ensures a confidence level of 95% or greater.

The correlation yielded an r value of .32, which is considered to represent a moderate relationship. This correlation was also considered to be significant with a p value of less than .05. This means that this analysis has more than a 95% chance of being accurate.

We also conducted a test to see if there was any evidence of a negativity bias. First, we analyzed those movies with a Rotten Tomatoes rating of Rotten, which is a rating of less than 60%, and a rating of Fresh, which is 60% or greater. Those movies with a Rotten rating had an r value of .13 with a p value of .05. In addition, those movies with a Fresh rating had an r value of .14 with a p value of .08.

However, a p value of at least .05 is the standard to determine a significant confidence level (i.e., 95%). With a p value greater than .05, the Fresh correlation does not meet this standard but the Rotten correlation does. Therefore, these results indicate that there is a slightly larger association for Rotten reviews compared to Fresh reviews.

Although, we thought that the threshold for a Rotten score of less than 60% was especially low and wondered if a rating of less than 80% would have a disproportionate influence compared to a positive rating.

To that end, we conducted a correlation analysis of those movies with a rating of less than 80% and those with a rating of 80% or greater. For the movies under 80%, the results showed an r value of .25 with a p value of less than .05. The movies at 80% or greater had an r value of .03 with a p value of .75.

As a result, we can see that this redefinition of negative reviews had a significant difference compared to positive reviews. This is not surprising as it is consistent with earlier findings of a negativity bias among critics' reviews.

Moreover, having found evidence to suggest that film critics served as influencers, we wanted to see if film critics served as predictors as well. To test this assumption, we conducted a correlation analysis between a film's Rotten Tomatoes scores and its total domestic box office gross. This analysis found an r value of .37 with a p value of less than .05. These findings suggest that film critics serve as both influencers and predictors.

We also wanted to see if a negativity bias was evident in the total domestic gross box office numbers. Using the 80% threshold, this analysis also found a significant difference between positive and negative reviews. The negative reviews had an r value of .29 with a p value of less than .05, while the positive reviews had a r value of .12 with a p value of .28.

In regard to limited releases, we analyzed 707 films from 2015-2017. We found no relationship between critics' reviews and first weekend revenue as this analysis found an r value of .03 and a p value of .49. There was, however, a slight relationship with total domestic gross revenue consisting of an r value of .14 and a p value of less than .05.

Additionally, there was no evidence of a negativity bias among the first weekend data with an r value of .01 and a p value of .83 for negative reviews and an r value .06 and a p value of .22 for

positive reviews. The total domestic gross revenue analysis showed a slight influence of the negative reviews with an r value of .15 and a p value of less than .05 compared to the positive reviews with an r value of .03 and a p value of .55.

Theaters

Part of the disparity between the correlation analyses of the wide releases and the limited releases in the first weekend can likely be attributed to the lack of a normal distribution in the limited releases data set. In fact, 71% of the limited releases were shown in 10 theaters or less. Although, this sample included as many as 579 theaters. This wide variability resulted in a sample that was highly skewed.

To more accurately compare the data sets, we also conducted a correlation analysis based on the amount of revenue that each theater generated after the first weekend. Unfortunately, we couldn't conduct this type of analysis for total domestic gross revenue as there aren't comparable metrics.

The wide releases analysis found an r value of .33 with a p value of less than .05. The limited releases had an r value of .16 with a p value of less than .05.

As before, we were curious to know if a negativity bias was detectable in this data. Therefore, we again analyzed those movies with a rating of less than 80% and those with a rating of 80% or greater.

The wide releases had an r value of .26 and a p value of less than .05 for the movies under 80% and an r value of .03 and a p value of .77 for those at 80% or greater. The negative and positive results for limited releases respectively were an r value of .21 and a p value of less than .05 and an r value of .02 and a p value of .69.

Revenue Impact

We conducted a further analysis to see to what extent film critics' moderate influence had an impact on movie revenue. To assess this impact, we performed a t-test on box office revenue to determine the difference between the sample means of negative and positive reviews and whether they were statistically significant.

While both wide releases and limited releases were analyzed, only the sample means of the wide releases were found to have a statistically significant difference. That is, the films with positive reviews earned statistically more money than films with negative reviews. The revenue difference between movies with negative and positive reviews was an average of $23 million on opening weekend (i.e., $21 million versus $44 million) and $83 million for total domestic gross revenue (i.e., $59 million versus $142 million).

DISCUSSION

It's clear that movie studios have historically felt that film critics wielded significant influence in the industry. There's no better illustration of this than the invention of the film critic David Manning by Sony Pictures Entertainment (Basuroy et al., 2003; Terry et al., 2004). In 2001, after being challenged by Newsweek, the company admitted that David Manning from The Ridgefield Press was created by an employee to lavish praise on several Columbia Pictures films including "A Knight's Tale" and "The Animal" (Horn, 2001).

It has also been noted that studios have tried to avoid negative reviews by not offering advance screenings for film critics. In 2000, when advance screenings were not offered for *Get Carter* and *Autumn in New York*, Roger Ebert stated, "The studio has concluded that the film is not good and will receive negative reviews" (Basuroy, et al., 2003).

That said, how much influence film critics had and have is still subject to debate. For instance, based on our results it appears that film critics serve as both influencers and predictors to some extent. This is a reasonable assumption based on the ubiquity of Rotten Tomatoes scores. It was recently reported that the site attracts 14 million unique visitors a month and that Fandango, its parent company, attracts 60 million unique visitors a month. Moreover, they also appear in Google and iTunes searches (Barnes, 2017).

However, there are a few caveats to this research. First, it should be noted that causality cannot be determined from this analysis. Second, our findings are not entirely conclusive. This is due to several possible interpretations of the results.

For the wide releases, one interpretation could be that film critics reviews simply reflect the tastes of audiences. In fact, Yves Bergquist found that critics scores and audiences scores are strongly correlated (Bergquist, 2017).

Although, in light of evidence of the negativity bias in both a film's first weekend and total domestic gross, another interpretation could be that critics' reviews continue to influence audiences throughout the life cycle of the movie.

When using revenue per theater as the basis of analysis for both wide releases and limited releases, we can see that film critics likely have a moderate influence on wide releases and a slight influence on limited releases as well. However, we found evidence that negative reviews likely had more of an impact than positive reviews in both of these samples.

What's also interesting is the lack of statistical significance among movies with Rotten Tomatoes scores of 80% or greater. This is likely due to the influence of other variables. For instance, research has found that variables such as stars, budgets, sequels, awards, marketing and word of mouth all affect movie outcomes (Basuroy et al., 2003; Terry et al., 2004; Eagan, 2016; Eagan, 2017).

	Correlation	R Squared
Wide Releases	.33	.11
Negative Reviews	.26	.07
Positive Reviews	.03*	.001
Limited Releases	.16	.03
Negative Reviews	.21	.04
Positive Reviews	.02*	.0004

** Statistically insignificant*

Exhibit 1: First Weekend (Revenue Per Theater)

	Correlation	R Squared
Wide Releases	.37	.14
Negative Reviews	.29	.09
Positive Reviews	.12*	.01
Limited Releases	.14	.02
Negative Reviews	.15	.02
Positive Reviews	.03*	.001

** Statistically insignificant*

Exhibit 2: Total Domestic Gross Revenue

The charts in Exhibits 1 and 2 provide a summary of the statistics for both the first weekend and total domestic gross revenue. Along with the correlation coefficient (i.e., r value), these charts include the r squared statistic. This statistic is calculated in regression analysis and is the square of the correlation coefficient. This figure represents the degree to which one variable influences another.

As the charts illustrate, though there is a weak to moderate correlation between critics' reviews and movie outcomes, the r squared figures indicate that most of a movie's performance for both wide releases and limited releases is determined by other factors.

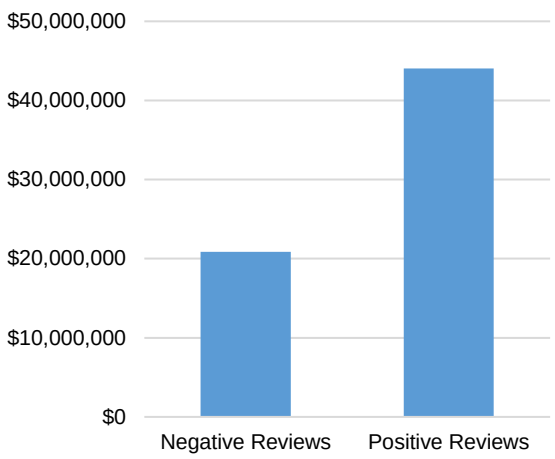

Exhibit 3: First Weekend Mean (Wide Releases)

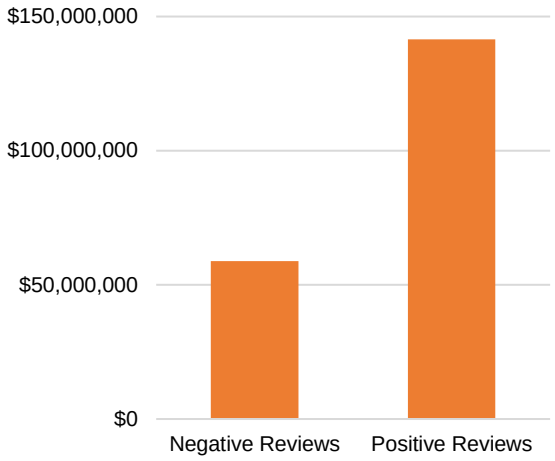

Exhibit 4: Total Domestic Gross Mean (Wide Releases)

In regard to the t-test referenced earlier, Exhibits 3 and 4 depicts the differences in the sample means between negative and positive reviews for wide releases. Again, these values were an average of $23 million for opening weekend revenue and $83 million for total domestic gross revenue.

This t-test helps shed further light on this subject by quantifying the influence of film critics. For example, our analysis of wide releases found that negative reviews explain about 7 percent and 9 percent of the variability for opening weekend and total domestic gross revenue based on the r-squared figures. This can translate into millions of dollars given the mean differences between the negative and positive reviews during these periods.

CONCLUSION

In sum, our findings show that film critics have a moderate influence on wide releases and a weak influence on limited releases based on reviews from Rotten Tomatoes. This applies to both opening weekend and total domestic gross revenue in each case. Also, negative reviews had more of an impact than positive reviews on both types of movies.

This research further found that this moderate influence could have a significant impact on box office revenue. In particular, the difference between negative and positive reviews on wide releases could translate into millions of dollars for both opening weekend and total domestic gross revenue.

Based on our analysis of Rotten Tomatoes scores and the results of similar studies, the weight of the evidence suggests that film critics moderately serve as both influencers and predictors. Moreover, these roles are more apparent among wide releases than limited releases. This study also confirms the existence of a negativity bias that occurs from critics' reviews in both categories of film.

As mentioned earlier, though we can't determine causality, the fact that a consistent relationship exists between critics' reviews and box office performance after the first weekend is noteworthy. That is, because moviegoers won't know if they like a film before they see it, they rely on such cues as marketing, critics' reviews and signaling properties such as a high-profile cast, elaborate sets and special effects (Lampel & Shamsie, 2000).

It has also been found that the higher the level of uncertainly consumers have about the quality of a product the more they are likely to rely on independent information providers. Hence, companies in the movie industry must find ways of leveraging the influence of opinion leaders early in the process to capitalize on the sales momentum and extend the life cycle of their films (Lampel & Shamsie, 2000).

These findings have other implications for studios and filmmakers as well. First, as Eliashberg and Shugan recommended in their groundbreaking study, movie critics should be consulted much like experts are in the development of new products (Eliashberg & Shugan, 1997). Moreover, this research confirms that negative reviews hurt more than positive reviews help movie revenue. As a result, studios and filmmakers should have more of an incentive to involve critics in their market research (Basuroy, et al., 2003).

Lastly, this study focuses on the aggregate scores of Rotten Tomatoes. As such, it does not measure the influence of individual critics. Thus, this research does have some limitations as previous research has shown that some film critics have more influence than others (Boatwright, Basuroy & Kamakura, 2007).

Some have lamented that the art of film criticism has been reduced to a movie score. In fact, director Brett Ratner characterized Rotten Tomatoes as "the destruction of our business" (Hibberd, 2017). Aggregating reviews also apparently creates pressure for critics to conform to the opinions of others (Gleiberman, 2018).

Nevertheless, the site offers us a glimpse of the impact of film critics on this process. It also provides insights on the influence of experts on experience goods including music, books, restaurants, etc.

REFERENCES

Barnes, B. (2017, September 7). Attacked by Rotten Tomatoes. *The New York Times*. Retrieved from https://www.nytimes.com/2017/09/07/business/media/rotten-tomatoes-box-office.html

Basuroy, S., Chatterjee, S. & Abraham Ravid, S. (2003). How Critical Are Critical Reviews? The Box Office Effects of Film Critics, Star Power, and Budgets. *Journal of Marketing, 67*(4), 103-117.

Bergquist, Y. (2017, September 10). Cognitive Hollywood, part 1: Data shows box office economics in turmoil. Retrieved from https://medium.com/vantage/cognitive-hollywood-part-1-data-shows-box-office-economics-in-turmoil-411a4b22f858

Boatwright, P., Basuroy, S. & Kamakura, W. (2007). Reviewing the reviewers: The impact of individual film critics on box office performance. *Quantitative Marketing and Economics, 5*(4), 401-425.

Box Office Mojo. Retrieved from http://www.boxofficemojo.com

Eagan, O. (2016). Movie buzz & information cascades. *Journal of International Business Discipline, 5*(2), 28-42.

Eagan, O. (2017). Twitter shows influence of buzz on movies. *Journal of International Business Disciplines, 6*(1), 19-30.

Eliashberg, J. & Shugan, S. M. (1997). "Film critics: Influencers or predictors?" *Journal of Marketing, 61*(2), 68-78.

Estroff Marano, H. (2003, June 20). Our brain's negative bias: Why our brains are more highly attuned to negative news. *Psychology Today*. Retrieved from https://www.psychologytoday.com/us/articles/200306/our-brains-negative-bias.

Gemser, G., Van Oostrum, M. & Leenders, M. A. A. M. (2007). The impact of film reviews on the box office performance of art house versus mainstream motion pictures. *Journal of Cultural Economics, 31*(1), 43-63.

Gleiberman, O. (2017, August 20). Healthy tomatoes? The danger of film critics speaking as one. *Variety*. Retrieved from http://variety.com/2017/film/columns/rottentomatoes-the-danger-of-film-critics-speaking-as-one-1202533533/

Hibberd, J. (2017, March 23). Rotten Tomatoes is 'the destruction of our business,' says director. Entertainment Weekly. Retrieved from http://ew.com/movies/2017/03/23/ratner-tomatoes-scores/

Horn, J. (2001, June 1). The Reviewer who wasn't tThere. *Newsweek*. Retrieved from https://www.newsweek.com/reviewer-who-wasnt-there-153387.

Kahneman, D. (2011). *Thinking, fast and slow*. New York:Farrar, Straus and Giroux.

Lampel, J. & Shamsie, J. (2000). Critical push: Strategies for creating momentum in the motion picture industry. *Journal of Management, 26*(2), 233-257.

Lehrer, J. (2009). *How we decide*. New York: Houghton Mifflin Harcourt Publishing Company.

Moon, S., Bergey, P. K. & Iacobucci, D. (2010). Dynamic effects among movie ratings, movie revenues, and viewer satisfaction. *Journal of Marketing, 74*(1), 108-121.
Numbers, The. Retrieved from https://www.the-numbers.com
Reinstein, D. A. & Snyder, C. M. (2005). The influence of expert reviews on consumer demand for experience goods: A case study of movie critics. *The Journal of Industrial Economics, 53*(1), 27-51.
Rotten Tomatoes. Retrieved from https://www.rottentomatoes.com
Smith, D. (2002). Psychologist wins Nobel prize. *Monitor on Psychology*. Retrieved from http://www.apa.org/monitor/dec02/nobel.aspx
Terry, N., Butler, M. & De'Armond, D. (2004). Critical acclaim and the box office performance of New Film Releases. *Academy of Marketing Studies Journal, 8*(1), 61-73.
Vogel, H. L. (2011). *Entertainment industry economics: A guide for financial analysis* (8th ed.). New York: Cambridge University Press.

A STUDY ON CLOUD COMPUTING ADOPTION WITHIN SMALL AND MID-SIZE BUSINESSES (SMBS)

Anthony S. Richardson, Southern Connecticut State University
richardsona4@southernct.edu

Geoffrey A. Mate, Southern Connecticut State University
mateg2@southernct.edu

ABSTRACT

A growing number of organizations have difficulty scaling-up their IT infrastructure to handle their growing needs and increased resource demands. Digital Technology Platforms (DTPs) have been identified by Gartner, Inc. as one of the top 10 strategic technology trends of 2017. While DTPs may be mainstream and easily adopted by large enterprise-sized organizations, there is an opportunity for such platforms within Small and Mid-Size Businesses (SMBs). The bottom line is that computing and server hardware is expensive for SMBs. Furthermore, it may be difficult for SMBs to assess and price the labor and resources needed for a company to have acceptable performance while controlling costs. The purpose of this paper is to examine how cloud computing technologies are adopted by SMBs and the respective drivers associated with costs and capability that may reduce costs for an organization. This paper explores how four variables – Robust Capability, Limited Capability, Cost Constraint, and Resource Abundance interact to impact the adoption of DTPs within SMBs. Adopters of DTPs are classified as Efficient, Proactive, Resistive, and Reactive. With respect to adoption efficacy, a model is proposed for assessing the capability and resource readiness as correlated to SMB adoption of DTPs. A study of 12 SMBs and the implementations of DTPs is presented and posited with the proposed adoption model. Due to the extensive investments required in procuring infrastructure services –adoption enablement is imperative for SMB-sized organizations to realize a return on investment. Implications are discussed.

INTRODUCTION

This research is relevant because companies must plan for the future and establish their technology base to handle any flux in business activity. If a business does not scale their IT infrastructure appropriately, it could cause the business to lose revenue later on or even come to a grinding halt. Many IT staff and engineers within SMBs are not completely aware of the options available or costs involved because technology is constantly evolving.

Managers must understand the technical needs of the company and the available solutions to make the most efficient and cost-effective decisions regarding what resources (if any) should be placed in the cloud. There is so much talk today about this subject that it is assumed by many that cloud

computing is necessary to grow. Many enterprises feel that cloud services are superior to in-house data centers or storage (Khajeh-Hosseini & Sommerville, 2010). This idea is further cemented in people's minds by powerful businesses trying to push other organizations to get into the cloud. These powerful businesses include Microsoft and Amazon. It has been predicted that by 2018, 30% of Microsoft's revenue will be cloud-based (Columbus, 2016). While making some businesses run faster and more efficiently, the main selling point for cloud services seems to be cost savings. Cloud computing is supposedly cheaper than buying physical computers. It is generally observed that Cloud computing makes eminent sense for SMEs; however, there are significant technical, organizational and environmental issues which need to be tackled before cloud computing services are effectively used by organizations (Al-Hujran et Al., 2018). SMEs are of interest in this paper because present research shows that cloud computing adoption does provide financial benefits to the adopting firms (Nicholas-Donald et Al., 2018).

There are many services that cloud providers offer, however, the most common services are Software as a Service (SaaS), Infrastructure as a Service (IaaS), and Platform as a Service (PaaS) (Furht & Escalante, 2010). The act of providing storage for a company's data is infrastructure as a service, or IaaS, and is what most people are thinking about and referring to when they say a company is "moving to the cloud." However, most companies use a combination of SaaS, IaaS, and PaaS, and many other DTP services fall under one of these broader categories. These services will be further defined in this paper.

The companies used as examples in this paper are indeed actual real-life businesses. Their names and any other identifying information will be removed due to privacy and compliance concerns. For example, the first company discussed will be referred to as "Company A." DTP solutions analyzed will specifically be cloud services. We will assess the companies' IT department budgets and their capability of moving into the cloud. A discussion will follow on how this resource availability affects a company's ability to move into the cloud. Finally, we will conclude as to whether or not it was cost effective for each company to use a cloud solution, or if it would have been cheaper to not use a cloud service. We will wrap up our discussion with future considerations and any potential threats to the research, including anything which we did not have direct control over and may have hindered the results.

What Is "the Cloud"?

Most organizations that offer cloud computing provide business applications online, which clients can access online from a web browser or web service. All of this software and data are stored on servers (Bhardwaj et. Al., 2010).

But more simply, cloud computing can be defined as one of three overarching services: SaaS, IaaS, and PaaS. Software as a Service, or SaaS, is when an organization offers you some set of software or applications which they manage, but you pay for what you use. For instance, a business user may use an application licensed by an organization, such as Salesforce, but the application is configured and managed by another service provider organization who charges the user for the amount they use it or the amount of storage that is used by the application. There are different

ways to charge for this service, but SaaS, like most other cloud offerings, use a pay-as-you-go kind of charge scheme.

IaaS, or Infrastructure as a Service, refers to computing machines and resources being utilized as a service. This includes cloud providers offering storage of software and data on their servers while offering a pay-as-you-use cycle. However, what many people do not understand is that IaaS does not just refer to storage of data, but also to having the computing resources you need at all times, on demand. This demonstrates one of the major selling points of cloud computing besides cost savings: speed and performance optimization. Administrators in organizations paying for IaaS can create a virtual machine and have it running in production within seconds. It will run just like a physical computer on site. This incredibly efficient benefit to every day IT work cannot be overstated and is one of the main reasons companies move to the cloud. Cloud providers say that no end-user should have to suffer a slow computer or lag in production time because their organization cannot provide adequate resources to perform their jobs. They claim to offer affordable solutions to this common problem in the form of IaaS (Armbrust et al., 2010).

PaaS, or Platform as a Service, is similar to IaaS, but also includes services that are required for a specific application, as opposed to just general storage and computing resources. This paper will mostly be examining companies that utilize IaaS and mainly use the cloud for storage and availability of resources.

Adoption Model Defined

A business is considered Under-Adopted in the cloud if they have migrated under 25% of their servers into the cloud. They are considered Moderately-Adopted if they have migrated 25% to 94.99% of their servers to the cloud. Businesses are considered Fully-Adopted if they have migrated 95% or more of their servers to the cloud. It may sound strange to say that a business has fully adopted IaaS when only 95% of their servers are housed and managed on the cloud, since "fully" would seem to imply 100%. But what must be understood is that it is difficult to have every server a company needs in the cloud. There are almost definitely a few or more servers housed on site for businesses to support the core requirements of businesses. There are not many companies generating the levels of revenue we are going to be looking at which do not have at least one or more servers on site being managed solely by the company and not a cloud provider. So, a third range is needed to qualify what it means to be fully adopted as opposed to assuming 100% transfer of server management; that is not realistic.

A business is small if their annual revenue is in the range of $0 to $499,999,999 (Between $0 and just under one million). A business is mid-size if annual revenue is within the range of $500,000,000 to $999,999,999 (between $500 Million and just under one billion dollars).

A company is considered Cost Constrained if their annual IT budget is less than 1.5 million dollars. A company is Resource Abundant if their IT budget is 1.5 million dollars or more. A company is an Efficient Adopter if they are both Cost Constrained and have Robust Capability. They are identified as a Proactive Adopter if they have Robust Capability and Resource Abundance. They

are a Resistive Adopter if they are Cost Constrained and have Limited Capability. And finally, they are considered Reactive Adopters if they have Limited Capability but are Resource Abundant.

Regarding employee resource depth and a company's capability to move into the cloud, a business is considered to have Robust Capability if there is a minimum of 5 years of total experience amongst their IT employees working with any cloud services. A business is considered to have Limited Capability if this overall IT departmental experience is less than five years. With these definitions set forth, we were able to examine and evaluate how different size businesses migrate and manage their storage with DTPs. By examining their costs and also their internal IT capabilities, we were able to examine further the cost and other possible circumstances surrounding why they moved to the cloud. This circumstance may shed some light on why and how these companies moved to DTPs. Figure 1 depicts the proposed segmented pyramid Adoption Model of Business, concerning Digital Technology Platforms.

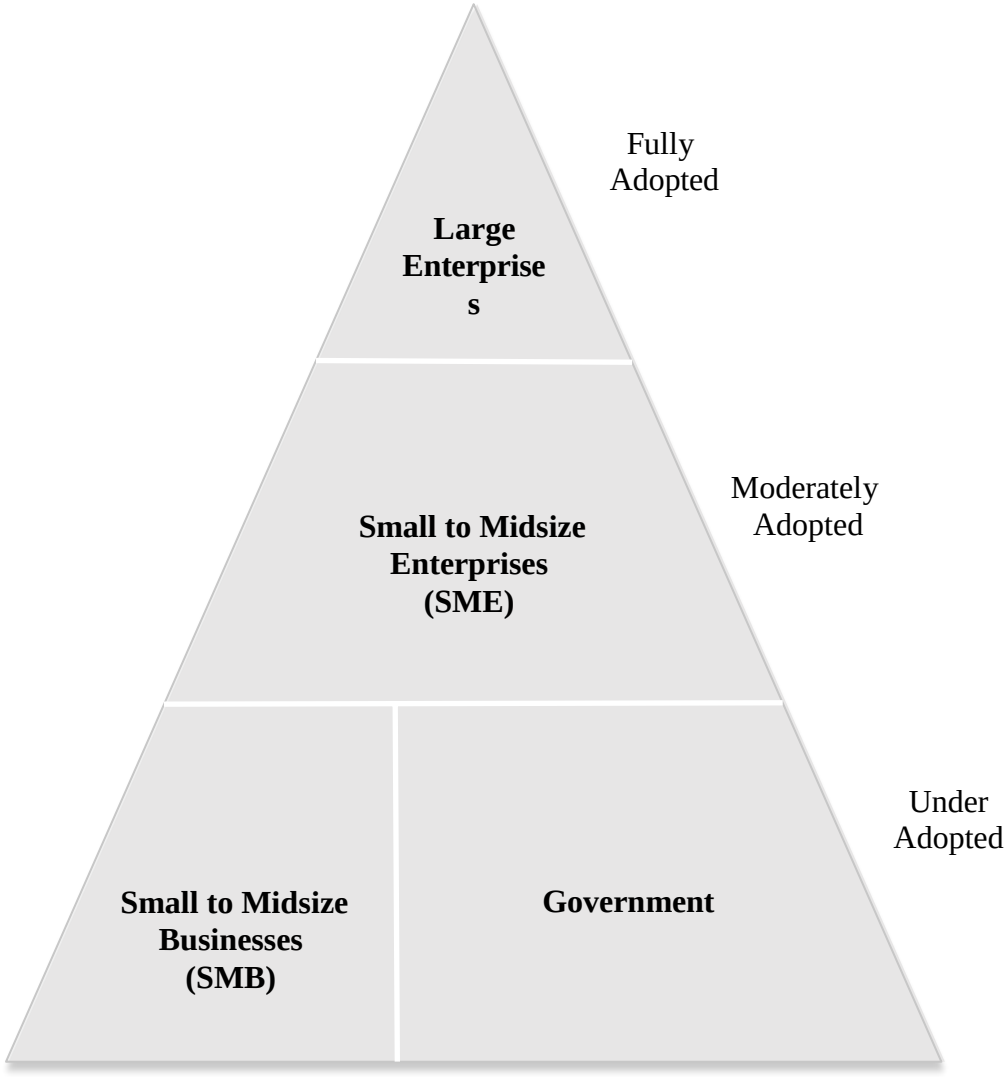

FIGURE 1. ADOPTION MODEL OF BUSINESSES

Figure 2 depicts the proposed quadrant model and classification of adopter types concerning digital technology platforms.

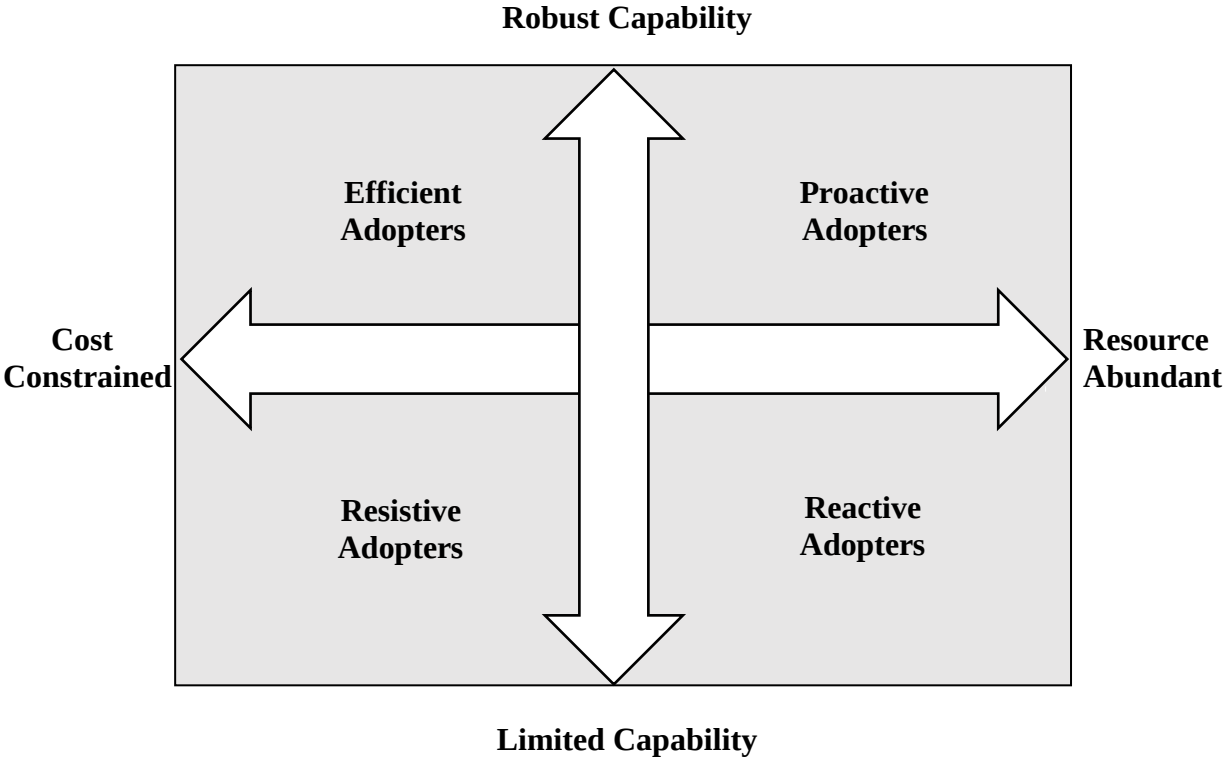

FIGURE 2. CLASSIFICATION OF ADOPTER TYPES

Revenue, IT Budget, and Cost Constraint

Of the twelve organizations studies, six of them (Companies A-F) are considered small businesses and the other six are medium-sized businesses (companies G-L), based on the most recent annual revenue from 2016. In reviewing the adoption model of businesses, it is important to note that no large businesses are discussed in this paper as only small and mid-sized businesses are studied. Table 1 on the following page details the types of organizations and annual revenues that were sampled for this study.

TABLE 1. ORGANIZATIONS SAMPLED FOR THE STUDY

Organization	Industry	Annual Revenue 2016
Company A – Small Business	Passenger Transportation	$ 4,700,000
Company B – Small Business	Marketing & Advertising	$ 10,100,000
Company C – Small Business	E-Commerce/Automotive Dealer	$ 10,500,000
Company D – Small Business	Software	$ 45,917,000
Company E – Small Business	E-Commerce/ Automotive Dealer	$ 365,107,000
Company F – Small Business	Energy (Utility)	$ 370,120,000
Company G – Medium-Sized Business	Retail	$ 639,100,000
Company H – Medium-Sized Business	Real Estate	$ 683,800,000
Company I – Medium-Sized Business	Construction	$ 782,800,000
Company J – Medium-Sized Business	Food Service	$ 800,000,000
Company K – Medium-Sized Business	Legal	$ 846,500,000
Company L – Medium-Sized Business	Financial Services	$ 864,400,000

It is sometimes assumed that the more revenue a company has, the higher their budgets are. Logically, one would think that out of two companies, the one with a higher revenue would have a higher budget for IT and would be willing to pay more for IT needs and changes. While sometimes true, a higher source of revenue does not necessarily mean that a company will be willing just to throw more money into their IT systems. This is observed within our data below which shows how company G, a mid-size business with revenue of over 600 million dollars, has less of an IT budget than some of the small businesses. The 2016 IT budget for company G was $800,000 per year, while the 2016 budget for Companies D, E, and F were all over $1,000,000. We believe the IT department budget can be affected by factors other than revenue. One factor may be talent or expertise of IT employees. If the IT department is very knowledgeable and has proven to be a major asset to the company, then management may be willing to allocate more resources to IT. All too often, businesses provide enough funding for IT to keep the company running, but not enough to expand or improve performance. It may take a very experienced and successful team to encourage management to allocate the appropriate funds. Table 2 details the annual IT budgets of the organizations that participated in the study.

TABLE 2. ANNUAL IT BUDGETS OF ORGANIZATIONS WITHIN STUDY

Organization	Annual IT Budget 2017	Monthly Budget
Company A	$ 400,000	$ 33,333
Company B	$ 500,000	$ 41,667
Company C	$ 500,000	$ 41,667
Company D	$ 1,000,000	$ 83,333
Company E	$ 1,250,000	$ 104,167
Company F	$ 1,175,000	$ 97,917
Company G	$ 800,000	$ 66,667
Company H	$ 3,000,000	$ 250,000
Company I	$ 3,000,000	$ 250,000
Company J	$ 1,500,000	$ 125,000
Company K	$ 1,200,000	$ 100,000
Company L	$ 3,000,000	$ 250,000

Each small business we investigated was rated Cost Constrained. Some of these organizations were severely cost constrained. It may be expected since small businesses should try to save money at every opportunity. The smaller the company, the more money you need to save. It is not about staying within budget when you are a small enterprise, but about being as far under budget as possible. But every mid-size business was resource abundant except two: company G and company K. These are both high revenue companies which have migrated the majority of IT storage and infrastructure to the cloud. They both have a high stake in their cloud structure since they are almost entirely managed in the cloud, yet only one company has an IT staff of significantly higher DTP experience. Company G has 12 years of experience while Company K has 19 years. Company K has a higher percentage of their infrastructure hosted in the cloud, so it makes sense that they would want to ensure that their staff can handle any issues when they occur.

Another factor may be the industry the business is operating within. It is possible that certain types of businesses may not need as much IT support as others, no matter how large or revenue generating they become. Company G is a retail entity, Company D produces a specialty product (alarms), Company E works in the automotive industry, and company F is an energy (utility) provider. These are all very different industries, and therefore all may have different IT needs, but all still have a significant difference in budget size. It is possible that retail does not use as many computing resources or need as much IT maintenance, which would allow them to have a lower IT budget and still operate at a capacity to generate large revenue. A closer look at all of these businesses operations would be needed to break down why a mid-size business would have such a lower IT budget than several of our small businesses.

The IT budget is, of course, a critical aspect of deciding whether to migrate an organization's resources to a DTP such as the cloud. We would be willing to wager that there are many managers or even leaders in organizations who would say this is the most important measure of whether a company could or should move to the cloud. However, one other factor to consider when making this decision is the company's Resource Capability. Resource Capability defines how competent, and able an organization is (or would be) at shifting IT services to the cloud if it decided to do so.

Infrastructure is included as well as supporting cloud services and maintenance. It can be a blessing to unload certain IT services to another organization because some IT functions can be a real headache to have to manage (Akkad, 2010). However, a business considering this transition must ask itself, how does it know that it is ready to move to the cloud and how can the business-be sure this will be a success without any major delays in business-as-usual? One way would be to take stock of current IT resources and staff and see if they are knowledgeable enough and experienced enough to handle this transition. If management were to decide to move IT operations to the cloud because they thought it would save the business money in the long run, but nobody on the IT staff has any working knowledge of cloud technology, this could be a disaster. It does not matter how much money one invests into a project; a company must have the right staff to execute any project, let alone a project that could disrupt the entire operation. To evaluate how prepared an organization is to make the jump into DTPs, we have developed a model as defined earlier.

Digital Technology Platform (DTP) Expertise

Table 3 details the experience and depth each small business entity has with the respected cloud models, IaaS, PaaS, and SaaS.

TABLE 3. SMALL BUSINESS DTP EXPERTISE (BY LETTER)

Type of Cloud Experience	A	B	C	D	E	F
Total Years' Experience IaaS	10	8	7	4	4	7
Total Years' Experience PaaS	3	4	7	3	3	2
Total Years' Experience SaaS	3	5	5	7	6	4
Total Years Cloud Experience	16	17	19	14	13	13

Table 4 details the experience and depth each mid-size business entity has with the respected cloud models, IaaS, PaaS, and SaaS.

TABLE 4. MID-SIZED BUSINESS DTP EXPERTISE (BY LETTER)

Type of Cloud Experience	G	H	I	J	K	L	Average for all companies
Total Years' Experience IaaS	3	5	5	7	6	4	**5**
Total Years' Experience PaaS	4	5	7	7	4	5	**4.5**
Total Years' Experience SaaS	5	3	4	8	9	7	**5.5**
Total Years Cloud Experience	**12**	**13**	**16**	**22**	**19**	**16**	**15**

As observed in the above table, each business has its cloud experience rated by the number of years of experience in each service, then by a total number of years in all three cloud-related services. This experience is defined by the number years working for a company that utilizes cloud technology and the number of years working with that particular service. Hands-on employee experience is the criterion that counted toward cloud experience. The same hands-on experience applied to an IT employee who worked for a business using the cloud. Moving into the cloud is a major trend which many enterprises are following (Christauskas & Miseviciene, 2012) and it is important that these businesses have the talent to support such a migration.

There are a couple of key observations to be made based off this table alone. One thing to notice is that businesses with higher revenue do not necessarily have the most experienced IT staff for cloud computing. In a generation where cloud computing is becoming critical for businesses to compete with other large businesses consistently, one might jump to the conclusion that a company with significantly higher revenue would higher the most experienced staff it could. Strikingly, this table shows that is not always true. Company H has 13 years of cloud experience, which seems like a lot, but is not as much as others within the table; less than almost all of the mid-size companies we examined had comparable years of experience. Companies E through F equal company H with 13 years of experience, but all other small businesses here have more years of experience. So once again, larger organizations with higher revenue do not necessarily hire or hold staff with more cloud experience, even though this could be considered a necessary technology for most of them; these decisions could also be influenced by industry.

Another important observation is that the median experience is higher for IaaS. On average, most of these companies have IT staff more experienced in IaaS than either of the other major cloud services, suggesting that this service is more important to an organization. Because IaaS by definition is a service for the IT foundation of a business, it could be more critical for a business to have than other services (Giordano, 2017). It would depend on the type and size of the business, but based on this table, IaaS is a more important and critical service than either of the other two overarching cloud solutions (PaaS and SaaS). If the data in this table correlates with the number of servers each business has migrated into the cloud, then this hypothesis may be supported. In the next section, this paper will examine the metrics of computing resources each company has moved into the cloud.

The Adoption Model of Businesses

Using the server data presented below, we can see which companies are moderately adopted and which ones are under adopted. We can then compare these findings with the proposed adoption model of businesses previously shown.

TABLE 5. THE CONTRAST OF ON-SITE VS. CLOUD SERVER ADOPTION

Organization	Number of servers on-site	Number of servers in the cloud	Percentage of servers in the cloud
Company A	90	12	0.13
Company B	138	43	0.31
Company C	114	24	0.21
Company D	70	11	0.16
Company E	153	115	0.75
Company F	204	199	0.98
Company G	121	79	0.65
Company H	90	86	0.96
Company I	220	157	0.71
Company J	253	205	0.81
Company K	238	217	0.91
Company L	201	190	0.95

TABLE 6. CLASSIFICATION OF ORGANIZATIONS BASED ON SERVER PLACEMENT (ON-SITE VS. CLOUD)

Organization	Under Adopted	Moderately Adopted	Fully Adopted
Company A	Yes		
Company B		Yes	
Company C	Yes		
Company D	Yes		
Company E		Yes	
Company F			Yes
Company G		Yes	
Company H			Yes
Company I		Yes	
Company J		Yes	
Company K		Yes	
Company L			Yes

The model hypothesized that small businesses would be under adopted (under implications from their supposedly smaller IT budgets), while mid-sized businesses would be at least moderately adopted. As expected, mid-size companies who had not migrated to the cloud at a moderate capacity, migrated fully to the cloud. The small companies were a bit more surprising. The data shows that smaller businesses are only 50% under-adopted cloud technology and services, while the other half are moderately- or even fully-migrated.

It is surprising that a small business would be fully migrated because a business that is smaller but still has a large revenue may want more control over their resources, as opposed to giving responsibility to a cloud provider to manage infrastructure and data. The only business that is small but fully adopted is company F. This energy company has revenue of over 370 million dollars, but still has a cost-constrained IT budget. The budget is well under 1.5 million dollars. It is possible that this business is growing rapidly and management feels that although it is small now, pretty soon it could grow too quickly, even quicker than they are ready to handle.~~,~~ I~~n~~ that case, perhaps the IT team needs the assistance of cloud technology and needs a cloud provider to make sure the business scales accordingly and has the infrastructure to handle the growing needs of an up and coming energy-company. Next, we will look at cost savings, which has been a major selling point of cloud services and long-held benefit (Mell & Grance, 2009).

Resource Costs

The following figures (3 & 4) detail the resource (dollars) spent both before and after DTP implementation between the second half of the 2016 calendar year and the first half of the 2017 calendar year.

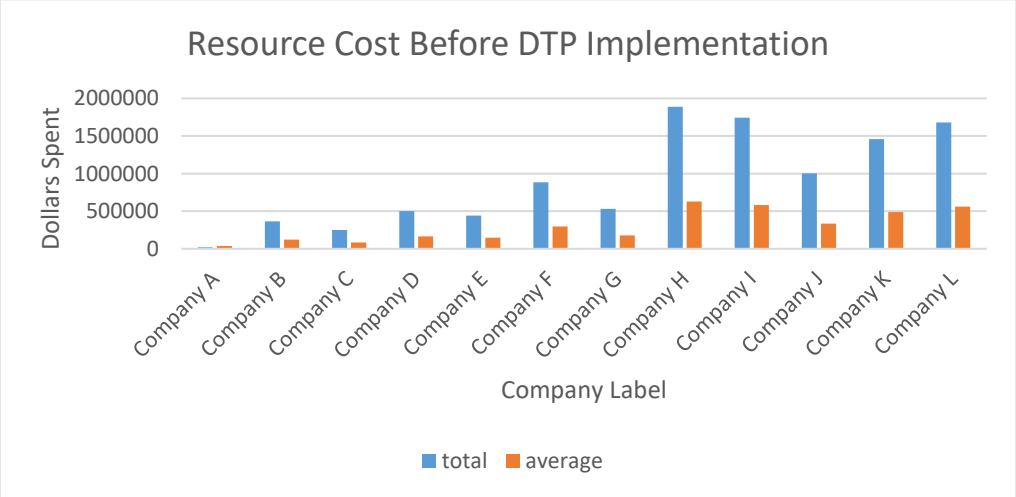

FIGURE 3. RESOURCE COST IN 2016 BEFORE IMPLEMENTATION OF DTPS

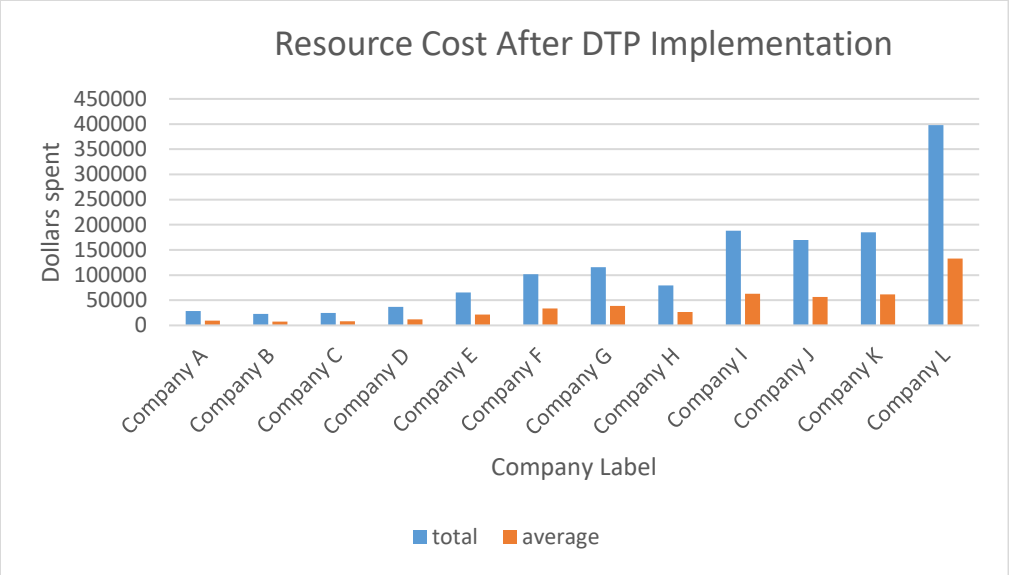

FIGURE 4. RESOURCE COST IN 2017 AFTER IMPLEMENTATION OF DTPS

In viewing the total IT computing resource cost for each company, we compared what they were for the last six months before the cloud migration and the first six months after the cloud migration. This method allowed for observation of the immediate cost-saving results of cloud technology. It showed that every company realizes cost savings from using the cloud. These savings are not minimal, but dramatic. Some companies save hundreds of thousands of dollars as was the case with Company L. The total cost of resources was $1,243,398 and after DTP implementation it was $301,000. Also keep in mind that cost savings can vary as time goes on because resource needs change and the price Microsoft charges for their cloud services may change, but for now it seems to be a large cost savings strategy to move into the cloud. This simple comparison is an enticing motivator for businesses to assess their needs and make a decision as to whether they need to move to save money. Along with saving money, moving into the cloud could help long-run productivity and other factors of business operation, but that is beyond the scope of this paper.

Classification of Adopter Types

After analyzing and reviewing all of the information and data gathered from these 12 organizations, it is clear that there are patterns emerging related to the type of companies that will tend to migrate to the cloud and at what capacity. But as with most models and rules, there seem to be some exceptions. Companies with more revenue do tend to migrate more of their IT infrastructure to the cloud and utilize more cloud services than those with less revenue. This is observed in the number of servers that each company has moved into Azure. However, the type of industry may affect the decision to migrate. For instance, Company A's business is training pilots to fly airplanes which requires a lot of simulation technology and computing resources to track flight information and data which can be sensitive data that needs to be accessed immediately for

several reasons, with safety being number one. For these reasons, Company A may want or need, to be completely responsible for their servers and data and not give access to anyone else, including Microsoft, which could explain why they have migrated only 13 percent of their servers into the cloud despite having millions in revenue. It could also be suggested that Company A might not migrate much more computing resources into the cloud even if they had 100 million dollars in revenue simply based on their industry and current migration percentage. Company A is cost constrained because its IT budget for 2016 was only $400,000, but high capability because its IT staff had more than five years of experience working in the cloud. Therefore, based on the definitions set forth at the beginning of this paper, this business would be classified as an Efficient Adopter. The term efficient seems appropriate for Company A because they appear to want to keep most of their data private and readily available to them without any interference or need to go to anyone else, yet they still utilize Azure cloud services when necessary as their budget allows. They use cloud services when it suits them as opposed to just jumping on board to use the cloud as many companies seem to be doing (Columbus, 2017).

We can see what type of Adopter each organization is by looking at the data collected regarding company budgets and cloud technology. Companies A, B, C, D, E, F, G, and K are Efficient Adopters, while Companies H, I, J, and L are Proactive Adopters. There are no Resistive or Reactive Adopters because none of these organizations are low capability. That is, they all have an IT staff which has a minimum of 5 years' experience working with cloud technologies. They all have double that amount of experience; this experience measure may suggest that companies migrating their IT resources to the cloud know they need people working for them who already know how to deal with this kind of tech, or it could be possible that these companies hired more staff or consultants who are trained in cloud technology to help with the migration. It would be interesting to see what these businesses' IT staff experience was one or even two years before their migrations.

Of the four Proactive Adopters (Companies H, I, J, and L), two of them have fully migrated to Microsoft Azure. These companies trust Microsoft to hold their data securely and provide access when needed. The future of these companies or at least the continued smooth operation of these companies over the next few years depends on their ability to leverage their cloud services and relationship with Microsoft successfully. These companies are large enough and have enough revenue to justify their need for using cloud services, but there are other reasons to migrate. Again, it could be said that the industry each business operates within their need to migrate and to what extent. There have been studies performed to see if certain types of organizations are moving into the cloud at a faster pace (Kerrest, 2016). It is also possible that some organizations have more proprietary or legally restricted information that is not allowed to be stored in the cloud, which would cause certain types of business to migrate less, even if they wanted to so (Badola, 2015). However, we cannot make that conclusion based on the results of this paper alone. Also, not every large business is a Proactive Adopter as we hypothesized they might be. Despite having large revenue and large IT budgets which would allow for full migration, not every large company did fully migrate, particularly Company G. This company only moved 65 percent of its resources to Azure even though it could have moved everything.

CONCLUSIONS

There is a pattern to which companies migrate to the cloud and to what extent, but not every company follows this pattern. The pattern appears to be that businesses with more experience and higher revenue migrate more computing resources to the cloud. Exceptions include Companies E, F, G, and I. Company E is an Efficient Adopter, but has moved significantly more resources to the cloud than Companies A, B, C, or D. Although Company E has not fully migrated, 75% is a large majority of resources and puts a lot of responsibility in the hands of Microsoft to handle their business needs. Company F has fully migrated and is more migrated at 98% than any other business studied in this paper, including all the large enterprises. Company G is a large business, but has only migrated just over half of its resources to the cloud, despite its massive revenue. Perhaps the company maintains that it does not need the cloud as much as other companies do and hasn't been swayed by popular opinion regarding how great the cloud is, and therefore, simply has not chosen to move everything over to Microsoft. Alternatively, perhaps their decision to not migrate as much is more strategic. This would make sense because most companies only migrate to the cloud if they can see some relative advantage in doing so (Alshamaila & Papagiannidis, 2012). Company I is an exception because although 71% is a large number of IT resources to move to the cloud, this is not nearly as much as most of the other large companies.

Most of the companies studied fit our models. The models suggest that companies with more revenue, larger IT budgets, and more trained staff will migrate more of their IT infrastructure and resources to DTPs, particularly cloud technologies. These technologies include IaaS, PaaS, and SaaS. The notable exceptions to this hypothesis are Companies E, F, G, and I. They appear to break from this line of thinking and logic; thereby breaking the pattern the models and other companies set forward. However, regardless of how much of their infrastructure they migrated, it is important to note that all of these companies did migrate to some degree. Cloud computing has already been shown to have major benefits; these benefits include a substantial increase in communication, collaboration, and real-time analysis (Bassett et al., 2015). Cloud computing is critical to staying competitive. This paper does not cover all of the benefits of cloud computing and only discusses a few. Others benefits include loss prevention, sustainability, and automatic updates, to name a few (Salesforce, 2017).

Limitations

The computing- resource costs compared for when these businesses utilized DTPs (and did not) were measured at different times of the year. Cost information analysis for DTP usage was from January through December. The months July through December were utilized to review the non-use DTP cost information. It is unknown if the different seasons or times of year would make a difference in computing resource costs. It may play a factor in how much cooling to apply to a server room because the temperature varies with the seasons. The temperature plays a huge part in determining how a pc or server run (Smathers, 2017). It can also destroy a computer if it gets too hot. It is well known, and those who have been in server rooms will attest, that servers very easily

can overheat. There may be other factors influencing data with the seasonal change other than temperature, but they are unknown at this time; this can be considered a limitation of the study.

The IT budget information is from 2017, while the revenue information and part of the cost information were from 2016. It is unlikely that the IT budget changed dramatically in one year, but it is possible it could have been significantly more or less in 2016. The IT budget determines what resources (PCs, servers, virtual machines, hardware parts, peripherals such as monitors and wires, etc.) will be available for a company's fiscal year. This number also determines what kind of equipment to order and what actions to take when making infrastructure change decisions. The decision to use DTPs and the extent to which a company wants to use DTPs depends on this budget. Differences in this amount can make a huge difference in an organization's ability and willingness to migrate to the cloud. This is especially true with IaaS since moving resources to DTPs in this fashion is very costly and time consuming for a company.

Also, once the migration to a cloud service is achieved, especially IaaS, moving back to self-managed resources is just as costly. It is also costly to change one's mind and switch DTP providers because everything that was moved will have to be moved again. An example of this would be a company migrating all their servers to AWS, then a year later deciding they can get a better monthly rate with Azure and then move all of those same servers to Azure. This can slow production down in business for months. This technical disruption in business can cause users to be unable to perform certain job duties at certain times since the resources housing their data are being put offline and moved briefly. In this scenario, not only would it be costly to move to IaaS with a DTP; it would also impact performance costs. Given that some of the data is being reviewed during times when there would have been a change in the IT budget, this may affect the results.

The mid-size businesses we analyzed had a higher IT budget than is typical for businesses of that size. This is according to a study done by Gartner. Companies that are mid-sized typically spend 6.7% of overall revenue on IT (Guevara, 2017). Some of the mid-size companies we looked at had almost double that percentage, and that may be because they simply can afford it and wish to make sure the money is budgeted accordingly and available in case of need. For instance, it would make sense to budget for those rare instances when the unexpected happens like an office burning down and new construction is needed.

A company that can afford it, generally will ensure that they have budget allocations to address any possible issues that may arise regarding their IT and infrastructure. The businesses we looked at are just a few of the thousands of companies with revenue in the range of $500 million to just under $1 billion, and the average IT budget may not be so high, as Gartner claims to be the case. However, because the companies we chose do not reflect what is believed to be the average cost of an IT budget, this could affect the results regarding what cost savings a typical mid-size company can expect to see with DTP implementation.

Today, there are cloud-based solutions for storing and managing data. The cloud is something relatively new and not every SMB has training or knowledge in this scope of practice. So, while it may be beneficial for a business to move their storage to the cloud, they might not have the talent or expertise to accomplish this move. Although saving money is always a top concern for businesses; some companies may not move into the cloud for reasons other than cost. Because it is difficult to understand with complete certainty the reasons a company is or is not moving to the cloud, making determinations based on the data can be deemed speculative. Although we considered the experience of the IT employees as a variable in the determination of whether a

business moves to the cloud, we must still remember that the assumptions made by this paper are not necessarily completely accurate.

We did not have any companies in this study which were Low Capability. All of these companies had IT staff well versed and experienced in DTP technologies with at least 5 or more years of IT experience.

Also, the companies studied in this paper have all just recently migrated to the cloud as of January 2017. It is common for cloud service costs to be higher during the initial transition from self-managed storage than they are once a company has adjusted to doing business in a DTP environment. In the beginning, the IT team for the client business is usually learning how to utilize the services offered by Microsoft Azure and utilize them effectively. Thereafter, the costs usually level off with time. The IT team understands the associated services and costs, and plan activities accordingly. For example, the system administrators and engineers for a company will learn how many virtual servers or PCs are required to test something as time goes on. Therefore, they become well-versed in the technology. This decision all depends on the IT team and their knowledge and level of experience in the cloud. So, these companies may see an even further cost reduction past the initial six-month period of operating in the cloud.

Future Considerations

While the core focus of this study was to examine how cloud computing technologies are adopted by SMBs and the respective drivers associated *costs* and *capability*, there exists an opportunity to extend this work further while uncovering other significant factors that are attributed to the spread and adoption of cloud computing technology across different organizations. The most appropriate lens for extending this work would be Diffusion of Innovation Theory, which is posited on seeking to explain how, why, and at what rate new ideas and technology spread (Rodgers, 2003). Rogers argues that diffusion is the process by which an innovation is communicated over time among the participants in a social system. The categories of adopters are innovators, early adopters, early majority, late majority, and laggards. Diffusion manifests itself in different ways and is highly subject to the type of adopters and innovation-decision process. The criterion for the adopter categorization is innovativeness, defined as the degree to which an individual adopts a new idea (Rodgers, 1962). At present, the authors of this paper were unable to identify any literature which covers Cloud Computing adoption juxtaposed to Diffusion of Innovation Theory. We believe extending this work will be a valid contribution to enhance the given literature on this broad topic.

REFERENCES

Adjei-Otchwemah, T. (2011, November 28). *Will virtualization really save you money?* Retrieved from http://www.dreamoval.com/will-virtualization-really-save-you-money-2/

Akkad, O. (2010, November 11). *Outsource IT headaches to the cloud*. Retrieved from https://www.theglobeandmail.com/report-on-business/small-business/sb-managing/outsource-it-headaches-to-the-cloud/article1318511/

Al-Hujran, O., Al-Lozi, E. M., Al-Debei, M. M., & Maqableh, M. (2018). Challenges of cloud computing adoption from the TOE framework perspective. *International Journal of E-Business Research (IJEBR), 14*(3), 77-94.

Alshamaila, Y., Papagiannidis, S., & Li, F. (2013). Cloud computing adoption by SMEs in the north east of England: A multi-perspective framework. *Journal of Enterprise Information Management, 26*(3), 250-275.

Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., & Zaharia, M. (2010). A view of cloud computing. *Communications of the ACM, 53*(4), 50-58.

Badola, V. (2015, October 1). *Cloud migration: Benefits and risks of migrating to the cloud*. Retrieved from https://cloudacademy.com/blog/cloud-migration-benefits-risks/

Bassett, R. A., Richardson, A. S., & Page, R. A. (2015). The risks and rewards of computing everywhere for small business entrepreneurs. *Issues in Information Systems, 16*(2), 236-245.

Bhardwaj, S., Jain, L., & Jain, S. (2010). Cloud computing: A study of infrastructure as a service (IAAS). *International Journal of Engineering and Information Technology, 2*(1), 60-63.

Christauskas, C., & Miseviciene, R. (2012). Cloud–computing based accounting for small to medium sized business. *Engineering Economics, 23*(1), 14-21.

Columbus, L. (2016, March 13). *Roundup of cloud computing forecasts and market estimates*. Retrieved from https://www.forbes.com/sites/louiscolumbus/2016/03/13/roundup-of-cloud-computing-forecasts-and-market-estimates-2016/#5b1608262187

Columbus, L. (2017, April 23). *2017 state of cloud adoption and security*. Retrieved from https://www.forbes.com/sites/louiscolumbus/2017/04/23/2017-state-of-cloud-adoption-and-security/#19279e6a1848

Furht, B., & Escalante, A. (2010). *Handbook of cloud computing* (Vol. 3). New York: Springer.

Giordano, D. (2017, May 5). *Future of the ECM cloud: Why IaaS is more important than SaaS*. Retrieved from http://documentmedia.com/article-2638-Future-of-the-ECM-Cloud-Why-IaaS-Is-More-Important-than-SaaS.html

Guevara, J. (2017, March 14). *Gartner IT budget: Enterprise comparison tool*. Retrieved from http://www.gartner.com/downloads/public/explore/metricsAndTools/ITBudget_Sample_2012.pdf

Kerrest, F. (2016, May 6). *10 Industries That Have Embraced the Cloud*. Retrieved from https://www.inc.com/frederic-kerrest/how-do-industries-stack-up-in-the-cloud.html

Khajeh-Hosseini, A., Greenwood, D., & Sommerville, I. (2010, July). Cloud migration: A case study of migrating an enterprise it system to IaaS. In *Cloud Computing (CLOUD), 2010 IEEE 3rd International Conference on* (pp. 450-457). IEEE.

Mell, P., & Grance, T. (2009). Effectively and securely using the cloud computing paradigm. *NIST, Information Technology Laboratory, 2*(8), 304-311.

Nicholas-Donald, A., Mahmood, M. A., & Trevino, L. L. (2018). Does adoption of cloud computing matter? The economic worth of cloud computing implementation. *International Journal of Information Systems and Management, 1*(4), 328-342.

Rogers, Everett M. (1962). *Diffusion of Innovation.* (1st ed.). Retrieved from https://books.google.com/

Rogers, Everett (2003). *Diffusion of Innovations.* (5th ed.). Retrieved from https://books.google.com/

Salesforce (2017). *12 benefits of cloud computing*. Retrieved from https://www.salesforce.com/hub/technology/benefits-of-cloud/

Smathers, M. (2017). *How does temperature affect the performance of computer components?* Retrieved from http://smallbusiness.chron.com/temperature-affect-performance-computer-components-28197.html

INTERNATIONAL JOURNAL OF INTERDISCIPLINARY RESEARCH

VOLUME 7, NUMBER 2 December 2018

Published By:
Eastern Washington University and the International Academy of Business Disciplines

ISSN 2165-3232 WWW.IJIR.NET

Printed in the USA by Eastern Washington University