

Understanding the Adoption of Additive Manufacturing in Construction: A Sociological Perspective through a Revised TAM Model

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Abstract

This article examines the adoption of additive manufacturing, or 3D printing, in the construction sector, with a focus on the sociological resistance to this innovation. Despite the clear advantages of this technology, including reduced costs and construction time, its large-scale deployment remains limited, mainly due to reluctance from entrepreneurs. The study adopts a sociological perspective to analyze the relationship between technology and professional identity, drawing on the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB). This study proposes a revised version of the Technology Acceptance Model (TAM), which integrates professional identity as a key factor in technology adoption. The model also incorporates additional variables such as contextual organizational factors, organizational support, and professional social networks, to provide a deeper analysis of the barriers to the adoption of 3D printing in this sector.

Keywords

Professional Identity, Organizational Change, Resistance to Change, Technology Acceptance, Sociology of Innovation

1. Introduction

The adoption of innovative technologies, such as 3D printing, in the construction sector presents immense potential to transform practices, reduce costs, and increase efficiency. However, despite these advantages, the acceptance of this technology is hindered by certain resistances, particularly those linked to the professional

identity of contractors. This resistance, deeply rooted in traditional craftsmanship and expertise, limits the integration of new technologies perceived as a threat to these skills.

3D printing, unlike traditional manufacturing methods based on subtraction or equalization, is an additive manufacturing technique. It transforms a 3D model into a series of 2D layers, allowing the creation of an object layer by layer (Chunhua & Guangqing, 2020). This approach offers considerable freedom as it is not constrained by the complexity of the model or the quantity of products to be manufactured. Thanks to its flexibility, 3D printing is particularly well-suited to the medical field, where customization plays a key role. Indeed, the use of 3D printing in this sector has seen significant advancements.

This article explores the various applications and recent developments of this technology in areas such as the creation of medical models, the design of rehabilitation equipment, tissue engineering, the manufacturing of medical hygiene materials, and lab-on-a-chip technologies. Some of its most common uses include medical education, surgical planning, prosthetic customization, tissue culture, and the production of biosensors. This wide range of applications is enabled by the digital model on which 3D printing is based, making the entire process more easily digitizable and, therefore, more adaptable to product updates and customization.

3D printing is a promising technology that could stimulate a true renaissance in the manufacturing sector in Nigeria and globally. It is revolutionizing many fields, including design, rapid prototyping, the arts, and the visualization of complex concepts (Balogun et al., 2018). Unlike traditional manufacturing methods, it allows objects to be created layer by layer, offering great flexibility and access to rapid production. This report explores the concepts of rapid prototyping and manufacturing, as well as the current technologies available for producing 3D components.

Furthermore, it highlights collaborative efforts between Edo Iyamho University (EUI) and the Federal University of Petroleum Resources to encourage research in additive manufacturing and develop locally made 3D printers. These initiatives aim to promote manufacturing innovation in Nigeria, with expected positive outcomes for academics, research institutes, and local industries. Ultimately, this work could help strengthen the share of the manufacturing sector in Nigeria's economy and boost growth in the country's Gross Domestic Product (GDP).

3D printing, or additive manufacturing, incurs variable economic costs depending on its uses and the industries involved. As Bourell et al. (2017) note in their study comparing the costs of additive manufacturing with traditional methods, the materials used, such as metal powders and polymers, are often more expensive to purchase. However, this technology reduces material waste due to its additive nature, leading to long-term savings, particularly in terms of waste management and production efficiency.

Mami (2015), in his analysis of the costs specific to 3D printing, highlights the

high cost of equipment. Industrial 3D printers require a significant initial investment, but they are particularly advantageous for producing small series or prototypes, given the absence of costly molds or tools. He also notes that 3D printing can streamline production processes for complex objects, reducing the need for manual assembly.

In terms of sustainability, Ford and Despeisse (2016) highlight the logistical benefits of 3D printing. Their study demonstrates that this technology can reduce storage and transportation costs by producing parts on demand, thus eliminating the need for large stock quantities. Moreover, 3D printing enables decentralized production, providing increased flexibility in environments where customization is essential.

Thus, while 3D printing involves higher initial costs, particularly in terms of materials and equipment, it can offer significant economic advantages in the areas of customization and flexible production, while reducing waste and logistical costs.

The Technology Acceptance Model (TAM), introduced by Davis in 1989, is widely used to explain technology adoption. This model is based on two main factors: perceived usefulness and perceived ease of use. However, while effective in many contexts, it does not account for the sociocultural specifics of the construction sector, where professional identity plays a central role in the decision to adopt or reject new technologies.

To address this gap, this study proposes a revised version of the TAM model, incorporating professional identity as a key factor influencing technology adoption. This enriched model also includes additional variables, such as contextual organizational factors, organizational support, and the influence of professional social networks, offering a more nuanced understanding of adoption dynamics in the construction sector.

In this framework, professional identity is introduced as a variable that directly influences how contractors perceive the usefulness and ease of use of 3D printing. Organizational factors, such as innovation culture and available resources, may also play a significant role in reducing resistance to change. Furthermore, organizational support, through training and adequate assistance, is essential to improve the perceived ease of use of the technology. Lastly, the influence of professional social networks, such as interactions with colleagues and mentors, proves to be crucial in fostering a positive attitude toward the adoption of new technologies.

Study Objectives

The aim of this study is to adapt the TAM model to the specifics of the construction sector by integrating professional identity and contextual factors to better understand the barriers to adopting 3D printing. Additionally, this research seeks to provide practical recommendations for overcoming these resistances and facilitating the integration of this innovative technology in the construction sector.

2. Research Context

3D printing, also known as additive manufacturing, allows for the creation of objects by adding layers of materials based on digital models. It offers significant flexibility, particularly for customization and rapid prototyping, while minimizing waste. Used across various sectors, it is revolutionizing production with its diverse and sustainable applications. Although promising, it still faces limitations regarding speed and the strength of printed materials.

Additive manufacturing is profoundly transforming production practices in the construction sector. It offers substantial potential for reducing both costs and production time. By utilizing 3D printing, buildings can be constructed in a fraction of the time typically required by conventional methods. Notable examples include the offices in Dubai¹, printed in just seventeen days, ten houses completed in only twenty-four hours in China², and a three-story building with the capacity to deposit a concrete stream at a rate of eighteen meters per minute³. Here is the corrected version of your text with improved phrasing and verified meaning: However, printing a building, rather than pouring concrete or stacking bricks with numerous workers, presents challenges for the construction industry.

The adoption of 3D printing in the construction sector offers considerable potential to transform practices, reduce costs, and improve efficiency. [Buswell et al. \(2007\)](#) demonstrate that this technology allows for the production of complex elements with high precision while reducing material waste. [Bogue \(2013\)](#) adds that 3D printing reduces construction costs and time compared to traditional methods. Moreover, [Perkins and Skitmore \(2015\)](#) highlight the design flexibility it offers, enabling better alignment with project needs. Finally, [Tay et al. \(2018\)](#) emphasize its positive impact in terms of sustainability, resource optimization, and shortening project timelines.

For this potential to be fully realized, the technology must be integrated into the construction process from the design phase. Large corporations have shown

¹3D Printing and Construction: Dubai Leading the Way.

Dawoud Al Hajri, Director General of Dubai Municipality, highlighted the significance of the office construction project for the municipality by stating, "This project represents a major turning point in the construction sector. 3D printing technologies will increase execution speed and lead to building completion in record time." The building's structure was 3D printed directly on-site, without any additional assembly stages.

The founder of the company responsible for this project explained, "3D printing technology for construction is still in its infancy. We are conducting extensive R&D work to make the technology accessible to everyone. We are very grateful to the Dubai Municipality for this project. [...] We are improving the current technology and developing a new version of our 3D printer that will be more reliable and twice as fast."

Reference: Apis Cor participates in the construction of the largest 3D-printed building in Dubai - 3Dnatives.

²In March 2017, an American startup 3D-printed an entire house in just twenty-four hours. The startup claims a cost saving of 25% to 40% compared to the expenses incurred by traditional house construction methods.

Reference: 3D Printers: Building a House in Less Than 24 Hours is Possible (latribune.fr).

³Fabrication additive secteur batiment construction (a3dm-magazine.fr).

interest in this technology, although many of them are based outside of French territory (e.g., major companies⁴ such as Bouygues Construction, Vinci⁵, and Saint Gobain⁶) and have adopted additive technology. Nevertheless, the diffusion of additive technology has not yet expanded on a large scale, and it faces difficulties being adopted by construction contractors.

3. Theoretical Framework

This article adopts a sociological perspective, examining the relationship between technology and individuals to better understand the factors influencing the acceptance of disruptive innovation. To achieve this, we explore various theoretical frameworks that have served as the basis for explaining individual acceptance of new technologies. We rely on the study of seven models that have provided conceptual frameworks for numerous research efforts in the field of information systems. These models can be classified according to their primary focus.

The first three models view individual behavior towards new technology as resistance to adoption by the potential user. The sixth model, the Technology Acceptance Model (TAM), synthesizes several theories, including the Theory of Reasoned Action (Ajzen & Fishbein, 1975), the Theory of Planned Behavior (Ajzen, 1991), Social Cognitive Theory (Bandura, 1985, 1986), and Innovation Diffusion Theory (Rogers, 1995), to explain specific behavior in the acceptance of new technologies.

The seventh model, the Unified Theory of Acceptance and Use of Technology (UTAUT), developed by Venkatesh et al. (2003), serves as the conceptual reference for our own research model. This model seeks to synthesize nearly fifty years of research on user technology acceptance. Information and communication technologies (ICT), which have experienced significant growth in recent decades, largely rely on the TAM model (Davis, 1989). Additive manufacturing follows this trend by incorporating ICT elements that offer undeniable advantages.

Based on the Theory of Reasoned Action proposed by Fishbein and Ajzen (1976), Davis (1989) developed TAM around two main factors: perceived usefulness and

⁴In 2017, Bouygues Construction and the University of Nantes partnered to build the first 3D-printed house in Nantes. Using 3D technology, the 95 m² house took shape in just 3 days through the use of an articulated robot arm. According to Contour Crafting (University of Southern California), 3D printing can reduce CO₂ emissions and embodied energy by 75% and 50%, respectively, compared to traditional methods. Additionally, the cost could be reduced by approximately 45%.

Reference: [Bouygues Construction - 3D Printing for Building a House] (<https://www.bouygues-construction.com/innovation/toutes-nos-innovations/limpression-3d-pour-construire-une-maison>).

⁵Vinci Construction, through its subsidiary Freyssinet, launched Concreative, a new company dedicated to 3D printing high-performance concrete. This subsidiary was established in Dubai to meet the regional market demand in the United Arab Emirates.

Reference: [High-Performance Concrete 3D Printing by Vinci] (<https://dailydigital.fr/limpression-3d-de-beton-haute-performance-cest-parti-via-vinci/>).

⁶The Dutch subsidiary of Saint Gobain, Weber Beamix, in the Netherlands, built a 94m² 3D-printed concrete house using the off-site concept. This involved printing 24 concrete elements layer by layer in a factory, which were then transported by truck to the construction site for assembly.

Reference: [First Individual House Made with 3D Printed Concrete] (<https://www.batiactu.com/edito/premiere-maison-individuelle-realisee-beton-imprimee-61831.php>).

perceived ease of use. According to Davis (1989), these two factors directly influence the intention to adopt and use a technology.

TAM, originally designed to explain behavior related to computer use (Davis, et al., 1992), is considered one of the most influential and popular theories in the field of information systems. It is widely used in empirical research (Chang, Chou, & Yang, 2010). Davis (1989) posited that the two core variables of his model are influenced by both cognitive and social factors at the individual and organizational levels. Perceived usefulness and perceived ease of use thus impact the individual's attitude and intention toward additive manufacturing.

Many improvements have been made to the basic model, including contributions by Davis et al. (Davis et al., 1992), Venkatesh and Davis (2000), Venkatesh et al. (2003), and Venkatesh and Bala (2008). However, while this integrative model is effective as a generic framework for technology acceptance, it must be adapted to the specific context and object to which it is applied. Researchers such as Roy et al. (2015), Jawadi (2014), and Bourdon and Hollet-Haudebert (2009) have already employed TAM to study contributions to knowledge bases in specific contexts.

Research Gap: This article proposes a revised version of TAM adapted to the context of additive manufacturing in the construction sector. Indeed, none of the existing variations of the TAM (TAM 1, 2, and 3) account for issues related to professional identity. This is especially crucial in a sector where practices and norms have become rigid since the 1970s. The identity construction of actors in the sector has evolved alongside these developments, allowing individuals to align with their professional environments. Thus, we propose incorporating mechanisms of professional identity protection into our revised version of TAM to better understand resistance to change and its impact on the acceptance of additive technology.

4. Key Concepts

Professional identity is primarily a social identity rooted in a profession, resulting from the incorporation of professional knowledge. It is considered a form of secondary socialization. In this context, Renaud Sainsaulieu (1997) highlights that identity undergoes specific socialization due to the effects of power, professions, and social classes. He argues that “*work life is not only a place of technical relations, power relations, or class struggles, but also a place of socialization where people learn more or less flexible and rich forms of relationships with others, thereby ‘charging their experience’*” (Dubar, 2000).

According to Jean Piaget, professional integration is both a goal and proof of an individual's professional abilities. We follow Claude Dubar (Dubar, 2000, 2001, 2007, 2021), in describing the attributes of professional identity in our work. We also draw on Social Identity Theory (Turner & Tajfel, 1986), which posits that identity is constructed throughout life through a process of socialization. This socialization stems from an individual's representation of the world, and this

representation of identity can become a variable influencing the acceptance of new technology in a changing context.

Our theoretical framework is based on Ajzen's (1985) Theory of Planned Behavior (TPB), an extension of the Theory of Reasoned Action. This theory posits that the intention to adopt a behavior is the key factor in the generation of that behavior. In other words, an individual's decision to engage in a behavior directly stems from their intention to adopt it.

According to TPB, beliefs (positive or negative) are antecedents to attitude, subjective norm, and perceived behavioral control. In our study, we also associate this theory with the concept of professional identity (Dubar, 2000) to explore how social identity (De Ryckel & Delvigne, 2010; Laruelle, 1992), influences the acceptance of new technology.

By using TPB as a predictive theoretical model, we refer to studies like those of Whitley and Kieth-Spiegel (2001), which reveal that students with a favorable attitude toward cheating, including electronic plagiarism, are more likely to cheat than those with an unfavorable attitude. Attitudes are more likely to trigger behavior when based on direct experience with the attitudinal object (Leyens & Yzerbyt, 1997).

Research Question

Our research question stems directly from the realities observed in the field, leading us to adopt an empirico-formal approach. To formulate this research problem, we conducted an exploratory phase that included various types of interviews, such as semi-structured interviews and life stories, as well as a period of participant observation.

To what extent does identity-based resistance among actors in the construction sector influence the introduction of disruptive technologies such as 3D printing, and how does this resistance challenge the effectiveness of the current TAM model in predicting the adoption of these technologies?

In terms of context, the construction sector faces major challenges related to disruptive innovation and structural transformation. This sector is characterized by high levels of CO₂ emissions, heavy energy consumption, and substantial waste production on construction sites, which still heavily rely on manual labor. The construction industry has long operated in a craft-like manner, with most companies adopting extensive growth models based on the use of labor (Topalov, 1973, 2017). The construction workforce has grown more rapidly than in other sectors (Campion & Lord, 1982; Campion, Papper, & Medsker, 1996).

However, the profession suffers from a shortage of skilled workers. Sector leaders view the "main bottleneck" as precisely this lack of skilled labor. For a long time, French contractors have relied on specialized workers from abroad to fill this gap. Despite the gradual introduction of machinery and improvements in equipment, such as cranes and metal formwork, technical advances remain limited and are mostly reflected in increased task repetitiveness.

In this context, additive technology (3D printing) emerges as a solution to

address these challenges, offering contractors and other construction actors a way to overcome these constraints. However, resistance to change at a micro-level, particularly related to the acceptance of this new technology, remains a barrier. This resistance, which has not been previously studied in the literature, is closely linked to the professional identity of contractors. These professionals preserve their craft identity and see new technology as a threat that could disrupt the work organization and technical skills they have developed over time. It may also disturb the self-image these professionals associate with their trade.

Taking professional identity into account in this problem allows for a better understanding of its ambivalent influence on change. Thus, our research question can be formulated as follows: To what extent can barriers to the adoption of additive technology become rejection strategies through defense mechanisms of professional identity?

Professional identity is subject to a series of contemporary challenges that are redefining how individuals perceive themselves and act within their professional sphere. Among these challenges, Richard [Susskind \(2010\)](#) highlights the role of rapid technological changes, particularly automation and artificial intelligence, which are disrupting traditional professions. These developments require workers to constantly adapt their skills and rethink their roles, or risk being replaced or marginalized.

Furthermore, globalization introduces additional pressure on professional identity, as noted by [Ulrich Beck \(2001\)](#). Global competition forces individuals to stand out and reinvent themselves in an increasingly individualized environment, where competitiveness is no longer just local but global. This aspect is accompanied by the evolution of work forms, often more precarious and flexible. [Guy Standing \(2011\)](#) refers to the rise of the “precariat”, a class of workers characterized by job instability, which complicates the formation of a stable professional identity.

Additionally, societal expectations are evolving. According to [Charles Handy \(1994\)](#), the concept of “portfolio work,” where individuals take on multiple roles, is becoming more prevalent with the growing importance of values such as sustainability, diversity, and inclusion. These values change the way professionals perceive their roles and how they must conform to societal norms.

The challenge of balancing professional and personal life is also crucial. [David Whyte \(2014\)](#) shows that the constant pressure to be available and perform can destabilize identity coherence. The blurred boundaries between private and professional life make it more complex to build a unified identity.

Finally, the necessity for continuous learning is emphasized by [Peter Senge \(1990\)](#), who discusses the concept of the “learning organization”. In the face of rapidly changing environments, professionals must constantly redefine their skills and prepare for unpredictable changes, which can have a lasting impact on their identity.

These various challenges, although diverse, share a common point: they impose

a constant and dynamic redefinition of professional identity in a context of technological, economic, and social transformations.

Conversely, technology acceptance models, such as TAM, do not consider social and professional communities, nor the established practices shaped by norms and rules to which these technologies are subjected. We, therefore, turn to Theory of Planned Behavior (Ajzen, 1985, 1991; Fishbein & Ajzen, 2011) to ground our reflections in the field of social psychology, as a way to predict behaviors related to the adoption of new technologies.

5. Methodology

In our research, we outlined a heuristic methodology rooted in interpretive sociology, inspired by the work of Max Weber (1978), focusing our epistemological attention on the actions of actors as the main object of study. This approach emphasizes the subjectivity and motivations of individuals, moving away from a strictly objectivist and positivist view to adopt a constructivist stance. We opted for a qualitative method in three phases, similar to the triangulation of methods described by Koners and Goffin (2007).

Method Triangulation

Our qualitative approach relies on three distinct but complementary phases, allowing us to capture the richness of interactions between the actors studied. As Jonsen and Jehn (2009) point out, this constructivist approach, which favors triangulation, enhances the quality of results by integrating various methodological perspectives. Each phase corresponds to a data collection type designed to capture different dimensions of the subject of study:

- Phase 1: Semi-structured interviews

In this first phase, which follows a comprehensive analytical approach, we conducted semi-structured interviews with 56 entrepreneurs and 25 architects in the construction sector. This method allows for in-depth responses regarding their perceptions and practices while providing participants with the flexibility to express their own views on the technological innovation challenges in their industry.

- Phase 2: Participant observation

The second phase involved immersion in the studied environment through participant observation. This data collection method allowed researchers to integrate into the daily practices of construction actors, particularly around projects using additive manufacturing. Observing the interactions between different actors in the technological validation process offers an essential complement to the interviews, allowing us to grasp non-verbal behaviors and social dynamics in real-life situations.

- Phase 3: Life stories

Finally, the third phase involved gathering life stories from entrepreneurs and architects. This method aims to capture personal and professional trajectories, providing a better understanding of the subjective factors influencing their relationship with additive innovation. These narratives offer insights into the deeper

motivations of individuals and the identity dynamics that influence their adoption or rejection of new technologies.

Research Axes

These three methodological phases revolve around three main research axes, aiming to understand the factors facilitating or hindering the adoption of technological innovations in the construction sector.

1) Understanding additive innovation dynamics

The first research axis focuses on understanding the relationships between construction actors and the technological validation processes in the sector. Semi-structured interviews enabled us to model these relationships, highlighting the complex interactions between entrepreneurs, architects, and technological innovators. Additive innovation, in particular, is a key area of interest as it redefines professional practices and decision-making structures within construction companies.

2) Resistance to change

The second axis concerns analyzing forms of resistance to change, specifically related to the acceptance of additive manufacturing in the sector. Through participant observation, we identified real-life resistance behaviors and applied a resistance-to-change measurement model to diagnose these behaviors. This observation allowed us to study how actors cope with technological and organizational transformations, revealing the tensions that can arise during the introduction of innovations.

3) Factors hindering technological acceptance: an identity-based approach

The third research axis explores the individual and collective factors that slow the acceptance of new technologies, particularly through life stories. This micro-sociological approach highlighted the importance of professional identity in the technology adoption process. The life stories revealed that attachment to traditional professional norms and practices plays a central role in rejecting or accepting new technologies such as additive manufacturing. Professional identity thus proves to be a key factor in adopting these technologies.

Data Analysis

Data analysis was conducted using a qualitative and inductive approach, inspired by the work of [Strauss and Corbin \(1997\)](#) and [Gioia et al. \(2013\)](#). After collecting data from interviews, observations, and life stories, we performed a thematic analysis using NVivo software to code the data and identify emerging categories.

These categories allowed us to connect the different phases of the methodology to relevant theoretical concepts, such as resistance to change and professional identity. Inductive coding revealed recurring themes, including the importance of professional social networks, the perception of risks associated with innovation, and how actors adapt to new technologies. Each phase was analyzed based on the collected narratives to better understand how entrepreneurs and architects perceive and adopt innovation in the construction sector.

This triangulated method, based on inductive qualitative analysis, allowed us to gain deep insights into the social, organizational, and individual dynamics influencing the acceptance of additive innovation in the construction sector. By emphasizing professional identity, this research sheds light on the underlying mechanisms of resistance to change and makes a valuable contribution to the sociology of technological innovations.

6. Results

6.1. Theoretical Contributions

This study introduces a new dimension—professional identity—to the Technology Acceptance Model (TAM). This external factor directly influences the intention to use and the perceived usefulness of the technology, particularly concerning its impact on the identity formation of construction entrepreneurs. In this context, professional identity acts as a barrier to technological acceptance from the outset, due to observed patterns of collective and individual resistance among actors in the sector, particularly construction entrepreneurs.

Additionally, the research revealed another key aspect: the perception of the risk of sudden technological change. 3D printing, perceived as a major disruption, not only affects the social production space of companies but also challenges the professional identities of construction sector actors. These identities thus become key factors in the technological transformation dynamics, confirming that the adoption of this technology is hindered by deep-rooted identity-based resistance within the sector.

6.2. Evolution of TAM Research

Since its development in 1989, research on the TAM has followed three main trends: the theoretical development of the model, its application to the study of e-commerce acceptance, and the analysis of information and communication technologies (ICT). Hsiao and Yang (2010) distinguish two groups of studies: those examining task-related ICT (offline and online information systems) and those exploring e-commerce (traditional and mobile). These studies highlight three primary applications of the TAM: productivity systems, e-commerce systems, and hedonic systems.

Initially designed to analyze productivity-oriented ICT, the TAM gradually evolved toward the study of e-commerce and leisure systems. However, a major criticism of the TAM is its overemphasis on organizational efficiency, which limits the relevance of the usefulness variable in certain contexts, such as entrepreneurial adoption. To address these limitations, we developed a revised model that adapts the TAM to modern dynamics and includes new correlations between various variables influencing technological acceptance in complex organizational contexts.

6.3. Literature Review on the TAM Model

The TAM model has been the subject of numerous studies since its inception.

Initially developed to study the acceptance of technologies within business software applications, TAM is based on two main dimensions: perceived usefulness (PU) and perceived ease of use (PEoU). These two factors influence users' attitudes toward the technology, which in turn determines their intention to use it, leading to actual usage.

The initial version of the model was tested by [Davis \(1989\)](#) and [Davis & Granić \(2024\)](#) using a word processing application with a group of MBA students. This first study confirmed that both factors (PU and PEoU) directly influence users' behavioral intentions. Since then, TAM has been expanded and enriched by several researchers to include additional variables, resulting in extensions such as TAM2 and UTAUT (Unified Theory of Acceptance and Use of Technology).

In TAM2, [Venkatesh and Davis \(2000\)](#) introduced additional variables to better understand the factors influencing perceived usefulness, such as subjective norms, result demonstrability, and output quality. These additions help explain how social and organizational factors can modulate the perception of a technology's usefulness. The UTAUT model, proposed by [Venkatesh et al. \(2003\)](#), further expanded the theoretical framework by adding social influence, facilitating conditions, as well as moderators like gender, age, experience, and the voluntary or mandatory nature of technology use.

Despite these developments, models derived from TAM have not yet sufficiently accounted for the importance of social and cultural factors specific to certain professional sectors, such as professional identity. This is particularly relevant in fields where technology adoption is strongly influenced by identity considerations, as is the case in the construction sector.

6.4. Limitations of the TAM Model in the Construction Sector

In the construction sector, the adoption of disruptive technologies such as 3D printing faces obstacles that cannot be explained solely by the classic factors of usefulness and ease of use. The TAM model, in its current form, does not account for the identity resistance of actors who view 3D printing as a challenge to their traditional practices and roles within the industry. This omission limits the model's ability to accurately predict technology adoption in this type of sector.

Therefore, by integrating professional identity into the TAM model, our research proposes a more nuanced approach capable of explaining why objectively advantageous technologies may encounter significant resistance in certain professional contexts. This approach not only helps better understand the dynamics of adoption but also offers strategies to overcome these resistances.

In summary, this research makes a significant contribution to the literature on technology acceptance by proposing a revised version of the TAM model that incorporates professional identity. This enriched model helps better understand the complex dynamics underlying the adoption of disruptive technologies, such as 3D printing, in highly traditional sectors like construction. Practically, it provides recommendations for overcoming resistance to change, taking into account the

identity and organizational factors that influence technology acceptance.

6.5. Revised MATAST Model—Key Modifications

1) Incorporation of Contextual Organizational Factors:

The original model focuses on individual perceptions such as perceived usefulness (PU), perceived ease of use (PEoU), and professional identity. Our revised model introduces contextual organizational factors, such as corporate policies, organizational culture, and resource availability. These factors moderate the influence of Perceived Risk of Change (PRC) and Mechanisms of Resistance to Change (MRC), as a favorable organizational environment can reduce individual resistance to technological change.

2) Addition of Organizational Support (OS):

Our model also incorporates Organizational Support (OS), which refers to the level of training and support provided by the organization to facilitate the adoption of new technologies. This factor has a direct impact on the Perceived Ease of Use (PEoU). The more adequate the organizational support, the easier the technology is perceived to adopt and use.

3) Integration of Professional Social Networks (PSN):

Professional Social Networks (PSN), particularly interactions between colleagues and mentors, play a crucial role in the acceptance of change. The revised model highlights the importance of PSNs in shaping the Attitude Toward Use (ATT), as peer influence can alter the perception of technology and its usefulness.

4) Consideration of User Engagement (UE):

The revised model also includes the variable User Engagement (UE), which depends on Behavioral Intention (BI) and real experience with the technology. User engagement, in turn, influences the Perceived Ease of Use (PEoU) and Perceived Usefulness (PU), creating a positive feedback loop. In other words, the more actively a user engages with the technology, the more they improve their skills and perceive its usefulness.

This section provides a comprehensive overview of the study's theoretical contributions, the evolution of TAM research, and the key modifications introduced in the revised MATAST model, emphasizing how these adjustments address the limitations of the traditional TAM and better align with modern organizational contexts (Figure 1).

6.6. New Correlations in the Revised Model

1) Contextual Organizational Factors (COF) and Resistance to Change Mechanisms (RCM):

There is an inverse correlation between these two variables. A favorable organizational environment, with a culture of innovation and adequate resources, can reduce individuals' resistance to change.

2) Organizational Support (OS) and Perceived Ease of Use (PEoU):

Organizational support (through training, demonstrations, or close guidance)

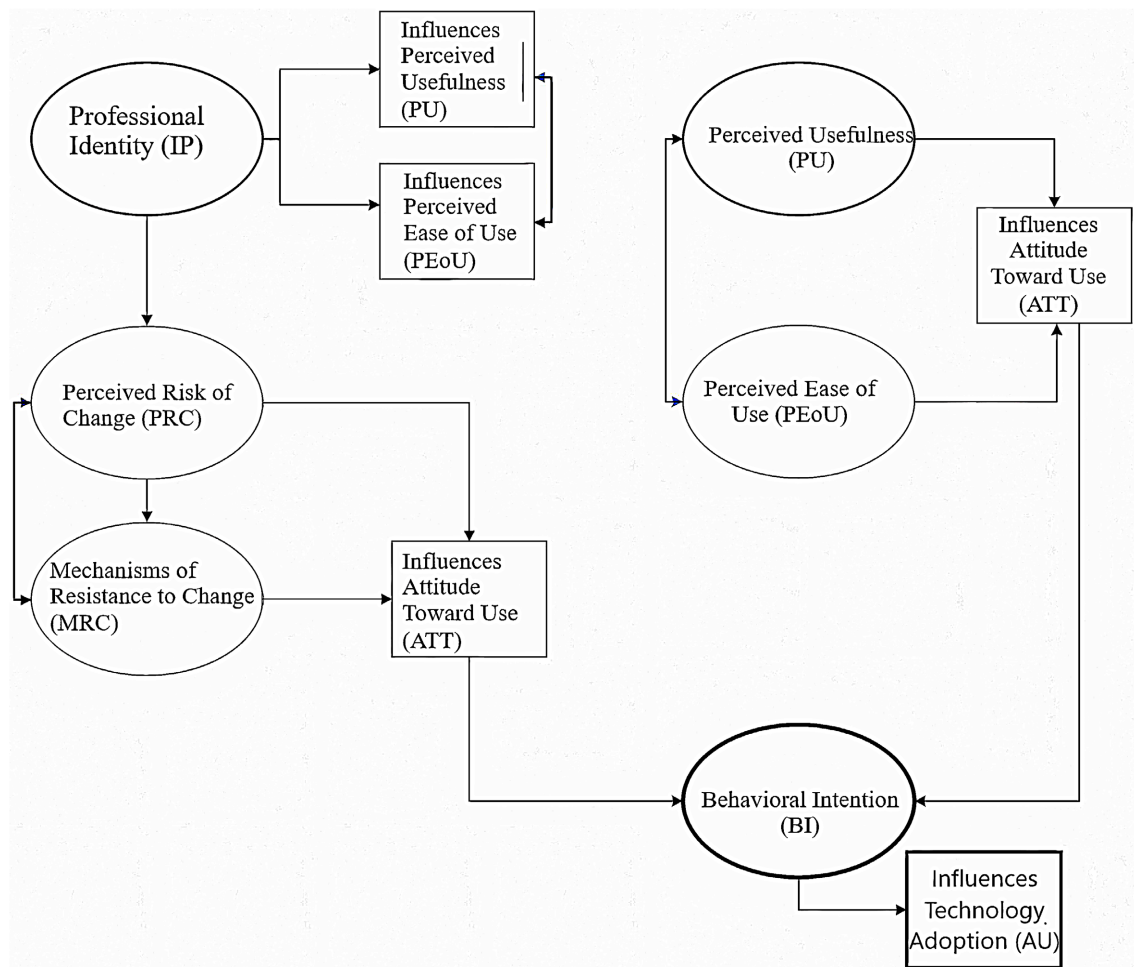


Figure 1. Diagram of the MATAST Model (by author).

is positively correlated with Perceived Ease of Use. The more proactive the organization is in its support; the easier users perceive the technology to master.

3) Professional Social Networks (PSN) and Attitude Toward Use (ATT):

Interactions within professional social networks, both internal and external to the organization, strongly influence users' attitudes toward technology. Positive feedback and recommendations from colleagues or mentors often lead to a more favorable attitude toward adoption.

4) User Engagement (UE) and Attitude Toward Use (ATT):

Active user engagement promotes a positive attitude toward technology. Consequently, a positive correlation is established between these two variables, indicating that the more a user invests in using a technology, the more favorable their attitude toward it becomes.

7. Discussion

This study revealed that resistance to the adoption of 3D printing in the construction sector is largely influenced by the professional identity of actors, an aspect often overlooked in traditional technology acceptance models. By incorporating

this variable into a revised version of the TAM model, we were able to better understand the dynamics of resistance.

1) Resistance to Change and Professional Identity:

Professional identity, rooted in traditional practices, is a major obstacle to the adoption of 3D printing. [Dubar \(2000\)](#) shows that professional identity, shaped by practices and experiences, makes individuals more resistant to innovation. Our revised model proposes professional identity as a moderating variable, directly influencing the perception of usefulness and ease of use. Although the technology may be perceived as useful, it is rejected due to the threat it poses to artisanal skills.

2) Contextual Organizational Factors and Technology Acceptance:

Contextual organizational factors, ignored in earlier versions of TAM, play a crucial role in the adoption of 3D printing. Companies with an active innovation culture and support for technology adoption facilitate acceptance. This aligns with [Jawadi's \(2014\)](#) work, which highlights that organizations supportive of innovation are more likely to adopt new technologies ([Roy et al., 2015](#); [Royer, 2002](#)).

3) Organizational Support and Perception of Ease of Use (PEoU):

Organizational support emerges as a key factor in technology acceptance. Our results show that companies investing in training and guidance improve perceptions of Ease of Use ([Canet & David, 2009](#); [Davis, 1993](#); [Venkatesh et al., 2003](#)). Entrepreneurs receiving organizational support show a more favorable attitude toward 3D printing.

By integrating new dimensions into the revised TAM model, this study provides a more comprehensive approach to understanding resistance to the adoption of technologies such as 3D printing in the construction sector. Professional identity, contextual organizational factors, organizational support, professional social networks, and user engagement play key roles in this process. Unlike classical models, our revised version shows that perceptions of usefulness and ease of use are influenced by social and organizational factors specific to the sector. By considering these variables, we propose a nuanced framework for improving the adoption of disruptive technologies.

8. Contributions

8.1. Theoretical

The Technology Acceptance Model (TAM), introduced by [Davis \(1989\)](#), occupies a central place in studies on technology adoption. This model, widely used in the field of information systems, has been applied to numerous technological contexts, ranging from the adoption of business applications to the acceptance of disruptive technologies. However, despite its widespread use, TAM continues to raise questions about its ability to effectively predict technology acceptance and the specific factors that influence acceptance in different contexts.

In this research, we focus on the limitations of the TAM model as an analytical tool in the construction sector, particularly in the context of adopting emerging technologies such as 3D printing. While TAM focuses on two main dimensions—

Perceived Ease of Use (PEoU) and Perceived Usefulness (PU)—it does not sufficiently consider sociocultural and professional factors such as users' professional identity. This omission is particularly problematic in traditional sectors, where professional identity is often associated with artisanal practices and specific technical skills.

With this in mind, we propose a revised version of the TAM model that incorporates professional identity as a key moderating factor in technology adoption. Integrating this concept enriches the understanding of technology acceptance by accounting for social and cultural resistances often ignored in classical adoption models. This new dimension allows for a better understanding of how users, particularly entrepreneurs in the construction sector, perceive disruptive technologies like 3D printing, and why some of them resist adoption despite perceived benefits in terms of efficiency and cost.

8.2. Practical

From a practical perspective, applying this revised model allows for a better understanding of adoption dynamics in sectors where professional identity plays a crucial role in the decision to adopt or reject a new technology. In the construction sector, entrepreneurs and decision-makers are facing a major technological transition with the introduction of 3D printing. This technology, while offering significant advantages in terms of cost reduction, design flexibility, and production timelines, encounters substantial resistance due to the perception that it may radically alter well-established professional and artisanal practices.

The revised model suggests that resistance to the adoption of 3D printing cannot be explained solely by technical or economic factors. It highlights the importance of professional identity as a barrier to adoption. Construction entrepreneurs often perceive 3D printing as a threat to their traditional skills and roles within the industry. This perception reinforces psychological and organizational resistance, slowing the adoption of the technology, despite its objective advantages.

The application of the revised TAM model offers several avenues for improving the adoption of 3D printing in this sector:

- 1) **Training and Personalized Support:** By integrating specific training programs that allow entrepreneurs to master 3D printing while preserving their artisanal skills, it is possible to reduce perceptions of threat and improve technology acceptance.

- 2) **Organizational Support:** Creating an organizational climate favorable to innovation while valuing traditional skills can help overcome resistance to change. Continuous support, in terms of resources and managerial backing, is essential for fostering the adoption of disruptive technologies.

- 3) **Use of Professional Social Networks:** The model also highlights the importance of professional networks and peer exchanges in positively influencing the adoption of new technology. Positive feedback from entrepreneurs who have already

adopted 3D printing can play a key role in the dissemination of this technology within the sector.

9. Conclusion

This study has revisited and enriched the MATAST model by integrating social, organizational, and professional dimensions, often overlooked in traditional technology acceptance models. The revised MATAST model notably incorporates professional identity as a key moderating factor, helping to explain the resistance to the adoption of disruptive technologies, such as 3D printing in the construction sector. Although this technology offers undeniable advantages in terms of cost, efficiency, and flexibility, it faces strong resistance, particularly due to the perceived threat it poses to artisanal skills and the traditional roles of professionals in the sector.

Moreover, the integration of new concepts such as contextual organizational factors and organizational support within the revised MATAST model highlights their crucial importance in reducing resistance to change. Companies that foster an innovation culture and provide adequate organizational support, through training and guidance, facilitate the acceptance of new technologies. Additionally, professional social networks and user engagement emerge as essential levers for positively influencing users' attitudes toward emerging technologies.

Thus, the revised MATAST model offers a more comprehensive theoretical and practical framework for understanding the dynamics of adopting disruptive technologies, particularly in sectors deeply rooted in artisanal traditions. By considering identity, organizational, and social dimensions, this enriched model provides concrete strategies to overcome resistance to change and promote the adoption of technologies such as 3D printing, thereby contributing to digital transformation and innovation within the construction sector.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

- Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In J. Kuhl, & J. Beckmann (Eds.), *Action Control: From Cognition to Behavior* (pp. 11-39). Springer. https://doi.org/10.1007/978-3-642-69746-3_2
- Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, 50, 179-211. [https://doi.org/10.1016/0749-5978\(91\)90020-t](https://doi.org/10.1016/0749-5978(91)90020-t)
- Ajzen, I., & Fishbein, M. (1975). A Bayesian Analysis of Attribution Processes. *Psychological Bulletin*, 82, 261-277. <https://doi.org/10.1037/h0076477>
- Balogun, V. A., Otanocha, O. B., & Ibadode, A. O. (2018). The Impact of 3D Printing Technology to the Nigerian Manufacturing GDP. *Modern Mechanical Engineering*, 8, 140-157. <https://doi.org/10.4236/mme.2018.82010>
- Bandura, A. (1985). Model of Causality in Social Learning Theory. In M. J. Mahoney, & A. Freeman (Eds.), *Cognition and Psychotherapy* (pp. 81-99). Springer US.

- https://doi.org/10.1007/978-1-4684-7562-3_3
- Bandura, A. (1986). *Social Foundations of Thought and Action* (pp. 23-28). Prentice Hall.
- Beck, U. (2001). La politique dans la société du risque. *Revue du MAUSS*, 17, 376-392. <https://doi.org/10.3917/rdm.017.0376>
- Bogue, R. (2013). 3D Printing: The Dawn of a New Era in Manufacturing? *Assembly Automation*, 33, 307-311. <https://doi.org/10.1108/aa-06-2013-055>
- Bourdon, I., & Hollet-Haudebert, S. (2009). Pourquoi contribuer à des bases de connaissances? Une exploration des facteurs explicatifs à la lumière du modèle UTAUT. *Systèmes d'information & management*, 14, 9-36. <https://doi.org/10.3917/sim.091.0009>
- Bourell, D., Kruth, J. P., Leu, M., Levy, G., Rosen, D., Beese, A. M. et al. (2017). Materials for Additive Manufacturing. *CIRP Annals*, 66, 659-681. <https://doi.org/10.1016/j.cirp.2017.05.009>
- Buswell, R. A., Soar, R. C., Gibb, A. G. F., & Thorpe, A. (2007). Freeform Construction: Mega-Scale Rapid Manufacturing for Construction. *Automation in Construction*, 16, 224-231. <https://doi.org/10.1016/j.autcon.2006.05.002>
- Campion, M. A., & Lord, R. G. (1982). A Control Systems Conceptualization of the Goal-Setting and Changing Process. *Organizational Behavior and Human Performance*, 30, 265-287. [https://doi.org/10.1016/0030-5073\(82\)90221-5](https://doi.org/10.1016/0030-5073(82)90221-5)
- Campion, M. A., Papper, E. M., & Medsker, G. J. (1996). Relations between Work Team Characteristics and Effectiveness: A Replication and Extension. *Personnel Psychology*, 49, 429-452. <https://doi.org/10.1111/j.1744-6570.1996.tb01806.x>
- Canet, E., & David, A. (2009, May). Stratégie en action et capacités organisationnelles: une comparaison entre le balanced scorecard et la méthode 5 steps. In *Colloque Management des capacités organisationnelles, ACFAS 2009* (pp. 95-114).
- Chang, S.-H., Chou, C.-H., & Yang, J.-M. (2010). The Literature Review of Technology Acceptance Model: A Study of the Bibliometric Distributions. In *PACIS 2010 Proceedings* (p. 158). <http://aisel.aisnet.org/pacis2010/158>
- Chunhua, S., & Guangqing, S. (2020). Application and Development of 3D Printing in Medical Field. *Modern Mechanical Engineering*, 10, 25-33. <https://doi.org/10.4236/mme.2020.103003>
- Davis, F. D. (1989). Technology Acceptance Model: TAM. In M. N. Al-Suqri, & A. S. Al-Aufi (Eds.), *Information Seeking Behavior and Technology Adoption* (pp. 205-219). IGI Global.
- Davis, F. D. (1993). User Acceptance of Information Technology: System Characteristics, User Perceptions and Behavioral Impacts. *International Journal of Man-Machine Studies*, 38, 475-487.
- Davis, F. D., & Granić, A. (2024). *The Technology Acceptance Model: 30 Years of TAM*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-45274-2>
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and Intrinsic Motivation to Use Computers in the Workplace. *Journal of Applied Social Psychology*, 22, 1111-1132. <https://doi.org/10.1111/j.1559-1816.1992.tb00945.x>
- de Ryckel, C., & Delvigne, F. (2010). La construction de l'identité par le récit. *Psychothérapies*, 30, 229-240. <https://doi.org/10.3917/psys.104.0229>
- Dubar, C. (2000). *La socialisation. Construction des identités individuelles et collectives*. Armand Colin.
- Dubar, C. (2001). La construction sociale de l'insertion professionnelle. *Éducation et Sociétés*, 7, 23-36. <https://doi.org/10.3917/es.007.0023>

- Dubar, C. (2007). Les sociologues face au langage et à l'individu. *Langage et société*, 121, 29-43. <https://doi.org/10.3917/lis.121.0029>
- Dubar, C. (2021). *Les recherches en sciences sociales et les dispositifs publics en France: Une histoire compliquée*.
- Fishbein, M., & Ajzen, I. (1976). Misconceptions about the Fishbein Model: Reflections on a Study by Songer-Nocks. *Journal of Experimental Social Psychology*, 12, 579-584. [https://doi.org/10.1016/0022-1031\(76\)90036-6](https://doi.org/10.1016/0022-1031(76)90036-6)
- Fishbein, M., & Ajzen, I. (2011). *Predicting and Changing Behavior: The Reasoned Action Approach*. Psychology Press. <https://doi.org/10.4324/9780203838020>
- Ford, S., & Despeisse, M. (2016). Additive Manufacturing and Sustainability: An Exploratory Study of the Advantages and Challenges. *Journal of Cleaner Production*, 137, 1573-1587. <https://doi.org/10.1016/j.jclepro.2016.04.150>
- Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods*, 16, 15-31. <https://doi.org/10.1177/1094428112452151>
- Handy, C. B. (1994). *The Age of Paradox*. Harvard Business Press. <https://books.google.com/books?id=v1baPx03VpwC>
- Hsiao, C. H., & Yang, C. (2010). Predicting the Travel Intention to Take High Speed Rail among College Students. *Transportation Research Part F: Traffic Psychology and Behaviour*, 13, 277-287. <https://doi.org/10.1016/j.trf.2010.04.011>
- Jawadi, N. (2014). Facteurs-clés de l'adoption des systèmes d'information dans la grande distribution alimentaire: une approche par l'UTAUT. In *17ème Colloque de l'Association Information et Management (AIM)* (pp. 21-22).
- Jonsen, K., & Jehn, K. A. (2009). Using Triangulation to Validate Themes in Qualitative Studies. *Qualitative Research in Organizations and Management: An International Journal*, 4, 123-150. <https://doi.org/10.1108/17465640910978391>
- Koners, U., & Goffin, K. (2007). Learning from Postproject Reviews: A Cross-Case Analysis. *Journal of Product Innovation Management*, 24, 242-258. <https://doi.org/10.1111/j.1540-5885.2007.00248.x>
- Laruelle, F. (1992). *Théorie des identités*. Presses Universitaires de France. <https://doi.org/10.3917/puf.larue.1992.01>
- Leyens, J.-P., & Yzerbyt, V. (1997). *Psychologie sociale* (Vol. 77). Editions Mardaga.
- Mami, F. (2015). *Éco-efficience et analyse des coûts du cycle de vie: Développement d'un outil d'aide à la conception dans l'industrie aéronautique*. PhD Thesis, École Polytechnique de Montréal. https://publications.polymtl.ca/1738/1/2015_FaresMami.pdf
- Perkins, I., & Skitmore, M. (2015). Three-Dimensional Printing in the Construction Industry: A Review. *International Journal of Construction Management*, 15, 1-9. <https://doi.org/10.1080/15623599.2015.1012136>
- Rogers, E. M. (1995). Diffusion of Innovations: Modifications of a Model for Telecommunications. In M.-W. Stoetzer, & A. Mahler (Eds.), *Die Diffusion von Innovationen in der Telekommunikation* (pp. 25-38). Springer. https://doi.org/10.1007/978-3-642-79868-9_2
- Roy, M., Chartier, A., Crête, J., & Poulin, D. (2015). Factors Influencing E-Government Use in Non-Urban Areas. *Electronic Commerce Research*, 15, 349-363. <https://doi.org/10.1007/s10660-015-9193-4>
- Royer, I. (2002). Les procédures décisionnelles et le développement de nouveaux produits. *Revue française de gestion*, 3-4, 7-25.

- Sainsaulieu, R. (1997). *Sociologie de l'entreprise: Organisation, culture et développement*. Presses de la Fondation nationale des sciences politiques.
- Senge, P. (1990). *La cinquième discipline* (trad.). Editions First.
- Standing, G. (2011). Behavioural Conditionality: Why the Nudges Must Be Stopped—An Opinion Piece. *Journal of Poverty and Social Justice*, 19, 27-38.
<https://doi.org/10.1332/175982711x559136>
- Strauss, A., & Corbin, J. M. (1997). *Grounded Theory in Practice*. Sage.
- Susskind, R. (2010). Legal Informatics: A Personal Appraisal of Context and Progress. *European Journal of Law and Technology*, 1, 88-110.
- Tay, L., Zyphur, M., & Batz, C. L. (2018). Income and Subjective Well-Being: Review, Synthesis, and Future Research. In E. Diener, S. Oishi, & L. Tay (Eds.), *Handbook of Well-being*. DEF Publishers.
- Topalov, C. (1973). *Capital et propriété foncière: Introduction à l'étude des politiques foncières urbaines*. Centre de sociologie urbaine Paris.
- Topalov, C. (2017). *Les promoteurs immobiliers: Contribution à l'analyse de la production capitaliste du logement en France* (Vol. 4). Walter de Gruyter GmbH & Co KG.
- Turner, J. C., & Tajfel, H. (1986). The Social Identity Theory of Intergroup Behavior. *Psychology of Intergroup Relations*, 5, 7-24.
- Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences*, 39, 273-315.
<https://doi.org/10.1111/j.1540-5915.2008.00192.x>
- Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, 46, 186-204.
<https://doi.org/10.1287/mnsc.46.2.186.11926>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, 27, 425-478.
<https://doi.org/10.2307/30036540>
- Weber, M. (1978). *Economy and Society: An Outline of Interpretive Sociology* (Vol. 1). Univ. of California Press.
- Whitley Jr., B. E., & Keith-Spiegel, P. (2001). *Academic Dishonesty: An Educator's Guide*. Psychology Press. <https://doi.org/10.4324/9781410604279>
- Whyte, D. (2014). Regimes of Permission and State-Corporate Crime. *State Crime Journal* 3, 237.